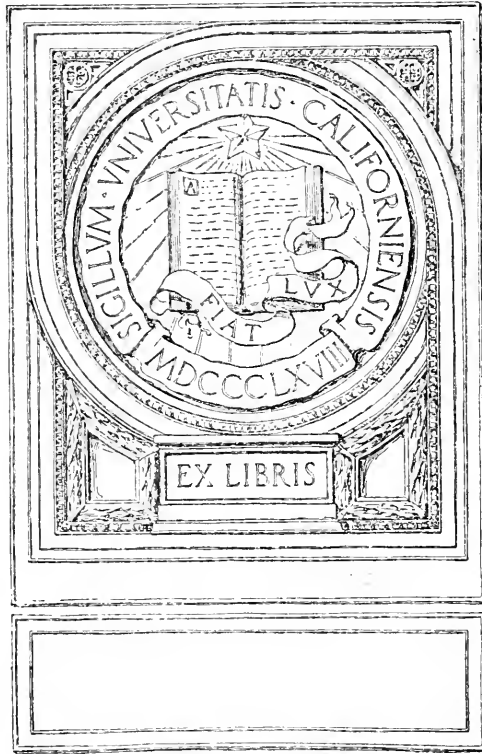


DEPARTMENT OF AGRICULTURE
NEW SOUTH WALES

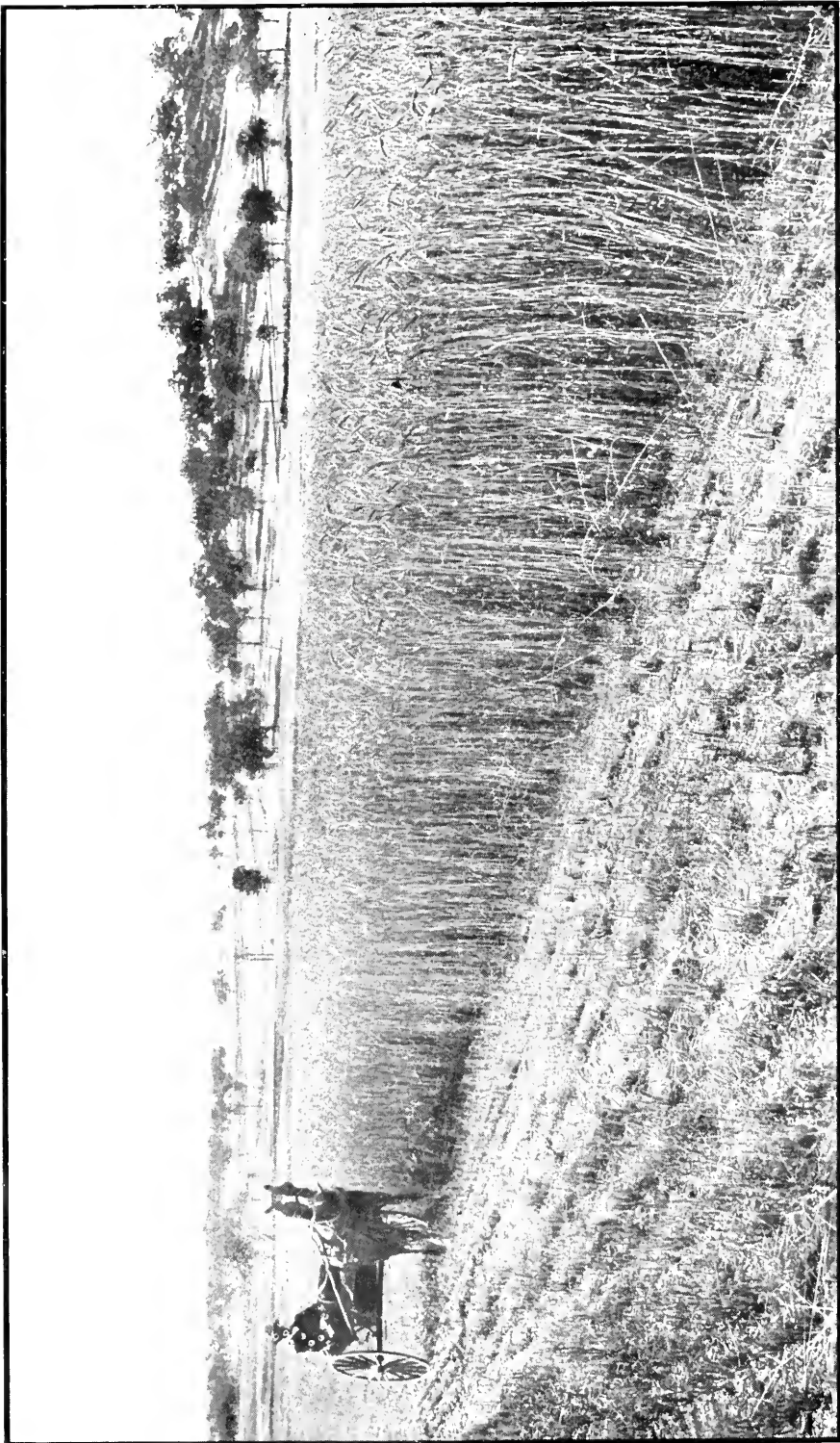
THE
FARMERS' HANDBOOK

FOURTH EDITION



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Typical Wheat Country in New South Wales.



DEPARTMENT OF AGRICULTURE,
NEW SOUTH WALES.



The
Farmers' Handbook

[FOURTH EDITION.]

Issued by direction of the Minister of Agriculture,
The Hon. F. A. CHAFFEY, M.L.A.

Compiled by
W. H. BROWN, *Editor of Publications.*

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Editors of Agricultural and Country Papers are especially invited to reproduce any of the articles contained in the Farmers' Handbook, in whole or in part, provided the usual acknowledgment is made.

PREFACE TO FOURTH EDITION.

No better evidence of the value of the Farmers' Handbook could be desired than the demand with which each edition has been met. In the twelve years that have elapsed since the first edition appeared in 1911, over 10,000 copies have been sold, and there are ample indications that the present edition is as eagerly anticipated as any of its predecessors.

The Handbook has proved an indispensable work of reference to thousands of farmers in this State, and has found its way into other States of Australia, even creating a demand for itself in New Zealand and South Africa. Indeed, it has found readers as far afield as Canada, India, the United States, and Great Britain, and has become a text-book of indisputable authority in Agricultural Colleges and High Schools throughout Australasia.

This wide popularity may, no doubt, be attributed very largely to the practical flavour that has always pervaded its pages, though each issue has represented an effort to maintain the equilibrium between the suggestions of modern science and the limitations of field practice. None know better than the contributors to this Handbook that occasions arise when it is not possible—not even desirable—to adopt the counsels of perfection, but that does not deter the Department from urging upon farmers the methods that experiment and research have demonstrated to be the most profitable under average conditions.

The First Edition, compiled by Mr. W. H. Clarke, and piloted through the press by his successor, Mr. J. E. O'Grady, immediately commanded attention for its variety, comprehensiveness, and general soundness, and it has proved invaluable as a basis for later issues. The Second Edition, for which Mr. P. G. Gilder was responsible, represented an extensive revision and amplification of the earlier issue, while the Third Edition, which also bore Mr. Gilder's name, chiefly differed from the second in a new and more complete statement about maize.

For the present (the Fourth Edition), the whole of the matter has again been thoroughly revised, every section being subjected to close criticism in the light of the Department's latest experience. In fact, it may be said that no portion of the book has received more attention than another. It has been found possible to omit or condense certain features of former issues and to introduce others, while several sections have been appreciably amended and enlarged. The space previously afforded grasses and native fodder

plants has been considerably curtailed in view of the early appearance of a book specially devoted to that subject. The total result has been a further increase in size, which it is hoped will be considered justified by the increased utility of the book.

The compilation of a work with such a variety of subjects has only been made possible by the generous and hearty co-operation of the officers of the Department. Their contributions in the way of new articles and of revision of old ones have made the book what it is, and have placed their own valuable experience on record in an easily accessible form.

In the compilation of the matter and perusal of the proofs, Mr. O. G. Ferns, of this office, has been unremittingly attentive to the many details that contribute to the value of such a work.

W. H. BROWN,
Editor of Publications.

Sydney,
1st December, 1922.

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THE FARMERS' HANDBOOK.

SECTION I.

Farm Lands of New South Wales.*

Armidale Land Board District.

Includes Armidale, Uralla, Walcha, Hillgrove, Guyra, Bundarra, Tingha, Inverell, Glen Innes, Tenterfield.

THE country in this district is, in general, hilly to mountainous, with tablelands and valleys, the New England Range and its spurs running right through the centre. Basalt, granite, and trap are the prevailing rocks. Much of the soil is inferior, and suitable only for grazing, with rich patches of alluvial and basaltic soils. The richest soil is generally found in the valleys and basalt tablelands.

West of Glen Innes, and near Tooloon and Koreelah, there are extensive areas of cultivable land. About Tenterfield the country is granite, and suited to wheat and English fruits. To the south and east of Glen Innes the country is mountainous, with ridges and fairly level areas suitable for agriculture, especially about Ben Lomond, Glencoe, Stonehenge, Glen Innes, and Red Range.

In the Inverell and Armidale districts the country is undulating to hilly, with soil varying from black to light red loams of volcanic origin with large areas of granite and trap country.

Generally speaking, to the east of the range the soil is of the black or chocolate type, derived from basalt; whilst a more sandy type of soil, derived from granite, is found on the west.

The climate is superb, and very healthy both for human beings and stock. The New England district is a favourite summer health resort. The mean annual temperature for the district is about 61 deg. Fah. The mean summer temperature is about 71 deg. Fah. The summer temperature in Armidale is 90 deg. Fah.

The winters are cold, and snow is common on the hills. The mean winter temperature for the district is given as 46 deg. Fah.

The rainfall is good, and the whole district is well watered.

The average rainfall is 33 to 35 inches, about one-third of which falls between December and February.

* The information under this heading was supplied by the District Surveyors in the various parts of the State. All prices given are approximate only and subject to alteration, but were revised by the District Surveyors in 1921.

The district is mainly pastoral, and it is considered one of the best wool-growing districts in the State. A little dairying is carried on, but this industry can be said to be only in its infancy.

The principal crops are potatoes, maize, and fruit, such as apples, cherries, &c. Potatoes are pretty extensively grown in some districts, such as Guyra and the counties of Sandon and Gough.

Timber is plentiful throughout the district. Of the softwoods, pine, cedar, rosewood, silky oak, and coachwood were the most common; with blackbutt, tallow, woollybutt, grey and red gum, and stringybark among the hardwoods, but, excepting in the inaccessible places, these timbers have been well culled.

In the Inverell district, box, apple, ironbark, and white box are the principal timber trees; in the Tingha district, stringybark, red and white gum, box, and pine; and in the Bundarra and Ashford districts ironbark, gum, box, and apple are the common timbers.

With the exception of box, all the New England timbers are very hard to burn, and the cost of clearing is thereby much increased. Ringing and killing costs from 5s. to 15s. per acre. The preparation of land containing dead timber for the plough costs from £1 to £4 per acre. When not ring-barked, the timber, being mostly hardwood, is usually grubbed, felled, and cut up.

The supply of fencing material is good, on the whole; scarce in parts. The best woods for posts are ironbark, stringybark, oak, blackbutt, and red gum. Posts should not be too slight, should have as little sapwood as possible, and the bark should be removed from most timbers to prevent the sapwood rotting. White ant is fairly prevalent in the district. Charring the bottoms of posts and applying of coal tar are means used for the prevention of white ant.

The cost of cattle-proof fencing, four plain or three barbed wire, is from £30 to £45 per mile. For 6 or 7-wire sheep fence, £40 to £60. Rabbit-proof fence costs about £100 per mile.

The cost of well-sinking runs from 15s. to £1 per foot; but there are not a great number of wells in the district, except for household purposes, as the country is fairly well watered.

Excavating for tanks costs from 1s. to 1s. 6d. per cubic yard.

The native grasses are good, but, in general, rather coarse. The herbage is greatly improved after ringbarking. The best English and other imported grasses do well.

The roads are for the most part hilly, with fair gradients as a rule. In ordinary seasons they are hard. The cost of transport is from 1s. to 2s. per ton per mile.

The district is well watered, and is suitable for dairying. With regard to pests, dingoes and rabbits are fairly common. Prickly-pear is bad in certain districts, such as about Tenterfield, Tooloon, and the head of the Clarence River. Blackberry is found in patches all over the district.

The seasons are regular, and, as the records quoted show, without violent inequalities. Inverell provides a good centre for marketing produce in the west. The northern railway line runs through the centre of the district; and this main line will, doubtless, eventually be connected with the coast from Guyra to Kempsey, and from Guyra to Inverell, thus affording ready access for starving stock in drought times to and from the coast.

Dubbo Land Board District.

Includes Dubbo, Wellington, Gilgandra, Narromine, Warren, Nyngan, Nevertire, Tottenham, Canbelego, Coonamble.

Nyngan and Warren Districts.—The country is for the most part level; about one-fifth consists of gravelly ridges to gently undulating country, the remainder being rich black and red soil country. West of the Bogan the country is heavily timbered; east of the Bogan it is mostly plain country, with heavily-timbered areas. The soil is black, red, and chocolate heavy soil with sandy patches. The heavy soil is extremely fertile, and is generally prolific in herbage in autumn and winter, and is in good seasons also heavily grassed, but it may be looked upon in summer as a semi-arid area.

The climate is dry, very hot in summer and mild in winter, with occasional frosts.

The rainfall is about 20 inches annually, of which about a third falls during January, February, and March.

The average temperature is about 80 degrees Fah. in summer and 51 degrees in winter.

The district is partly within the artesian area, within which water can always be obtained by boring, the average depths being 2,000 to 2,500 feet. Sub-artesian water is also obtainable in parts.

Wheat-growing is the only class of farming carried on to any extent, the district being essentially a pastoral one.

The principal timbers are box, pine, gum, belar, myall, yarran, supplejack, and rosewood.

The grasses are all of good fattening qualities, and this is one of the best stock districts in the State, though in parts not heavy carrying. West of the Bogan the chief grasses are mulga grass, corkscrew, spear grass, kangaroo, blue, and star grass. East of the Bogan, Mitchell grass, blue grass, star, couch, and umbrella grasses predominate.

Clearing costs about 25s. per acre, varying with the nature and density of the timber. Most of the timbers are easily killed except gum and box.

Timber for fencing is plentiful in the Nyngan district, limited about Warren. The timber best adapted for posts are yarran, box, gum, and pine, with pine and yarran for rails, but rails are not largely used.

White ants attack the hardwoods where they are sappy, the best ant-resister apparently being the pine. There is very little charring done now.

The cost of well-sinking runs from 15s. per foot for the first 50 feet, up to 25s. per foot for greater depths.

Excavation for tanks is about 9d. to 1s. per cubic yard in good seasons when feed is plentiful.

Transport is for the most part over level country on black or red soils, which are very soft in wet weather. About one-fifth is of a hilly nature, with hard gravelly soil. Generally speaking the country is a pastoral one, though agriculture is progressing rapidly. In good seasons plenty of hay is grown. The soil is suitable for any class of farming, provided it receives enough moisture.

The Dubbo District.—The country in the Dubbo district, which includes the southern and eastern portion of the Land Board District, varies in character. To the north of Dubbo, towards Nevertire and Gilgandra, it is generally flat, whilst to the south, towards Wellington, it is hilly in character, and towards Tomingley very hilly.

The soils vary from sandy loams to rich red and chocolate loams and black soil plains, the latter with clay subsoils. On the higher levels the soil is red and of a more loamy nature, and sandy to gravelly on the ridges.

The climate is hot and dry, especially in the western part of the district. In the eastern portion the climate is milder, with a better rainfall. It is very hot in the summer; the winters are mild and bracing. The mean summer temperature for this district is about 76 deg. Fah., with a winter average of 49 degrees.

The rainfall at Dubbo is 22½ inches annually.

The principal crop is wheat, which is grown extensively about Narromine and Wellington, and in the southern parts of the district. Lucerne is also grown, and does splendidly on the river flats.

The principal timbers are box, pine, buddha, wilga, mallee, ironbark, yarran, gum, myall, coolabah, belar, bull oak, currawong, red box, ironwood, a little kurrajong (fodder tree), whitewood (fodder tree), needlewood, &c.

The grasses are of good fattening quality, and include Mitchell, umbrella grass, corkscrew, crowfoot, and barley grass.

For clearing dead timber the cost is from 7s. 6d. to £1 per acre; green timber costs from £1 10s. to £3. The average cost may be set down as about 25s. per acre. Yankee grubbing is not extensively practised. The cost would be from 10s. to 15s. per acre.

Fencing material is abundant, and in most parts good. For posts, box, pine, ironbark, yarran, and buddha are chiefly used. Pine posts withstand white ant best, but yarran and buddha are exceptionally lasting. Charring butts is resorted to in some cases to protect posts from white ant and rot, but it is not a general practice.

Post and rail fences are hardly ever used. Their cost would be prohibitive for general use. Cattle-proof fences cost from £40 to £60 per mile for 4-wire fences, but these fences are little used. The cost of 6-wire sheep fences most generally in use is from £50 to £70 per mile. Rabbit-proof fencing costs from £120 to £160 per mile. For well-sinking the price is from (say) 20s. per foot for the first 50 feet, the cost increasing with the depth up to 25s. to 30s. per foot.

The cost of excavating for tanks, which is now chiefly done with scoops, is from 1s. per cubic yard; however, if feed is plentiful in the locality, this may be a little reduced.

The transport is level in the western part and hilly in the eastern parts of the district. The roads are for the most part good and hard except in wet weather.

The Coonamble District embraces the northern and eastern part of the Dubbo Land Board District. Except for the Warrumbungle Mountains in the east, the country is flat in character, with rich black and red soils, alternating with belts of sandy soil. The climate is hot and dry, with a rainfall of from 17 to 25 inches annually. The average temperature in summer is 80 deg. Fah., and in winter 51 deg. Fah. It is at present mainly a pastoral district, but agriculture has considerably increased in the eastern part and will eventually overshadow pastoral pursuits more particularly around Gilgandra and the eastern side of the railway between Dubbo and Gular. Maize is grown under irrigation, but only in small areas.

The chief timbers are yarran, box, pine, belah, gum, buddha, and ironbark, with plenty of edible scrubs such as myall, wilga, kurrajong, rosewood, wild orange, whitewood, and leopard-wood.

The grasses are Mitchell, blue grass, sugar grass, umbrella grass, star and barley grass, with winter and spring herbage, saltbush and cotton bush.

Yankee grubbing, except in grazing areas, is on the decrease. The present cost of ordinary clearing is about 12s. 6d. per acre in dead country. An estimate for green country is not reliable, as so little is done, but probable cost ranges up to £3 per acre. About three-fourths of the district is plain country or open forest.

The supply of fencing material is ample: box, pine, buddha, yarran, iron-bark, and gum are used for posts. White ants are said not to be troublesome in this district.

Neither post and rail, nor ordinary wire cattle-proof fences are used. The cost of a 2-wire (No. 8), with barbed wire on the top, would be from £38 per mile.

For a 6-wire (No. 10) sheep-proof fence with 11 foot panels, the cost would be from £40 per mile upwards.

For rabbit-proof fencing, 42 in. netting on sheep fence, up to £140 per mile.

Wells cost from 10s. to 25s. per foot, according to the depth. The cost of artesian boring is 20s. to 22s. 6d. per foot. Excavating for tanks runs from 1s. per cubic yard.

Transport is mostly over level and soft country, except in the eastern part, which is somewhat hilly. The district includes extremely good pastoral country, the grasses are fattening, and disease amongst stock is almost unknown: one of the worst troubles in connection with stock being the prevalence of blow-flies.

Artesian water is procurable everywhere by boring at a depth of 500 feet onwards. Bedrock is struck at from 2,500 to 2,700 feet. The flows from the bores vary from 50,000 gallons to 1,500,000 gallons per day.

Forbes Land Board District.

Includes Forbes, Parkes, Grenfell, Barmedman, Temora, Wyalong, Ardlethan, Ariaah Park, Eugowra, Condobolin, Trundle, Peak Hill, Bogan Gate, Tullamore.

The country comprised in this district is of fairly uniform character, being for the most part undulating to flat. There is some hilly country at the eastern end of the district. In the western and southern parts the country is for the most part flat. The soil varies—the typical soil being a rich red loam, generally with a rather stiff subsoil: chocolate loams, clayey loams, black clayey loams and sandy loams of a light colour are represented, and black alluvial soils are found on the river flats.

The climate is fairly even over the district; the average summer temperature being about 76 deg. Fah., with a winter average of 56 deg. Fah., the western portion being somewhat hotter in summer. The district generally may be described as rather dry, the mean annual rainfall varies from 24 inches on the east to 17½ inches on the west. It is a good, healthy climate.

A considerable area is cultivated in the eastern and southern part of the Land Board District; the western part is used chiefly for grazing, but even here mixed farming is gradually increasing. The principal cereals cultivated are wheat and oats, both for grain and hay. Mixed farming is generally followed. Lucerne, sorghum, Sudan grass, &c., are grown on some of the

alluvial flats, but only in limited quantity. All kinds of fruit grow well throughout the district, and especially about Grenfell and Forbes, and generally in the more eastern part of the district. The river country is extremely well adapted for irrigation, and the further development of this district depends largely on the closer settlement of these rich lands, which are capable of carrying a big farming population.

The principal timbers are pine, white box, yellow box, red gum, ironbark, kurrajong, myall, belar, wilga, and yarran. In the western part there are fairly large areas of mallee country.

The grasses in general are of a good fattening nature—corkscrew, silver grass, blue grass, panic and umbrella being the principal summer grasses, with barley and other grasses in the winter. Crowfoot, trefoil, clover, &c., are also fairly abundant. Generally the country is good, sound pastoral country.

The greater part of the district has been improved by ringbarking and scrubbing, the present cost of which, exclusive of suckering, would be 1s. to 3s. 6d. per acre.

To clear dead timber for the plough costs from 10s. up to 30s. per acre, according to the density and nature of the timber.

Yankee grubbing is extensively adopted, and costs from 5s. to 17s. 6d. per acre, according to the density and nature of the timber.

To clear green timber for the plough the cost varies from £2 up to £5 per acre. In the case of mallee scrub this can be rolled down at a cost of about 15s. per acre, and then burnt off.

The supply of timber suitable for fencing is still fairly good in most parts, though it is diminishing, especially in the eastern part of the district. For posts, ironbark, white and yellow box, pine, red gum, and yarran are the best timbers. Pine, yarran, red gum, and ironbark are said to be immune from the attacks of white ant, which is plentiful over the greater part of the district. The best fence for all kinds of stock is said to be one made of split posts 8" x 4" or 10" x 3", 22 inches in the ground, with five wires and one barbed wire on top; the height of the top wire should be about 3 feet 7 inches from the ground. The cost for such a fence would be about £52 per mile. For sheep the fence may be lower and the posts further apart.

Other estimates for sheep fencing vary from £38 up to £52 per mile.

Rabbit-proof fencing costs from £90 to £135 per mile.

The Lachlan River contains permanent water, and on most of the river country good water can be obtained from wells, at depths up to about 40 feet. A number of bores have been put down to tap the sub-artesian supply, with varying success; in some instances the water has been found too brackish for general use. In the eastern part of the district there are occasional springs, but speaking generally, and excluding the country with river frontage, tanks, and in some cases, dams, are relied upon for water supply.

Nearly all over the district there is good holding ground for tanks, and sinking is fairly easy.

For excavating tanks the cost varies from 10d. to 1s. 4d. per cubic yard; the average cost in good seasons would be about 1s. per cubic yard.

The district is well served by railways. Access by road is generally good, except during wet weather and a few days thereafter; where the roads are unformed, and more especially on the river country, they become very heavy. The roads generally are level or of easy gradients; a fair amount of formation has been effected on the main roads and near the towns.

Goulburn Land Board District.

Situated in the south-eastern corner of the State; extending westerly to the Snowy Mountains, Kiandra, Burrinjuck Dam, Jugiong, and Galong, and northerly to the Lachlan and Crookwell Rivers, and the head of the Abererombie River; embracing the Southern Tableland to as far north as Mittagong, and part of the South Coast from Durra Water, near Bateman's Bay, to Cape Howe, and including the following towns and districts, viz. :—

1. *Southern Tableland*.—Robertson, Mittagong, Moss Vale, Taralga, Crookwell, Goulburn (City), Bungendore, The Federal Territory, Queanbeyan, Braidwood, Cooma, and Bombala.
2. *Western Slopes*.—Gunning, Yass, Galong, Boorowa.
3. *Coastal*.—Eden, Bega, Bodalla, and Moruya.

1. *The Southern Tablelands* occupy the bulk of the Land Board District, and are traversed throughout their length by the Main Dividing Range. The country is mostly undulating to hilly, with mountains in places. The southern end is known as Monaro. The formation is granite, basalt, slate, and sandstone with minor outcrops of limestone and trap.

Soils vary from light sandy to dark chocolate loam, with some alluvial on the river banks.

There are areas of plain and very thinly timbered country around Goulburn, Queanbeyan, Cooma, and Breadalbane, the soils being of granitic and basaltic origin.

The climate is mild in summer and somewhat cold in winter. Frosts occur from May to October, but on the mountains, particularly on the Southern Alps, the period of liability is longer. The average rainfall varies from 20 inches at Cooma to 40 at Moss Vale, but at Robertson the average is 69 inches, and at Kiandra 63 inches, the excess being due to coastal and mountain influences respectively. The ruling average is, however, about 24 inches per year.

The tablelands are served by the Great Southern Railway, and by the branch lines Goulburn to Cooma and Goulburn to Crookwell.

The road systems are extensive and convenient, the surface and grades are generally good. The South Coast ports are availed of by Monaro interests.

The principal industries are grazing, sheep and cattle. The tablelands are suitable for the production of strong Merino and crossbred wool, and mutton sheep. The carrying capacity is from 1 to 2 acres per sheep on the improved lands.

Dairying is carried on extensively in the Moss Vale, Robertson, Taralga, and Crookwell districts, and parts of Monaro; potato and mixed farming at Moss Vale, Crookwell and Taralga, and part of Goulburn district; vegetables are grown extensively around Moss Vale; wheat and oats for grain, and hay practically throughout the tablelands in moderate degree; lucerne in small patches on river and creek flats, especially near Cooma. Cold climate fruits do well throughout, especially between Goulburn and Moss Vale.

Goulburn is an important store stock market, and local markets are established at all the principal towns.

Butter factories are established in the Moss Vale, Bowral, Mittagong, Robertson, Crookwell, Taralga, Goulburn and Cooma districts.

Flour mills are established at Goulburn and Laggan (Crookwell district).

Eucalyptus oil is produced in the Braidwood district.

There are large areas of inferior and undeveloped country throughout the tablelands, the better parts of which, together with the Snow Belt, are largely availed of for relief purposes in time of drought.

The prevailing timbers are brittle, blue, ribbon, and red gum, stringybark, yellowbox, messmate, peppermint, argyle apple, bastard apple, mountain ash, (gigantea and brown barrel), pine, sallee, wattle, and oak. Milling timber is obtained in the Moss Vale end of the district, around Braidwood and parts of the Snowy Mountains. Suitable fencing timber is conveniently obtainable in most districts. Some forest reservations exist throughout.

The classes of fencing mostly adopted are 4, 5, 6, and 7 wires and rabbit-proof netting. Split rail fencing is scarcely ever erected now. Fencing costs from £35 to £60 per mile for wire fencing, and from £90 to £150 for netting, according to the class of material used.

Ringbarking and killing timber for grazing costs from 4s. to 10s. per acre. Clearing for cultivation costs from £1 to £5 per acre for dead timber, and from £8 to £40 per acre for green timber, according to species and density.

There is extensive tourist traffic throughout the tablelands, the principal items of attraction being Wombeyan Caves, waterfalls in Moss Vale district, Lake George, the Snowy Mountains, trout fishing streams, and the Federal capital site.

A natural water supply is provided by Wollondilly, Shoalhaven, Upper Lachlan, Upper Murrumbidgee and Snowy Rivers, with their tributaries, and in addition springs are fairly plentiful. Tanks are necessary in some localities. The cost of excavation varies from 1s. 3d. to 1s. 6d. per cubic yard.

There are large areas of Crown lands available, mostly of inferior grazing capacity and suitable only for grazing, and, although a great proportion is sound for sheep, the cost of improvements and liability to rabbit infestation detract from its value.

The Western Slopes extend roughly from Gunning to Harden, and include Yass, Boorowa, Binalong, and Galong. The country is generally undulating to hilly, but mountainous country fringes the area in parts. The formation is principally granite, with small patches of slate and a little basalt and limestone. The soil is gritty or clayey loam. There are considerable areas of country the timber on which is very open. Timber is generally white and yellow box, bastard apple, stringybark pine, oak, and ironbark.

Water supply is partly provided by the Boorowa River, its tributaries, and streams feeding the Murrumbidgee and Lachlan Rivers. Tanks are necessary in many parts, costing 1s. 3d. to 1s. 6d. per cubic yard to excavate. The climate is moderate to warm; the altitude varies from 1,200 to 1,700 feet above sea level. Average rainfall varies from 20 to 25 inches.

The district is served by the Great Southern Railway and the Boorowa branch line. The road systems are convenient, the roads being generally good and on moderate grades.

The principal industries are grazing and wheat-farming. The secured lands have a capacity of from $\frac{3}{4}$ to 2 acres per sheep. The wheat farms yield an average of about 20 bushels per acre.

Stock markets are established at the principal towns, and provision has been made for stacking wheat at convenient railway sidings.

There is a comparatively small area of inferior and undeveloped Crown lands.

There is a flour mill at Yass and another at Murrumburrah just outside the district. Timber for fencing is fairly plentiful and of very good lasting quality. There are a few forest reservations to provide for the future. The natural grasses are relied upon for pasture purposes; they being generally of high nutritive value. The country fattens stock readily in fair seasons. The principal tourist attraction of the district is the Burrinjuck dam

situated on the Murrumbidgee River. Improving land for grazing costs from 3s. to 8s. per acre, subsequent picking up and burning off 10s. to £2 per acre. Clearing green timber for cultivation costs £3 to £10 per acre according to density. The timbers generally are very hard but burn readily when killed. The class of fencing now adopted is six or seven wires, costing from £50 to £60, and wire netting costing from £90 to £150 per mile.

South Coast.—Undulating and hilly, rising to mountainous approaching the tableland. The formation is mostly granite and slate, with basalt and diorite patches. The soils vary from light loam to chocolate and clayey. The climate is even and moderate. Rainfall averages about 35 inches per annum. The South Coast is served by the ports of Twofold Bay (Eden), Merimbula, Tathra, Bermagui, Moruya, and Bateman's Bay, and is well intersected by good roads with regular motor services—Nowra to Eden, Cooma to Bega, and Braidwood to Moruya.

The principal industries are dairying, mixed farming, grazing, pig-raising, timber-getting, and fishing. The South Coast is noted for its dairy pastures, while maize, lucerne, hay, and fodder crops do well. Butter and cheese factories are variously established at the principal dairying centres, while cheese and bacon factories are operating at Kameruka, Bega, Bodalla, Narooma, Moruya, &c.

The timbers are mostly spotted, grey, and red gum, box, black-buttr, apple, oak, mahogany, tea-tree, and wattle. Wattle culture for tan bark is carried on in different parts of the district. The district is well watered by rivers and permanent creeks. There are considerable areas of inferior and undeveloped country behind the settled districts.

Grafton Land Board District.

The principal towns of this district are Woogoolga, Grafton, Copmanhurst, Ullmarra, Maclean, Yamba, Kyogle, Casino, Coraki, Woodburn, Ballina, Lismore, Alstonville, Bangalow, Byron Bay, Mullumbimby, Murwillumbah, and Tweed Heads.

The district embraces the north-east corner of the State from Woolgoolga to Tweed Heads, about 135 miles long and averaging 65 miles wide. Area about 5,500,000 acres. Includes the counties of Rous, Richmond, Clarence, Drake, and parts of Buller, Gresham, and Fitzroy.

The Clarence River district includes considerable areas of good alluvial soil along the river frontage. The same applies in a lesser degree to the main tributaries, the remainder being undulating to hilly and steep mountainous country, chiefly of sandstone and slate formation with basalt, granite, and ironstone in parts.

The soil on the alluvial flats is an easily worked fertile soil, eminently suited to crop production. A large area of the lower ridges is suitable for dairying and mixed farming: the remainder, which forms a large proportion of this part of the district, is suitable for grazing only.

In the northern part of the district, including the Richmond, Tweed, and Brunswick Rivers, extending back to the head waters of the Clarence River, the land varies from flat and undulating to hilly and mountainous country. A fringe along the coast is sandy, with fairly extensive swamps, some of which have been drained and are very fertile.

The greater portion of this northern part of the district is of volcanic formation with smaller proportions of slate and sandstone and fairly extensive alluvial flats. It includes what is known as the "Big Scrub" in the

county of Rous now practically all under introduced grasses and fodder crops, closely subdivided into dairy farms, and is undoubtedly the richest part of the State.

The northern part including the Richmond and Tweed has an average annual rainfall varying from 73 inches along the coast to 40 inches inland. The Clarence River portion (the southern part of the district) has an annual coastal rainfall of about 55 inches, varying about 1 inch less for each mile distant from the coast up to 20 miles inland, the western part having a mean rainfall of about 36 inches.

The climate is sub-tropical, generally hot and humid in summer, but the nights are usually cool and dewy and light frosts are not uncommon in winter.

The principal crops are maize, sugar cane, and potatoes on the river flats, except on the Tweed where most of the sugar cane is grown on the hillsides. The Tweed, Richmond and Clarence Rivers produce the only sugar cane grown in the State, totalling about 170,000 tons. These rivers also account for one-third of the total amount of maize produced in the State.

The cultivation of tropical and semi-tropical fruits is a growing industry, especially in the Tweed and Brunswick valleys, where great progress has been made within the past 10 years in the cultivation of bananas. Practically all the bananas consumed in this State are now grown on these rivers, and quantities are also sold in Melbourne.

Dairying is the principal industry in the district, and good facilities exist for the carriage of cream by road, rail, and boat. Other important industries include the breeding of cattle, pigs and poultry, and the production of maize, sugar, bananas and potatoes.

There are twenty-eight butter factories and three or four cheese factories in the district.

The total production of butter is in the region of 35,000,000 lb. per annum, which is approximately one-half the total yield of the State.

The timber industry is also of great importance. There are large areas reserved for timber containing immense quantities of both hardwoods and softwoods. Hoop-pine, teak, beech, rosewood, cedar, cudgera, silky oak, and other useful varieties are included in the latter. The principal hardwoods are spotted gum, grey gum, red gum, flooded gum, bloodwood, iron-bark, blackbutt, tallow-wood, messmate, turpentine, red mahogany, stringybark, and scrub-box.

There are also large quantities of timber, principally hardwoods, on alienated and other Crown lands throughout the district.

In the forest country blady and kangaroo grass are the chief natural grasses, with couch and foxtail on the low lying lands, but paspalum is the mainstay of the district. It thrives luxuriantly, especially on the Richmond and Tweed. Under suitable conditions of soil and rainfall, paspalum will exterminate all other grasses except clover, which is sown with the grass and provides a valuable fodder, more especially in the early spring when the paspalum is short. For this reason other varieties of grasses are seldom cultivated, except as fodder crops.

The coastal scrub or softwood brush is felled and when sufficiently dry is fired, the remaining logs are then stacked and burnt; grass seed is sown immediately afterwards. The total cost is about £5 or £6 per acre. The process of clearing such country for the plough is generally delayed until the stumps have decayed or are sufficiently dry to burn.

In many parts hardwoods are interspersed with the softwood brush.

The hardwood forest is ringbarked and the trees allowed to die before clearing for the plough. Only small areas of such country are cleared for cultivation, as the soil is generally of poorer quality and the cost is heavy, varying from £4 to £8 per acre.

In such country the growth of seedlings is usually heavy after ringbarking, more especially on poor land timbered with spotted gum, stringybark, and mahogany.

The cost of killing the timber and clearing the undergrowth varies from 10s. to 25s. per acre, extended over a period of from two to five years.

Open forest is usually easily treated. Where the timber is open the soil is generally of better quality. This may be accounted for by the thick growth of natural grasses, assisted by bush fires, preventing the growth of young timber.

Timber for fencing is plentiful and of good quality. For posts the best timbers are bloodwood, ironbark, and grey gum; and for rails, stringybark, bloodwood, grey gum, red mahogany, and blackbutt.

The grazing capacity of forest country, with natural grasses, varies from 4 to 10 acres to a beast. The best land cultivated with paspalum or couch will carry one beast to the acre. The winters are mild, and hand-feeding is seldom necessary.

A good deal of damage is done by white ants, but preventive measures are not much employed in this district. Bloodwood, red mahogany, teak, and beech are seldom attacked by white ants; on the other hand, pine and tallow-wood are readily attacked.

The cost of post and rail fence is from £80 to £120 per mile according to character of country and timber available.

Wire fences cost £50 to £70 per mile at present prices of material and labour.

Sheep and rabbit-proof fences have not been used in the past, but rabbits have made their appearance in places within the western part of the district and the erection of netting fences is now found necessary within those areas.

Well-sinking costs 5s. to 7s. per foot without timbering, 15s. to 20s. per foot with bricks or slabs. There is not much well sinking, and practically no tank sinking done in this district, as it is generally well watered by creeks and springs.

The poorly watered parts are generally of sandstone formation, and the soil is usually too porous to hold water; also, owing to the excessive amount of silt and rubbish washed down the gullies in this class of country, tanks and dams are impracticable as a rule.

The nature of the transport varies according to the state of the roads. Horse waggons are generally used for delivery of cream to nearest railway siding, wharf, or factory from outlying parts.

A railway runs from Grafton to Murwillumbah, with a branch line from Casino to Kyogle, but there is no connection across the Clarence River with the line from South Grafton to Glenreagh. This line is now being extended to connect with Coff's Harbour and the present railway terminus from Sydney at Macksville.

There are good motor services between the principal centres and the roads as a whole are fairly good.

Hay Land Board District.

Includes Hay, Carrathool, Narrandera, Barellan, Cargellico, Hillston, Gunbar, Booligal, Moulamein, Barham, Mathoura, Deniliquin, Conargo.

This district, embracing the south-western and southern portion of the Central Division, is principally occupied as grazing country, Barellan, Yanco, Narrandera, Deniliquin, Moama, Mathoura, and Barham being the chief agricultural centres. Except on the irrigation areas, the principal cultivated crop is wheat, for which soil and climate are admirably suited, the only drawback being the comparatively low rainfall, 12 to 18 inches, and the danger of droughts. Other cereals do well where they have been dried, and excellent malting barley is obtainable. Warm climate fruits all thrive to perfection, and good crops are always assured of citrus fruits, peaches, apricots, grapes, figs, and passion-fruit, provided a sufficiency of water is assured, either naturally or by irrigation. The Yanco and Mirrool Irrigation Areas are becoming important cultivated districts, also land around Barham.

The country is for the most part flat, with a few sand-hills. Towards Narrandera and in the northern portion of the district, in the neighbourhood of Bootheragandra and Conapaira, the country is more rocky and hilly in nature. The soil varies from black and grey stiff clays to reddish sandy loams.

In the Jerilderie district the country north of the Billabong Creek is a heavy reddish soil, with the exception of the boree country, not very suitable for agriculture, whilst the better class farming land is found south of the creek, where the soil is of a better nature.

To the north of the Murrumbidgee at Narrandera are ranges of conglomerate rock, with level country, whilst open plain country predominates south of the river. In the Narrandera district south of the Murrumbidgee red and grey soil plains predominate. The country is for the most part open plain, sparsely timbered, except in the neighbourhood of Narrandera and towards Hillston, where it is heavily timbered. The principal timbers are pine and box, with red gum near the rivers, oak, yarran, and myall (mallee in the Narrandera, Hillston, and Balranald South districts).

The climate is exceedingly healthy, with a mean summer temperature of about 75 deg. Fah., and a mean winter temperature of 49 deg. Fah. Hot dry winds are prevalent in the summer, and the south and south-west winds in winter are frequently very cold. The extreme temperatures recorded are 122 for summer and 28 for winter.

The grasses are of a nutritious kind, and in good years produce as good grazing as is to be found in the State. The best winter feed is trefoil, barley grass, and crowfoot. The best grasses are white-top and spear grass; other grasses are umbrella and Timothy. Good summer and winter feed is saltbush and cotton-bush.

Timber for fencing is very scarce in the Hay district. Generally speaking, box, gum, and pine are the best timbers for posts. For rails timber is not used in this district. Pine is practically immune from white ant. Clearing is generally done by ringbarking, and burning-off after four or five years.

Timber for fencing posts costs £4 to £6 per 100 in the Hay district, whereas near Gunbar and Hillston the cost is about £2 to £3 per 100.

The cost of clearing varies a good deal; roughly it averages 4s. 6d. per acre for grazing to 10s. to £1 for the plough, running to as high as 40s. per acre in the Narrandera district in the case of green timber. This includes ringing, scrubbing, picking-up, and burning-off.

The cost of fencing is—for sheep-proof fence, £50 to £60 per mile; for rabbit-proof fencing, £80 to £100. Post and rail fences are not used.

The cost of well-sinking is about 25s. per foot up to 100 feet, including timbering and centering. There are few wells sunk in the district, water being chiefly obtained by boring. The cost of sinking a 4-inch bore with tank and windmill would be about £200. Permanent water is generally found at a depth of from 80 to 120 feet.

It is a sound, healthy district for sheep, there being practically no disease. Rabbits are well in hand, and the country carries on the average about a sheep to 3 acres improved.

There is good railway communication both with Sydney and Melbourne in the eastern and central parts of the district. The Moama to Deniliquin Railway connects the southern portion of the district with Melbourne. Railway lines from Griffith to Hillston, and another from Barmedman to Rankin's Springs are in course of construction. The cost of transportation is about 1s. 6d. per ton per mile, the roads being good natural roads, level, hard, and dry in the dry weather, soft and often exceedingly heavy when wet.

The Crown lands in the district are mostly leased under improvement and scrub-clearing conditions, or reserved for specific purposes, the Murray red gum forests being a profitable asset of this State.

Kempsey Land Board District.

Comprises Coff's Harbour, Bellingen, Dorrigo, Nambucca, Bowra, Trial Bay, Kempsey, Port Macquarie, Camden Haven, and the Bellinger, Macleay, and Hastings Rivers.

The country is generally hilly to mountainous, with alluvial flats on the Hastings, Macleay, and Bellinger Rivers and their tributaries. In the southern portion of the district the soil is for the most part of a rather poor nature, the country consisting of gravelly ridges, with patches of shallow dark loam with a yellow clay subsoil.

The ridges leading to the Comboyne carry a dark loam, with quartz-gravel in places. On the Comboyne itself there is a great deal of deep, red-volcanic soil from 20 to 30 feet deep, and the country is undulating to hilly tableland, well watered, formerly all heavily timbered, carrying a softwood scrub now mostly cleared.

The Comboyne is not as high as the Dorrigo plateau, and the climate is milder.

On the Hastings River there is a good deal of alluvial soil, of rich quality and considerable areas of rather sour tea-tree flats. The bulk of the country is hilly in nature, with a rather shallow loam on the surface. The best of the land along this river is alienated; large areas are ringed and held as grazing leases.

Between the Hastings and Macleay the country is hilly, with gravelly ridges carrying a sandy loam to black loamy soil. The best of the country is along the creek frontages, and is here also nearly all occupied.

The Macleay is an old settled district, and farms on the alluvial land are worth from £40 to £85 per acre. There is not a great deal of Crown land available. The soil on the ridges varies from stony country to a red or black sandy loam with a clay subsoil. The alluvial land is sometimes of great depth. The Upper Macleay is well watered. On the Lower Macleay salt water is often struck when sinking for wells.

North of the Macleay, the Nambucca district contains some good agricultural land in small patches on the upper reaches of the Nambucca River. Settlement is proceeding rapidly in this district, which is heavily timbered.

The alluvial soil on the river and creek frontages is a rich and deep chocolate to dark loam. On the ridges, the soil is mostly a black loam with quartz out-crops and a stiff subsoil.

From the Nambucca to the Bellinger and Coff's Harbour the country is all hilly. The Bellinger Valley is extremely rich land, and farms fetch up to £60 per acre.

The Dorrigo country is mountainous, and very heavily timbered with softwoods, now very largely cleared.

The soil varies from red volcanic soil to black alluvial, of good quality, with sandy and clayey patches of rather inferior land. The country is very well watered.

To the north of Bellinger, towards Coff's Harbour, there is some good grazing land; the country is heavily timbered, the soil volcanic, chocolate to red, with alluvial flats, generally in very small areas.

The climate over the whole district is mild, the summers not too hot, and the winters short. On the Comboyne (1,500 feet) and Dorrigo (3,000 feet) plateaux the climate is colder.

The mean annual temperature for the district is about 66 deg. Fah., with a summer average of 73 degrees to 74 degrees, and a winter average of 56½ degrees.

The mean annual rainfall is about 54 inches in the northern portion of the district, and 59 inches in the southern part, February and March being the wettest months.

The chief industries are dairying, maize-growing, cattle-grazing, pig-farming and the timber industry; grasses of most kinds do well, paspalum especially. All English fruits do well on the high lands, and fairly well at lower levels; citrus fruits do particularly well except on the coast, and on the very high land potatoes and turnips are particularly good crops.

It is one of the most heavily timbered and best watered districts in the State. Enormous forests of both soft and hard wood timbers are still to be found. Some of the best milling timbers are found on the Dorrigo and Bulga plateaux, including pine, beech, cedar (somewhat rare), tulip, sassafras, and rosewood. Of the hardwoods, ironbark, blackbutt, tallow, grey, blue, and spotted gum, box, red and black oaks, and mahogany are amongst the valuable timbers represented in the district.

Of the grasses—blady grass, blue grass, and kangaroo are among the chief natural grasses, but introduced grasses are replacing them, among the best being paspalum, rye, foxtail, prairie, clover, &c.

Fencing material is abundant, except in the flat country. For posts, the best timbers are bloodwood, tallow-wood, and gum; and for rails, ironbark, blackbutt, and mahogany.

Sometimes the butts of posts are charred as a protection against white ant.

The cost of post and rail fence is from £80 to £100 per mile, according to the number of rails. Four-wire cattle fencing costs £60.

The cost of well-sinking runs from 20s. to 30s. per foot with timbering. The best timber to use is mahogany, as it is very durable and does not discolour the water.

The cost of excavating for tanks is from 1s. 6d. to 2s. 6d. per cubic yard.

The transport is for the most part hilly, and over good hard roads.

The natural water supply is very good.

Maitland Land Board District.

Includes Maitland, Singleton, Muswellbrook, Scone, Merriwa, Wingen, Gloucester, Camden Haven, Taree, Stroud, Raymond Terrace, Morpeth, Cessnock, Newcastle, Wyong, Gosford, Wollombi, Dungog.

The district embraces the coast line from Broken Bay to Camden Haven and stretches inland westwards along the Hunter and Manning Rivers. It includes a very considerable variety of country and all classes of soils. The land varies from river flats to undulating and hilly country, the latter with a general easterly slope towards the coast. The geological formation is, for the most part, Carboniferous or Permo-Carboniferous, and includes the Newcastle coal measures. There are frequent outcrops of granite and basalt, and occasional patches of limestone. The district is well watered by the Hunter and Manning Rivers and their tributaries, and the river flats of both are among the most fertile soils in the State. On the ridges the soil varies considerably in character, including nearly all types, from sandy or gravelly loam to heavy clay. South and west of Wollombi the soils become poorer and more sandy in character. The climate is mild, having a mean summer temperature of about 74 deg. Fah. and a winter mean of about 53 deg. Fah. The nights in summer are usually cool, and in winter cold and frosty. The mean annual rainfall is 38½ inches, distributed fairly evenly throughout the year.

The water supply is fair, and water is generally readily and cheaply stored. The country is very suitable for dams or tanks.

A great variety of farming is carried on, and the district is suitable for almost every kind of cultivation. The principal crops are lucerne, maize, sorghum, millets, grapes, oranges, peaches, passion-fruit, and all kinds of vegetables. Wheat is grown principally in County Brisbane, in the western part of the district. Dairying is carried on extensively in all parts of the district, and there are several large butter factories in operation.

This is one of the finest wine-growing districts of the State; and the Hunter River wines have a deservedly high popularity. The principal vineyards are in the Pokolbin and Allandale districts, County Northumberland, in which about 2,000 acres of the 5,000 odd acres of wine grapes of the whole State are situated.

On the Hunter River flats is grown a large proportion of the lucerne produced in the State.

In the country towards Wollombi grazing and dairying are carried on. The whole of the district, except near the coast, is from fair to good fattening country.

The Hunter River flats are extremely fertile, and being subject to floods, their fertility is constantly renewed by the rich deposits left by the inundations.

A great variety of timber is met with, including some of the best hardwood timbers of the State. Among the trees reported are ironbark, tallow-wood spotted gum, brush box, rosewood, red and blue gum, bloodwood, turpentine, pine, box, mahogany, blackbutt, stringybark, apple, oak, &c.

The cost of clearing varies very considerably, and no very accurate data are available. Ringbarking alone costs from 2s. 6d. to 5s. per acre; ring barking, falling, and scrubbing for pastoral occupation, from 10s. to £1. The usual practice is to fell and burn off stumps when sufficiently decayed. Grubbing is not much practised in this district, except on the alluvial flats.

To clear the land for the plough costs, according to the nature of the timber, from £5 to £15 per acre. In heavily-timbered country it may go as high as £30 per acre. When heavy, the value of the timber will often partly repay the cost of clearing. Fencing material is abundant. For posts, the woods most in favour are ironbark, bloodwood, white mahogany, box, turpentine, and grey and red gums. For rails, stringybark, ironbark, blackwood, tallow-wood, and flooded gum. White ant is prevalent in the district. Turpentine timber is partially immune from its attacks.

The cost of a post and 2-rail fence—640 posts to the mile—is from £64 to £96 per mile.

Cattle fence—4-wire (No. 8), with 480 posts to the mile—from £40 to £60 per mile.

Sheep-proof fence—7-wire (No. 8), with 480 posts to the mile with droppers—from £48 to £70 per mile.

Rabbit-proof fence—6-wire (No. 8) with netting, 480 posts to the mile, and droppers—£120 to £160 per mile. Rabbits are plentiful in the western parts of the district.

The cost of excavating dams is from 1s. to 2s. per yard, the latter price being for deeper dams. For wells, including timbering, the cost is about £1 per foot, the price varying according to the depth.

It is not easy to speak of the nature of transport as the country varies so very much. In the Maitland, Muswellbrook, and Taree districts the roads are generally good, but soft and rough off the main tracks, and steep, but hard, at the heads of rivers. Towards the coast they are good but hilly. On the whole, the roads are fairly hard and good. Most of the available land suitable for occupation in the district is alienated.

Moree Land Board District.

Includes Moree, Warialda, Bingara, Narrabri, Pilliga, Wee Waa, Carinda, Walgett, Boggabilla and Mungindi.

Very little farming is done in this district, which is at present almost entirely devoted to sheep-breeding. The railway communication is the line from Narrabri to Burren Junction, with branches, thence to Walgett and Collarenebri; and the main line from Sydney *via* Narrabri, through to Moree with branches, thence to Inverell and Mungindi.

The rainfall varies in different parts of the district, the western portion being the driest with an average annual rainfall of about 18 inches, whilst in the eastern (Warialda) district it is about 29 inches. Most of the rain falls during the summer months, January to March.

The temperature is fairly constant over the district, the mean for the year being about 63 deg. Fah., with a mean temperature in summer of 80 degrees, and in winter of about 52 deg. Fah.

From these figures it will be seen that the climate is hot in summer and mild in winter. Generally speaking it is hot and dry, but healthy both for human beings and stock. In the more elevated regions about Warialda and Bingara the nights are almost always cool.

The Warialda district includes flat country and rolling downs to hilly. The hilly country lies chiefly in the eastern portion of the district, and is principally basalt. In the centre are undulating downs merging into black soil plains in the west of the district. In the plain country are numerous sandy ridges where the soil is not so good, but for the most part the soil on the plains is first-class, and carries heavy belts of belar and brigalow.

A considerable amount of wheat is grown about Warialda, and from 16 to 20 bushel crops are obtainable. Very little other farming is done, except in the vicinity of the railway, as the want of easy communication prevents cultivation, except for home use. A little maize and lucerne is grown along the rivers.

The Bingara district (county Murchison) is more hilly, and even mountainous in character, and the general contour of the country is hilly to undulating, with level to undulating areas along the Gwydir, Horton, and other water-courses. The soil is principally red to chocolate, with black soil on the plains. On the hills it is more or less stony in character. Sheep and cattle fatten on the flats, but the country is used more for breeding and wool-growing than for fattening. What farming there is is mostly mixed, sheep, cattle, wheat, and a little maize.

In the Narrabri district the spurs of the Nandewar Ranges render the eastern portion hilly to mountainous, the rest of the district being mostly level plains in the western portion and level to undulating in the centre. The plain country north of the Namoi River and in the western part of the district is black soil. In the Pilliga scrub country red soil predominates, a good deal of which is sandy in character with patches of grey or black soil. On the foothills in the eastern part good loamy soil is found. East of Wee Waa some mixed farming is carried on, sheep, wheat, dairying, fruit, and vines, the black-soil plains being almost exclusively devoted to sheep.

In the Moree and Walgett districts (west and north of the Land Board District) there is some hilly to undulating country south of Moree, the remainder being plain country with heavy black soil in the north and west, and red and chocolate in the south. On the hills the land is more stony. Good wheat and hay is grown in this district in small quantities, especially in the eastern portion, also citrus and summer fruit, but the country is practically given over to sheep farming. The living area for closer pastoral settlement is calculated at 3,000 to 5,000 acres.

In the Warialda district, box, ironbark, and pine are the principal timbers with apple, myall, wilga, and thick belts of belar and brigalow.

In the Narrabri district the hilly country to the east and the Pilliga scrub carry box, pine, ironbark, belar, bloodwood, and rosewood, with coolabah, box, and belar on the plains.

Box, ironbark, with coolabah, belar, brigalow, pine, wilga, and rosewood, are the principal timbers in the Moree and Walgett districts. Most of the timber in the district is stunted, only a small percentage being good for commercial purposes.

The grass in the black-soil country is good and fattening, generally poor in the timbered country until ringbarked, when it is good. The principal grasses are blue, Mitchell, kangaroo, star, coolah, and wire, besides which there are many nutritious and fattening herbage during the winter months.

With regard to the cost of clearing, the following information is supplied: In the Warialda district the cost for dead timber is 20s. to 30s. per acre; for green timber, £4 to £7. Yankee grubbing is sometimes practised for green timber at a cost of £3 per acre.

Ringbarking only can be done for 3s. per acre in the case of box and ironbark, rising to 7s. per acre for belar and brigalow.

Firing can be done cheaply and easily, and without danger. All the timbers burn easily except bloodwood.

Fencing material is plentiful, except in the open plains, and from fair to good in quality.

Ironbark, box, belar, coolabah, and pine are the best timbers for posts.

White ants are not troublesome in this district if split posts are used. Round posts with hollow centres or small hollows are readily attacked. The holes through which the wires of fences pass through the posts, are frequently attacked, and the excrement deposited by the white ant, when damp, tends to rust the wires.

Post and rail fences are not used, and cattle-proof fences are not common. The cost for a three-wire cattle-fence would be about £32 per mile. Sheep-proof fence (six-wire) costs about £50 to £70, and rabbit proof fencing, 42-inch netting with three wires in netting and one barbed wire, from £120 to £160 per mile, the cost varying according to distance of cartage, and the facility of obtaining suitable timber. Very little wire-netting fencing is being done.

Well-sinking, including timbering, varies in cost from 20s. to 30s. per foot according to the depth. The cost of excavating for tanks runs from 1s. 3d. to 1s. 9d. per cubic yard. Excavating for drains costs from £30 to £60 a mile if ploughs and delvers are used.

The roads in the Moree and Walgett districts, and generally in the flat country, are fairly hard and good when dry, but bad in wet weather, and sometimes impassable. In the eastern part the roads are better, and in the ridges often hard and stony. The main roads in the hilly country are metalled.

There is very little land available for settlement in this district except of inferior quality. The extension of the railway would encourage the increase of cultivation, as there are extensive areas of rich country in all parts of the district suitable for cereals; and wheat, corn, oats, and lucerne, all give good results when cultivated.

There is a great deal of land infested by the prickly-pear.

The price of land in the Warialda district is from £2 to £3 per acre on a freehold basis for conditional purchase. Land for settlement lease is from 10s. to 35s. per acre, carrying rentals of from 1½d. to 5d. an acre.

For agricultural land in the Bingara district £4 and upwards per acre is paid on a freehold basis, and for mixed lands £2 10s. to £3 10s. The average carrying capacity of the country is 1 sheep to 2 acres in the Moree district, and 1 sheep to 2½ acres in the Walgett district.

In the Narrabri district the neighbourhood of Narrabri itself is the most suitable for the man with limited capital, both because of the proximity to market and because water can generally be obtained in shallow wells.

In the western part of the district water is conserved in tanks or obtained from artesian bores. There is little surface water except along the Namoi, the frontage of which is alienated. The black soil should grow good wheat. The herbage makes excellent silage.

Orange Land Board District.

Includes Orange, Bathurst, Wellington, Lithgow, Molong, Cummoek, Millthorpe, Blayney, Carcoar, Canowindra, Cowra, Koorawatha, Eugowra, Manildra, Cudal, Mudgee, Gulgong, Dumedoo, Merrygoen, Coolah, Cassilis, Rylstone, Hillend, Wallerawang, Portland, Candos, Burruga, Trunkey, Tuena, Rockley.

The district is well watered by the Macquarie River and its tributaries, and is fairly well served with railways. The main western line passes through the centre of the district, and the Blayney-Harden line through the south-western portion, while the Molong-Forbes line connects the western part with the main line. A line from Molong to Dubbo is in course of construction and will soon be completed as far as Cummoek, a distance of

about 16 miles. An extension from Cowra to Canowindra is now completed and a further extension is nearly completed to Eugowra, which will open up further agricultural land in the south-western corner. There is a railway line branching off the western line from Wallerawang which runs northerly *via* Mudgee and Merrygoen to Coonabarabran, with a connecting line from Merrygoen to Dubbo.

Bathurst lies in the centre of an undulating plain, and there is a good deal of level country south and west of the Canoblas Range from Molong to the south-west limit of the district.

The remainder is from undulating to hilly and mountainous. Near the extreme east lies the great dividing range, stretching northwards through counties Bligh and Phillip. The south-eastern corner is also mountainous, and in the western portion are the Canoblas Ranges and the hills about Blayney.

The climate may be classed as temperate over the whole district, being mild in summer and cold in winter, when snow is not unusual, especially on the Great Dividing Range, the highest point of which in this district is about 4,000 feet.

The average summer temperature is about 70 degrees Fah., with a winter average of about 44 degrees Fah., the average for the whole year being between 56 degrees and 58 degrees Fah. The annual rainfall is about 31½ inches, which is very evenly distributed over the twelve months.

The country in the neighbourhood of Orange and Millthorpe is undulating to hilly and rough, the formation being largely granitic and basaltic. The soils in this neighbourhood are, on the whole, fairly rich red and chocolate loams, of a rather heavy type, with black soil in the valleys. Mixed farming is carried on, principally cattle, sheep, pigs, wheat, fruit (chiefly apples, cherries, grapes, &c.), potatoes, and dairying. Marble quarries exist at Borenore, near Molong, and at Caloola.

East from Orange and towards Lewis Ponds and Ophir the land becomes more stony and shingly on the hills, with black soil in the valleys. The principal farming here is sheep and potatoes.

Towards Wellington the country is more broken with ridges and valleys, especially about the Macquarie and its tributaries. A good deal of wheat cultivation is carried on here. The soil is very variable, changing from good rich basalt soils to poor sandy soils. Slate and dioritic marble are to be found near Mullion.

Round Molong the country becomes more open, and varies from undulating to fairly level country. Works are being established for limestone. To the south and south-west of Molong the country varies from flat to hilly, with rich, red, volcanic soil on the flats, and black soil in the valleys. On the high hills the land is generally poor, stony, and scrubby. There is plenty of very fertile soil in this part of the district, especially round Manildra, Eugowra, and Canowindra. Promising shows of phosphate apatite are being explored on Gamboola, near Molong.

In the south-western corner of the Land Board District the country ranges from flat and undulating to hilly and mountainous, granite and basalt being the principal soil-forming rocks. In the lower portions the soils are fairly rich to rich red and chocolate loams, with black soil in the valleys. The land here is principally used for grazing sheep and cultivation of wheat, maize, and oats. Lucerne does well, and is cultivated on the flats along the Lachlan. Fruits, barley, vines, rye, potatoes, and pumpkins are also cultivated in this district, and all do well.

Round Carcoar and along the Blayney line the country is hilly to mountainous, chiefly slate formation, with ironstone and volcanic outcrops. On the hills the soil is poor and stony, but the lower country carries considerable areas of rich red or chocolate loam. Good black marble exists at Rockley.

Farming in this district is principally confined to sheep, wheat, fruit, and potatoes. There is a good deal of first-class wheat-land about Lyndhurst and Mandurama. About Forest Reef a considerable area of potatoes is grown.

About Bathurst the country varies from slaty ridges with granite to undulating to flat and sometimes swampy. The soil varies from light, sandy loam to stiff clay, with occasional pipeclay. The chief crops are potatoes, wheat, oats, cauliflowers, and tobacco, with maize and lucerne on the river flats. There are plenty of good orchards in this district, which is especially suited to cool climate fruits, such as apples, pears, cherries, &c. Gooseberries, currants, and similar fruits also do well. The climate is too cold for grapes.

In the north-eastern portion of the district, including Mudgee and Rylstone, there is a great deal of rough country on the ranges, with fertile valleys merging into undulating and flat country. East of the Dividing Range the country rock is sandstone; to the west, slate and basalt predominate. In county Bligh (in the northern part) basalt is the principal soil-forming rock on the high land, the valleys having rich flats. There is also a good deal of sandstone in this district. Round Mudgee itself the country is hilly, with good fertile valleys. A little wine is made from grapes grown about Mudgee. For the most part sheep are grazed in this district, with some cattle and dairy-farming. On the flats, lucerne, maize, and wheat are cultivated, and in the cooler parts oats, potatoes, and apples. Large cement works exist at Portland, and others are being opened up at Candos.

Between this district and Bathurst there is a great deal of rough, mountainous country, unsuitable for cultivation. There is little arable land in this district, which includes Hill End and Sofala, where mining operations are carried on.

The eastern portion of the Orange Land Board District includes the Blue Mountains and its spurs. The country is principally sandstone, high, rough to mountainous. The soil is poor and sandy, generally stony. Some fruit is cultivated, but grazing is the principal occupation.

In the south-east corner, including Burruga, Tuena, and Bigga, the land is only fit for cultivation in patches, the greater portion being steep, broken, and mountainous country, which is given over exclusively to sheep grazing.

Timber is fairly plentiful over the most of the district. White, red, and yellow box are represented throughout, and are generally indicative of the better-class country. On the Dividing Range the typical Blue Mountain timbers are found, viz.:—Stringybark, peppermint, messmate, black ash, mountain ash, blackbutt, apple, and white gum.

Over the rest of the district, in addition to red, white, and yellow box, the most common trees are stringybark, apple, peppermint, ironbark, woolly butt, red and white gum, with pine in the Mudgee, Cowra, and Molong districts.

The grasses are generally good on ringbarked country, and include kangaroo, barley, and crowfoot. The herbage is generally stunted on the hills but good in the lowlands, and very good in the improved country.

The cost of clearing varies a good deal, according to the district. For pastoral occupation, ringing, suckering, and scrubbing cost from 5s. to 15s. per acre. The cost is rather higher in the eastern and hilly districts, running from about 6s. per acre for white box up to 15s. per acre for other timbers.

For cultivation, clearing dead timber runs from 20s. up to 60s. per acre, for green timber from £2 to £3; generally dearer in the colder country, going as high as £8 per acre.

Except in cleared country fencing material is plentiful. The best timbers for posts are ironbark, red box, red gum, and stringybark. White ants are not troublesome. Post and rail fences are hardly used in the district. The cost of post and split-rail fencing would be from £100 per mile.

The cost of a five-wire cattle-fence is about £50 to £60 per mile; for a six-wire sheep-proof fence, about £48, and for a seven-wire fence, about £53 per mile.

Rabbit-proof fencing costs £100 to £120 per mile.

The cost of well-sinking varies from 5s. per foot for the first 50 feet in soft ground. This price does not include slabbing; slab wells run from 20s. per foot upwards.

Excavating for tanks costs from 1s. per cubic yard. Neither wells nor tanks are much used in this district as the country is generally well watered.

The cost of transport is also very variable, the roads being in places very steep. East of the Dividing Range the roads are sandy, but in nearly all the country west of the range the roads are good and hard, with the exception of the northern portion (County Bligh), where the roads are impassable in wet weather unless metalled.

The cost of transport of wool and merchandise is stated to be 30s. per ton in the Mudgee district (where the country is hilly).

There is not much available Crown land in the plain districts, and the price of good land is very high, running up to £8 to £15 per acre for the best land; river flats reaching even £40 to £50 per acre. Land suitable for mixed farming fetches £4 to £7 per acre. Lower priced land is poor and carries a sheep on from 2 to 12 acres.

In addition to pastoral pursuits, generally speaking, the following are the crops principally grown in the different districts, or for which those districts are particularly suitable:—

Orange: Apples and pears, cherries, and other cold country fruits, and potatoes.

Potatoes are extensively cultivated about Millthorpe.

Carcoar: Wheat, fruit, and potatoes.

Cowra: Fruit, wheat, oats, and vines; lucerne, on the river-flats.

This district is well watered by the Lachlan and permanent creeks.

Molong: wheat, oats, fruit, and vines; lucerne on flats.

There is plenty of first-class wheat land around Eugowra and Canowindra.

The Belubula River flats about Canowindra are specially adapted for lucerne, and command high prices.

Sydney (Metropolitan) Land Board District.

Includes the coast from Broken Bay to Bateman's Bay, with the townships and districts of Windsor, Richmond, Penrith, Parramatta, Picton, Wollongong, Kiama, Nowra, Milton, and Ulladulla.

This district includes a considerable stretch of the coast south of Broken Bay, and the country to the east of the Main Dividing Range. The formation is for the most part derived from the Hawkesbury sandstone and Wianamatta shale formations, with granite and basic outcrops. The soil embraces almost every type represented in the State, from sandy soils to heavy clays derived from slate and basalt, with alluvial flats upon the rivers.

The climate is temperate and the rainfall good. The latter may be given as 30 inches annually on the average. Being the oldest settled district in the State, all land of productive value has been taken up.

The farming carried on is chiefly dairying, fruit-culture (especially citrus fruits in the Windsor and Metropolitan districts), poultry, market-gardening, and the ordinary cereal fodder plants and roots.

There is a fair amount of timber in the district, and representatives of most of the best Australian hardwoods are still to be found. Clearing and grubbing may be put down at £10 to £20 per acre, the cost varying with the locality and the timber. For grazing, ringbarking, felling, and cleaning up the cost would be from 12s. 6d. to 30s. per acre.

Timber for fencing is still fairly abundant in the coastal districts, except about Illawarra.

For posts: Red and grey gum, ironbark, box, turpentine, mahogany, bloodwood, peppermint, and redwood are all used.

For rails the best timbers are blackbutt, grey gum, stringybark, and red gum.

Turpentine is rarely attacked by white ant, which is prevalent in the district.

Post and rail fences, two-rail, 640 posts to the mile, can be erected for from £80 to £120 per mile.

Four-wire (No. 8) cattle fence, 640 posts to the mile, costs £55 to £80; and seven-wire sheep-proof fence, No. 8 wire, 528 posts to the mile, with droppers, will cost £70 to £90 per mile.

For rabbit-proof fencing, six-wire, with 42-inch netting, 440 posts to the mile, and droppers, the cost would be from £90 to £120 per mile.

Well-sinking in alluvial costs from 15s. to 20s. per foot, and excavating for tanks from 1s. 6d. to 3s. per cubic yard.

The prices are necessarily approximate, as the conditions of settlement and trade vary in this district very much, as will be realised by contrasting Central Cumberland with such places as Putty, Hawkesbury River, Burragorang, and the lower South Coast.

The transport varies considerably from level to hilly and mountainous with roads both hard and soft.

The district, both on account of its nature and its proximity to market, is better adapted to mixed farming, such as dairying, fruit-growing, poultry-raising, beekeeping, market-gardening, pig-keeping, &c., rather than to one crop.

Tamworth Land Board District.

Includes Tamworth, Manilla, Barraba, Nundle, Werris Creek, Quirindi, Bindella, Tambar Springs, Coonabarabran, Barradine, Gunnedah, and Boggabri.

The district may be conveniently divided into three divisions for the purpose of description: The eastern portion, east and west of a line through Barraba, Manilla, Tamworth, Murrurundi; the western division, with Coonabarabran as the centre; and the central or Gunnedah division.

The climate of this district is generally temperate, fairly warm in summer, with occasional frosts in winter. The coldest parts of the district are the ranges to the west of Coonabarabran, with an altitude of 4,000 feet.

The mean annual temperature varies between 57 degrees and 64 degrees Fah., according to the locality. With the same reservation, the mean summer temperature is from 68 degrees to 78 degrees Fah., and the winter from 46-

degrees to 50 degrees Fah. The average annual rainfall is about 27 inches, being fairly evenly distributed. July, August, and September are the driest months.

The country round Tamworth, and in the eastern division, is undulating to steep, being composed chiefly of slate, conglomerate, granite, and sandstone. In the centre of this district, and towards the west and south of Tamworth, the country may be described as undulating to flat, with slate, basalt, and sandstone.

The soil varies over the area from chocolate and reddish soil on the hills to black soil on the plains, and light sandy loam in the scrubs.

Some limestone occurs in the neighbourhood of Tamworth.

In the western portion of the district, with Coonabarabran as the centre, the country varies from undulating table tops to rough and mountainous in the centre (the Warrumbungle Ranges are from 3,000 to 4,000 feet high), of sandstone and basalt formation, and with a reddish sandy loam and clay soils on the ridges, interspersed with a good many patches of raw sand, to the black-soil plains on east and west.

The country lying between the above divisions, and in the centre of the Land Board District from Boggabri on the north, and stretching southward through Gunnedah and Bundella, is for the most part black soil plain country, with well-timbered basalt rocky nobs and undulations here and there rising to mountain ranges in the south. This portion is bounded on the north-east by the Nandewar Range, in the neighbourhood of which the prevalent soil is of a reddish or chocolate coloured sandy loam.

All classes of farming are carried on. Wheat is the principal crop in the neighbourhood of Tamworth, Manilla, Quirindi, Gunnedah, and the eastern portion of the district. Lucerne is grown extensively in county Parry. In this district (the south-east portion of the Land Board district), maize and barley are also extensively cultivated. The barley is particularly good for malting purposes. Tobacco is extensively cultivated near Tamworth and Manilla.

Wheat is also extensively grown in the Gunnedah district.

Round Tamworth, Quirindi, and Manilla there is some dairying, and butter factories have been established at Gunnedah, Tamworth, and Quirindi, which promise to become important dairying districts.

In the western portion of the district mixed farming is carried on over the greater part of the area. The black soil plains are chiefly devoted to wool and fattening, the natural grasses being good fattening grasses. Wheat and maize are cultivated, the area being extended annually. Lucerne is being more extensively grown with considerable advantages on grazing areas, and fruit is successful and of first-class quality wherever it has been tried, especially round the town of Coonabarabran, with 30 inches average rainfall.

These crops are only grown for local requirements, as the distance from the railway is against crop production on any extensive scale. There are two flour mills at Coonabarabran, a butter factory at Coolah, and freezing works at Coonabarabran and Binnaway.

There are at present considerable areas under cultivation with a 25-inch rainfall, which is the lowest in the district, the average being 27 inches. Yields are invariably good, and absolute failure of crops is unknown, where proper farming methods are adopted. The points at present accessible by railway are Gilgandra, Gulargambone, Dubbo to Merrygoen, Binnaway, and Coonabarabran, while construction work on the Coonabarabran to Barradine and Binnaway to Werris Creek is nearing completion.

Generally speaking, water is obtainable by sinking in the Tamworth district, at depths of from 20 to 150 feet. In the Gunnedah district it is stated to be found at an average depth of 80 feet, and in the Coonabarabran district at from 40 feet to 150 feet. The cost of well-sinking is about £1 per foot. Boring plants are coming into use in the Coonabarabran district at a cost of from 7s. 6d. to 10s. per foot. The cost of excavating tanks runs from 8d. per cubic yard for large tanks to 1s. for smaller ones. The cost is somewhat higher in the hilly country than on the plains.

There is plenty of timber in the district, especially on the ridges, and a great variety of timber is represented. In the eastern portion box, apple, red gum, stringybark, peppermint, yellow jacket, and a little pine and ironbark are the principal timbers.

In the Coonabarabran district, box, pine, gum, apple, ironbark, bloodwood, yellow jacket, and peppermint, with ironbark on the ridges are obtainable.

The black soil plains about Gunnedah originally carried myall, which is now dead; the balance of the flat country is principally pine, box, and scrub, such as belah, &c., with ironbark and gum on the sandy country.

Clearing costs from 10s. to 15s. per acre in old dead box country; and from 20s. to 25s. in recently dead timber. In green country clearing costs from £2 to £5 per acre, according to the timber. Ringbarking costs from 1s. to 5s. per acre. In nearly all cases the country is ringbarked some time before clearing. In the Gunnedah and Quirindi districts traction engines have been tried and found to be a cheap and effective means of pulling down both dry and green timber.

The supply of fencing material is generally fair. In the eastern part of the district it is becoming somewhat scarce. There are hardly any post and rail fences except in paddocks about dwellings. Ironbark, bloodwood, and box are the best for posts, and are not attacked by white ant in this district. Belah may be used for rails, but is no good for posts.

Cattle and sheep proof fences (six-wire) cost from £45 per mile and upwards; rabbit-proof fencing from £85. Rabbits are prevalent throughout the central and western portions of the district.

Transport is fairly good over the whole district. The main roads are good, and transportation is easy, except in the mountainous country and in wet weather on the black soil plains, which are impassable when wet. The gradients are not steep, and the roads are for the most part fairly hard.

Wagga Land Board District.

This district includes the Riverina, and is bounded on the south by the Murray. It includes Young, Cootamundra, Junee, Gundagai, Tumut, Tumberumba, Albury, Corowa, Berrigan, Finley, Jerilderie, Urana, Wagga, Koorowatha, Murringo, Harden, Murrumburrah, and Stockinbingal.

Wagga Land District.—This district includes a variety of country, from the mountainous country on the Great Dividing Range in the eastern part to the plain country in the west. It is watered by the Murray and Murrumbidgee Rivers and creeks such as the Billabong and Yanco.

About Wagga itself, and in the portion to the north and north-east, including Junee, and Young, the country is fairly uniform, being for the most part gently undulating, with ranges, hills, and stony ridges, but no mountains. About 80 per cent. of this country is level to moderately undulating, and can be profitably cultivated. The remainder is fair to poor grazing country.

The soil over the greater part is a red clayey loam, with a deep clay subsoil. In the western portion there is a good deal of black stiff "puggy" soil, with "gilgais" or "Coolamon holes," which is better suited for grazing than agriculture.

The cultivation of wheat, oats, and barley is very successful in the district, these cereals constituting the principal crops. Sorghum, rape, lucerne, and fruit are also successfully cultivated, but to specialise in any of these products recourse must be had to irrigation, which is now being successfully carried out on the Murrumbidgee in the neighbourhood of Wagga. The number of irrigation plants on the river is rapidly increasing. The fodder crops referred to are mostly grown under irrigation on the Murrumbidgee, but there is an increasing tendency to cultivate lucerne on the higher lands as well as the river and creek flats, without artificial watering.

The climate is hot and dry in the summer, with cold and braeing winters. Frosts are frequent. The average summer temperature is about 72 deg. Fah., the winter average being about 47 degrees. The average annual rainfall is about 26 inches, and is very evenly distributed throughout the year, June being the wettest month.

The chief timbers are grey and yellow box with white pine, ironbark, stringybark, and kurrajong. On the flats, red gum and apple are the principal timbers. The hills are mostly lightly timbered with stringybark, ironbark, stunted gum, red box, sheoak, and black pine.

The grasses are good. The principal native growths are corkscrew, umbrella grass, and geranium. Barley grass and trefoil are also plentiful. Dandelion is spreading.

The cost of clearing for agricultural purposes varies considerably; from 30s. an acre for thick and heavy box timber which has been dead for five years, down to 10s., or even less in the case of timber of lighter growth dead for twenty years. For grazing, the cost is less than half the above.

In the case of green timber, clearing for the plough will cost from 50s. to 60s. per acre. The usual procedure is to ringbark and sucker till dead, and then burn out the dead timber. Box burrs most easily of any of the timbers. The practice is that after the burning of the tree butt the roots have to be grubbed before ploughing can be carried out. Yankee grubbing is also practised occasionally.

Timber for fencing is fairly plentiful in places, but is being rapidly denuded and is becoming scarce in the agricultural districts.

For posts, white pine, red gum, box, and ironbark are the best timbers. White pine is the only wood that is immune from the attacks of the white ant, which is prevalent in the district. No special precautions are taken against it.

Post and rail fences are not used in this district except in short lengths where wire straining is impracticable. The cost of a six-wire stock proof (two wires barbed) is about £70 per mile, and of a first-wire rabbit-proof fence with 42-inch netting, about £140 per mile.

The cost of well-sinking is about 20s. per foot up to 50 feet. For deeper wells the cost is greater. For the Wagga Stock District the cost is given at 20s. Tanks up to 2,000 cubic yards capacity cost about 1s. per cubic yard; for very large tanks the cost would be lower.

With the exception of the south-east part of the Wagga Stock District, where some hilly country is met with, the transport is good and easy, the soil being firm and fairly hard, except on the flats, where the roads are wet and sticky in winter. Transport generally is good and easy, the soil setting firm and hard under prevailing traffic conditions, but there are many instances in the hilly parts of long and heavy grades, necessitating the employment of five horses to draw a three-ton load. The local shire councils, however, are gradually effecting improvements in grades and road surfaces, and many deviations have already been made.

The whole of the country is good for fruit-growing and general agriculture, the soil being strong and rich. The country is healthy for stock of all kinds.

The Urana District is for the most part level country, and from light-boree to box and pine country within the wheat belt. About one-third of the area is good agricultural land, and the district is well watered by creeks, such as the Billabong and others, which, although not permanent, afford good facilities for water conservation. Good stock water is obtainable over the greater part of the district by boring to a depth of about 120 feet. The soil is for the most part a heavy loam, and in parts a stiff clay of a rich nature which is good for agriculture, and grows fattening grasses.

The climate is good and temperate, though subject to dry spells, with an average rainfall of about 18½ inches, December to March being the driest months. The average summer temperature is 75 degrees Fah., and in winter 48 degrees.

Wheat is successfully grown in the eastern and southern parts. A good deal of cultivation is carried on about Lockhart. The western part of the district is for the most part grazing country.

Box and pine are general over the whole district, with stunted red gum along the creeks.

The western part of the district is mostly plain country, with timber along the creeks. The grasses are fairly fattening, and the country carries one sheep to 2 acres.

To clear dead timber for cultivation costs from 10s. to 25s. per acre; and for grazing about 4s. per acre. These prices apply to box and pine.

The supply of timber for fencing is limited; box and pine are used for posts. The fencing is generally light in character, with fewer posts than is usual in other parts of the district. For six-wire cattle and sheep-proof fence with posts 16 to 18 feet apart, and wooden or patent droppers, the cost is about £75 per mile.

Rabbit fences, with 12-foot panels, four-wire (one barbed), and 42-inch netting, £160 per mile.

Well sinking, with timber, costs about 10s. per foot, and tanks about 1s. per cubic yard; 2s. 6d. per chain is paid for tank drains.

Generally speaking, the eastern part of the district is the richest and most suitable for agriculture. The extension of the railway from Lockhart has promoted agricultural settlement. In the western portion, with its much lower rainfall, irrigation from the natural watercourses will be needed to render agriculture remunerative.

Corowa Land District.—One quarter of this district is undulating, the rest level. There are no creeks, but it is watered by the Murray. The soil is a rich loam for the most part, in part heavy loam. On the low sand hills there is sandy loam. It is mostly all good agricultural land.

The climate is warm in the western portion, being about the same as the Urana district. Cold in winter. Rainfall about 20 inches.

Sheep farming and wheat growing are the principal agricultural operations. A good deal of wine is made, and some of the principal vineyards in the State are situated here. Orchards are also plentiful, and fruit does well. It is a good agricultural district, especially suited for mixed farming. Lucerne is grown for a considerable distance along the Murray frontage. The principal timbers are grey and yellow box, gum, and pine, with red gum on the Murray flats. The grasses are good; trefoil is especially good. Barley grass is plentiful but not much thought of in this district.

The cost of clearing dead timber for grazing is about 4s. per acre. For the plough dead box costs about 17s. 6d. to 30s., and dead pine about 20s. per acre. With green timber no return can be expected for three years, and it would thus cost about 30s. per acre to bring it under cultivation. The supply of fencing timber is only fair. For posts, grey box, red gum, and pine are all good.

Cattle and sheep fence (six-wire), costs £75 per mile. Rabbit-proof fencing, four-wire (one barbed) with 12-inch netting, costs £160 per mile.

Well-sinking costs 15s. to 20s. per foot with timber. Tanks, 1s. per cubic yard for excavating; drains, 2s. 6d. per chain upwards.

For transport most of the district is level and firm, with good bottom in wet weather.

It is now watered by tanks, wells, and bores. It is a good wheat district, but subject to dry spells. Good stock water is obtainable over about half the district by boring to a depth of about 120 feet. Near the Murray good water is obtainable at depths of 20 to 50 feet.

Albury Land District.—About a quarter of this district is high land and hilly, becoming mountainous in the eastern portion. It is fairly watered by the Murray and by billabongs and other creeks. The balance is undulating with fairly rich grazing and agricultural land. The soil varies a good deal, being derived from granite, slate, and basalt. There are also rich alluvial flats along the rivers and creeks. The climate is temperate, very healthy, and the rainfall is regular and assured, the average being 22–24 inches. On the western side the rainfall is less certain, but absolute failure of crops from drought is unknown.

This is an old settled district, wheat, and all cereals except maize are grown successfully; fruit, vines, and mixed farming are carried on, as well as grazing.

There is a great variety of timber of good quality, the principal being box, messmate, stringybark, peppermint, gum, and pine, with red gum on the Murray.

Clearing for agricultural purposes costs about 15s. to 17s. 6d. per acre in dead pine or box country.

For grazing, about 4s. to 5s. for the above timbers, and from 7s. 6d. up to 10s. for other timbers, or in denser country.

In green timber clearing costs about 40s. to 45s. per acre in ordinary country, and up to £3 5s. in stringybark country.

The usual practice is to ringbark so as to kill slowly, keeping the sucker down.

Fencing timber is still plentiful, but becoming limited around agricultural centres.

For posts, red gum, yellow box, red box, and stringybark, are the best timbers.

White ants are very bad, but no precautions appear to be taken against them.

Cattle and sheep-proof fences (six-wire), with 9-foot panels, cost £75 per mile; rabbit-proof fencing up to £160.

Well-sinking costs 15s. per foot timbered; tanks 1s. per cubic yard; drains 3s. 6d. to 5s. per chain.

The transport is generally good. It is a good district for mixed farming, orchards, wine, grapes, and poultry; all do well. It is very healthy for stock, and the market facilities are good.

Tumbarumba Land District.—Half of this district is mountainous, the other half hilly, with good rich river flats on the Murray. The soil varies from very poor to rich, with patches of alluvial and a fair extent volcanic. The climate is good. There is usually snow on the mountains in winter.

The mean annual temperature varies from 72 degrees in summer to 46 degrees in winter. Rainfall about 35 inches. Taking the mean average of the whole district it is probably higher. Roughly it would range from 30 inches to 50 inches.

Dairying is in its infancy, but making good progress. The chief occupation is sheep and cattle grazing, but the area is suitable for fruit, apples, roots, cereals, pigs, and mixed farming.

The chief timbers are messmate, stringybark and gum, with mountain ash, mountain gum, and eurabbie on the hills. The timber is suitable for building and fencing. The flats carry fattening grasses. Those on the hills are inferior.

Cost of clearing for grazing, 10s. to 22s. 6d. per acre; cost of clearing green timber for cultivation varies considerably, being from £2 to £20 per acre. The timber takes 6 to 10 years to kill by ringing. The suckering is very strong, often producing a dense scrub of suckers and seedlings. The ringing has, therefore, to be done so that the timber is killed slowly, and then the existing suckers and seedlings destroyed every year.

Timber for fencing is good. For posts stringybark is mostly used away from the Murray, and red gum on the Murray.

The cost of cattle fencing (six-wire and one barbed) is about £70 per mile (without clearing the line); of sheep-proof (six-wire, No. 8) about £60. Rabbit fencing with 42-inch netting costs about £130 per mile.

Well-sinking costs 20s. per foot with timber. Tank excavation about 1s. per cubic yard.

The country is hilly and mountainous, and the transport consequently hard, though the roads are for the most part fairly good. The railway from Wagga to Tumbarumba has now been completed.

The district is well suited for mixed farming, and for intense culture. Deciduous fruits and English grasses do well. It is a favourite health resort.

Tumut District.—The Tumut River Valley is exceptionally fertile and picturesque, and compares favourably with some of the best land in the State. Maize and tobacco-growing and dairying are its most thriving industries.

The country immediately to the east and beyond changes abruptly into high, rough, steep, and mountainous, the geological formation, for the most part, being slate, with large intrusions of limestone at Yarrangobilly, and basalt and granite further out. This part of the Tumut district is very interesting in that it possesses some of the finest snow-clad belts and scenery in Australia, and in which is situate the highest mountain, Kosciusko, to the south-east of Tumbarumba. These hills are practically immune from droughts, and are in big request for relief grazing in times of stress elsewhere. The pasturage, however, is unsound and fluky.

The chief timbers are messmate, mountain gum, snow gum, mountain ash, stringybark, and highland apple on the hills. On the lowlands the timber consists principally of box, lowland apple, stringybark, and red gum. Of all these timbers, only the following make good fencing posts and stand satisfactorily in the ground:—Red gum, box, stringybark, and snow gum. The others mentioned are useless for that purpose.

The cost of clearing green timber for the plough is so high that it becomes unprofitable and prohibitive, being as much as £40 per acre about Batlow. To clear old rung country for cultivation varies, according to the density of the timber and the locality, from 20s. to 30s. per acre on the lowlands, and up to £10 per acre on the highlands.

A good 6-wire fence now costs about £60 per mile, and a good rabbit-proof fence about £150 per mile. The Tumut district is magnificently watered by running streams and springs, and consequently there is no need for artificial supplies by well sinking, dams, tanks, &c.

Gundagai District.—This is mostly hilly to undulating good grazing and agricultural land, with rich soil flats along both sides of the Murrumbidgee River, which river is also its main water supply, together with permanent creeks and gullies. Consequently, there is very little artificial water-supply in the district.

The timber is mostly box and stringybark on the hills, and red gum on the flats. Around Gundagai the timber is scarce, but is plentiful further out, and being of a kind which is durable in the ground, it makes good fencing posts.

The cost of a good six-wire fence is about £60 per mile, and of a good rabbit-proof fence about £150 per mile.

Western Division.

Including the country to the west of an irregular line through from Mungindi through Walgett, Coolabah, Euabalong, Booligal, Balranald, and extending to the Queensland, South Australian, and Victorian borders.

The country is nearly all flat, chiefly open plains, with red sandy soil, or black-soil plains along the watercourses. There are the Barrier Ranges and some undulating country in the western portion, and some low ranges of hills to the east of Wilcannia; also north and west of this place. There are stony ridges in the north of the district. The district is lightly timbered with rather small trees. On the open plain country the red soil is very often wind-swept, and the surface soil carried away by the strong westerly winds.

The only soil really suitable for agriculture would appear to be the greyish-black alluvial flats, where yarran, pine, and box flourish. Yarran indicates a soil of good depth, but cultivation without irrigation is not generally practicable.

The climate is very hot and exceedingly dry. The mean summer temperature in the Bourke district is 80 degrees to 83 degrees, sometimes going as high as 120 degrees. The winters are mild and occasionally cold, with an average temperature of 52 degrees to 54 degrees Fah.

The annual average rainfall varies from 18½ inches in the eastern portion to as low as 10 in the western part. At Bourke and the eastern district quite one-third of the 18½ inches falls during January, February, and March.

It is essentially a pastoral district, and there is no cultivation except under irrigation. A little wheat is grown (chiefly for hay), and vegetables are grown by irrigation from the rivers. Round Nymagee wheat has been grown for years, and lucerne in a very small way is being grown near Cobar.

But, on the whole, there is no prospect of cultivation becoming general for many years, and until some scheme of irrigation is adopted which will enable the country to be irrigated more cheaply than is at present possible.

The principal timbers are box, gum, pine, mulga, gidgea, wilga, yarran, coolabah, kurrajong, leopard-wood, and white-wood.

Red gum and box are the chief timbers on the river flats.

The grasses are wire grass, spear grass, barley grass, corkscrew, umbrella grass, Mitchell, cockspur, kangaroo, blue grass, and mulga grass.

Many of the scrubs are edible.

There is no clearing to speak of in the district, consequently it is difficult to obtain reliable information on the subject. Ringbarking costs from 9d. to 2s. 6d. per acre, the cost varying according to the nature of the timber.

In the mallee country in the southern part of the district, the initial cost of killing the timber for grazing is said to be about 10s. per acre.

Timber for fencing is fairly plentiful and sufficient in the eastern part of the Division, generally scanty elsewhere.

Mulga and gidgea are considered to be the best timber for posts. Belar, box, pine, and beefwood are also good.

Post and rail fences are not used in the division, neither are cattle-proof fences to any extent.

A six-wire fence would cost £40 per mile, and more if remote from rail or river.

Rabbit-proof fencing costs £100 to £150 per mile.

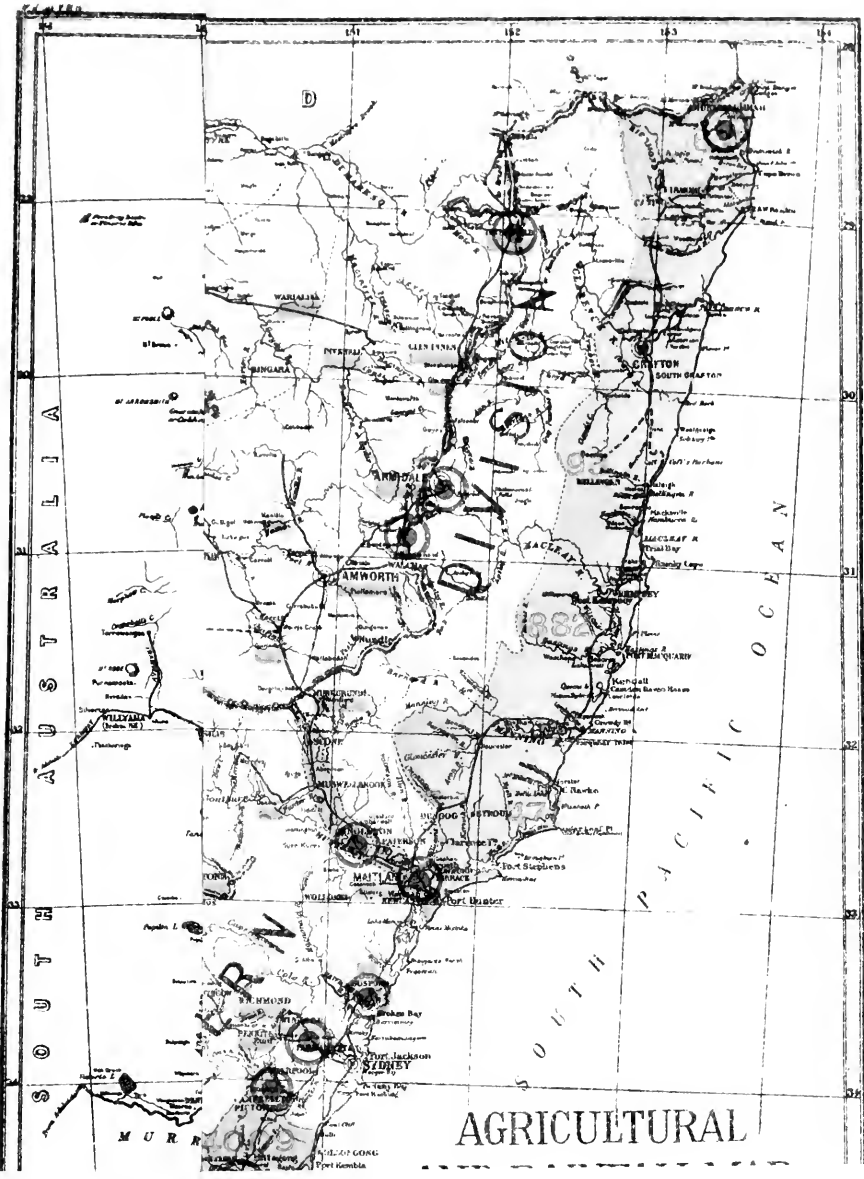
The cost of well-sinking averages, for the first 50 feet, if no blasting is required, about 20s.

Artesian bores cost 15s. per foot upwards according to depth.

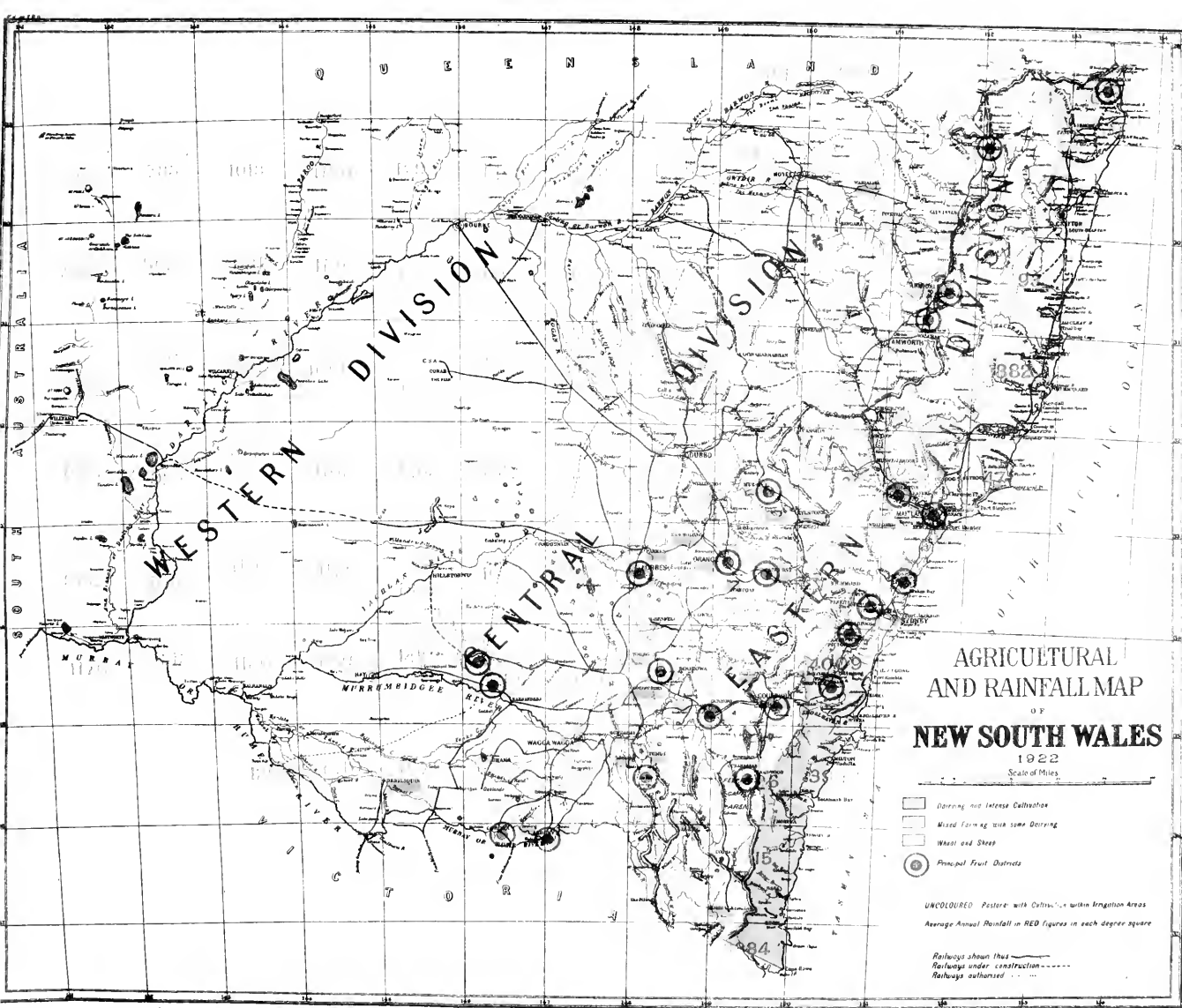
Tank excavation costs from 1s. per cubic yard. If through rock, much more.

Transport is, on the whole, easy, the country being flat and the roads good in dry weather. In some parts of this country, however, the roads are heavy, being either deep sand or sandy hills. The heavy river flats are fairly good in dry weather, but impassable when wet. Camels are used west of the Darling for transport, as well as horses and bullocks.

Water is scarce all over the district, and the water from the bores is saline or alkaline in character, and not suitable for irrigation by flooding.



AGRICULTURAL



RAINFALL AND TEMPERATURE TABLE.

Particulars furnished by MR. H. A. HUNT, Commonwealth Meteorologist.

District.	Altitude above sea level (ft.).	Average Annual Rainfall.	Number of Years' records.	Average Monthly Rainfall.												Extreme Temperatures.		Frosts.	
				Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Max.	Min.	Earliest recorded.	Latest recorded.
Albury	512	27.95	43	1.43	1.66	2.03	2.65	2.62	3.15	2.86	2.90	2.68	2.63	1.92	1.72	19.9	24 March	6 November.	
Armidale	3212	31.77	56	3.68	3.35	2.81	1.97	1.71	2.70	2.92	1.81	2.16	2.64	3.28	3.55	11.2	27 January	6 December.	
Barnedman	785	18.36	35	1.63	1.28	1.46	1.33	1.39	2.06	1.59	1.49	1.59	1.61	1.31	1.62	14.3	27 April	26 September.	
Bathurst	2246	23.93	63	2.49	2.16	1.96	1.62	1.80	2.00	1.71	1.77	1.78	2.17	2.15	2.26	13.0	11 March	4 December.	
Bega	50	33.47	39	3.63	3.52	3.98	2.23	2.46	3.31	2.38	2.96	2.19	2.43	2.92	3.17	109.6	18 April	16 October.	
Berrigan	388	18.19	47	1.91	1.24	1.45	1.43	1.85	2.11	1.44	1.84	1.69	1.67	1.27	1.16	24.9	13 "	6 "	
Berry	24	57.84	35	6.15	4.87	6.61	5.46	5.27	5.24	5.52	3.40	3.15	3.07	3.36	5.44	109.8	30 "	1 November.	
Blayney	2844	29.51	26	2.85	1.67	1.84	2.06	3.36	2.36	2.84	3.05	2.49	2.58	1.96	2.95	104.0	1 February	27 December.	
Bodalla	3001	23.21	46	1.90	3.90	4.27	2.81	2.71	2.98	2.51	2.69	2.88	2.76	2.61	2.95	17.0	18 April	15 October.	
Bombala	361	14.01	49	1.48	1.67	1.26	1.19	1.08	1.21	1.93	1.76	1.19	1.74	1.94	1.79	26.2	6 January	24 December.	
Bourke	2171	37.35	37	3.87	2.82	4.22	2.80	2.92	3.62	3.76	2.51	2.16	2.35	2.10	2.25	127.0	8 May	17 September.	
Bowral	3157	27.32	44	2.81	2.63	2.47	2.15	2.11	2.42	2.91	1.88	1.84	1.93	2.26	104.9	16 March	15 October.		
Braidwood	430	15.51	47	1.88	1.64	1.51	1.69	1.08	1.60	1.69	.94	1.16	1.03	1.21	1.18	129.0	2 January	27 December.	
Brewarrina	2000	30.19	36	3.74	2.47	2.92	3.91	1.74	2.40	1.71	2.91	2.67	2.75	2.83	3.63	106.0	18 February	1 September.	
Bundarra	2925	30.03	41	2.61	1.64	2.02	1.86	2.98	3.80	2.89	2.57	2.63	2.78	2.25	2.45	105.0	10 "	16 "	
Carcoar	82	43.52	48	5.19	5.76	5.89	3.97	3.17	2.48	2.57	1.99	1.77	1.76	2.00	2.41	109.5	24 May	21 September.	
Casalis	1500	23.58	50	2.51	2.36	2.11	1.47	1.43	1.99	1.75	1.77	1.76	1.74	2.00	2.15	115.5	10 March	30 November.	
Collarenebri	477	19.14	37	2.63	2.63	1.96	1.12	1.43	1.62	1.40	1.59	1.48	1.32	1.81	1.15	19.0	13 May	29 September.	
Condonbini	700	17.18	41	1.80	1.30	1.47	1.32	1.41	1.62	1.24	1.34	1.25	1.41	1.19	1.63	122.2	20 April	12 October.	
Coolamon	823	19.95	31	1.46	1.33	1.68	1.44	1.64	2.39	1.89	1.73	1.69	1.96	1.38	1.36	118.5	25 April	2 "	
Coonamba	2917	19.10	56	2.21	2.06	1.97	1.96	1.25	1.12	1.93	.89	1.63	1.72	1.80	1.86	112.9	9 January	24 December.	
Coonambundra	590	19.65	42	2.02	2.03	1.88	1.54	1.60	1.62	1.40	1.42	1.37	1.45	1.52	1.76	115.0	9 April	10 October.	
Cooramundra	1082	23.20	33	1.85	1.28	1.84	1.80	1.83	2.79	2.11	2.18	2.02	2.11	1.62	1.77	112.0	25 February	7 November.	
Corowa	503	20.30	32	1.21	1.21	1.57	1.30	1.82	2.47	2.02	2.01	1.93	1.78	1.42	1.36	113.0	4 April	30 September.	
Cowra	3000	23.62	38	2.34	1.52	1.91	1.79	1.63	2.49	1.93	2.08	1.90	2.05	1.45	2.44	113.0	16 April	24 November.	
Crookwell	2011	16.30	62	1.64	1.64	2.53	2.03	2.25	4.07	3.29	3.35	2.87	2.71	2.03	2.60	99.0	16 January	15 December.	
Deniliquin	3000	32.96	28	2.72	1.69	1.64	1.65	1.68	1.86	1.28	1.44	1.65	1.51	1.15	1.45	80.0	23 March	6 October.	
Dubbo	870	22.13	49	2.60	1.69	1.90	1.78	1.88	2.03	1.66	1.73	1.59	1.52	1.15	1.15	16.9	14 "	1 November.	
Eden	107	34.18	50	3.30	3.21	2.82	3.26	3.34	2.43	2.43	2.43	2.38	2.47	2.47	2.63	106.0	29 "	Not reported.	
Forbes	781	19.84	46	1.72	1.54	1.57	1.59	1.66	1.89	1.55	1.76	1.75	1.73	1.32	1.76	111.0	6 May	10 October.	

of alkane in character, and not suitable for irrigation by flooding.

RAINFALL AND TEMPERATURE TABLE.
Particulars furnished by Mr. H. A. HUNT, Commonwealth Meteorologist.

District.	Altitude (ft.) sea level (ft.).	Average Annual Rainfall.	Number of Years' records.	Average Monthly Rainfall.												Extreme Temperatures.		Frosts.	
				Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Max.	Min.	Earliest recorded.	Latest recorded.
Albury	512	27.95	55	1.43	1.66	2.03	2.65	2.62	3.45	2.86	2.68	2.68	2.63	1.92	1.72	117.3	19.9	24 March	6 November.
Armidale	3212	31.77	56	3.68	3.35	3.81	1.97	1.77	2.70	2.92	1.84	2.16	2.64	3.28	3.55	105.2	11.2	27 January	6 December.
Barnedman	788	18.36	35	1.63	1.28	1.46	1.33	1.39	2.00	1.59	1.49	1.59	1.61	1.31	1.62	114.3	15.5	27 April	26 September.
Barhurst	22.66	23.93	63	2.49	2.16	1.99	1.62	1.80	2.06	1.71	1.77	1.78	1.47	2.18	2.26	112.9	13.0	11 March	4 December.
Bega	50	33.47	39	3.63	3.52	3.98	2.23	2.46	3.34	2.38	2.96	2.19	2.49	2.62	3.17	109.6	20.0	18 April	16 October.
Berrigan	388	18.19	47	1.91	1.24	1.45	1.43	1.85	2.14	1.44	1.84	1.69	1.67	1.27	1.16	112.9	24.9	13 "	6 "
Berry	24	57.84	35	6.15	4.87	6.61	5.46	5.27	5.24	5.52	3.40	3.45	3.07	3.36	5.44	109.8	27.2	30 "	1 November.
Blayney	2844	29.51	26	2.85	1.67	2.81	1.84	2.06	3.36	2.84	3.05	2.49	2.58	1.96	2.95	104.0	25.5	1 February	17 December.
Bodalla	40	33.47	46	1.99	3.90	4.27	1.42	1.41	2.31	1.76	1.49	1.74	1.91	1.79	2.62	100.5	17.0	18 April	18 October.
Bombala	3001	26.22	37	2.54	1.92	2.25	1.81	1.41	2.31	1.76	1.49	1.74	1.91	1.79	2.62	100.5	17.0	6 January	24 December.
Bourke	361	14.01	19	1.48	1.67	1.26	1.19	1.08	1.21	.93	.85	.83	1.02	1.24	1.25	127.9	25.0	8 May	17 September.
Bowral	2171	37.35	37	3.87	2.82	4.27	2.82	2.92	3.62	3.76	2.61	2.16	2.39	2.50	2.59	104.9	16.9	2 January	15 October.
Bradwood	3157	27.32	44	2.81	2.63	2.47	2.18	2.11	2.42	2.01	1.88	1.84	1.93	2.10	2.59	104.9	16.9	16 March	18 October.
Breadwinna	430	15.51	47	1.98	1.64	1.51	1.69	1.08	1.60	1.69	.94	1.16	1.03	1.21	1.18	120.9	28.0	2 January	1 September.
Bundarra	2000	30.19	36	3.74	2.47	2.92	1.91	1.74	2.40	1.71	2.01	2.07	2.76	2.83	3.63	106.9	14.9	18 February	1 September.
Carcoar	2925	30.93	41	2.61	1.64	2.02	1.86	2.08	3.80	2.89	3.02	2.63	2.78	2.25	2.45	105.9	18.9	10 "	16 "
Casino	82	43.52	48	5.19	5.76	5.89	3.97	3.17	2.48	2.57	1.99	2.14	2.82	3.61	3.93	112.9	21.0	24 May	21 September.
Cassilis	1500	23.58	50	2.51	2.36	1.96	1.12	1.43	1.62	1.40	1.19	1.08	1.32	1.81	2.15	115.5	19.0	10 March	30 November.
Collarenebri	777	19.14	27	2.03	2.05	1.96	1.12	1.41	1.62	1.24	1.54	1.25	1.41	1.19	1.63	122.2	29.0	13 May	29 September.
Condobolin	700	19.14	41	1.80	1.30	1.47	1.41	1.43	1.62	1.24	1.54	1.25	1.41	1.19	1.63	122.2	29.0	26 April	12 October.
Coolamon	823	19.95	31	1.46	1.33	1.68	1.44	1.64	2.39	1.89	1.73	1.63	1.96	1.38	1.36	118.5	25.6	25 April	2 "
Coonamble	2617	19.10	56	2.21	2.06	1.97	1.26	1.25	1.42	1.93	.89	1.63	1.72	1.80	1.86	112.9	4.0	5 January	24 December.
Coonambidge	590	19.65	42	2.02	2.05	1.88	1.54	1.60	1.62	1.40	1.42	1.37	1.49	1.52	1.76	115.0	23.0	10 October.	10 October.
Coonamundra	1682	23.20	33	1.85	1.28	1.84	1.80	1.83	2.79	2.11	2.18	2.02	2.11	1.62	1.77	112.9	19.9	25 February	7 November.
Corowa	503	29.30	32	1.24	1.21	1.57	1.30	1.82	2.67	2.02	2.01	1.93	1.78	1.42	1.36	112.9	21.0	4 April	30 September.
Cowra	978	23.62	37	2.34	1.52	1.91	1.79	1.63	2.49	1.93	2.08	1.90	2.05	1.45	2.44	113.0	21.0	16 April	24 November.
Crookwell	2000	16.90	38	2.02	1.64	2.53	2.03	2.25	4.97	3.29	3.35	2.87	2.71	2.93	2.89	99.0	29.0	16 January	15 December.
Dentistown	311	46.30	62	1.91	1.69	1.39	1.35	1.68	1.86	1.28	1.44	1.65	1.51	1.15	1.15	116.5	16.9	23 March	6 October.
Dubbo	870	22.13	49	2.69	1.69	1.90	1.78	1.88	2.03	1.66	1.13	1.75	1.59	1.82	2.15	115.4	16.9	14 "	1 November.
Eden	107	34.16	50	3.33	3.21	3.41	2.82	3.26	3.34	2.63	2.73	2.38	2.71	2.47	2.63	106.0	29.3	Not reported	Not reported.
Forbes	781	19.84	46	1.72	1.54	1.57	1.59	1.66	1.89	1.55	1.76	1.75	1.73	1.32	1.76	111.9	23.0	6 May	10 October.

RAINFALL AND TEMPERATURE TABLE—continued.

District.	Altitude above sea level (ft.).	Average Annual Rainfall.	Number of Years' records.	Average Monthly Rainfall.												Extreme Temperatures.			Frosts.	
				Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Max.	Min.	Earliest recorded.	Latest recorded.	
Gilgandra ..	942	236.5	38	2.36	1.96	2.03	2.13	1.90	2.16	1.89	1.90	1.90	1.51	1.62	1.82	2.37	25.0	16 April	4 October.	
Glen Innes ..	331.8	41.83	40	4.33	3.90	2.95	1.64	1.81	2.42	1.90	1.96	2.04	2.98	2.98	3.04	3.77	14.4	6 Feb.	19 November.	
Goulburn ..	2697	24.84	57	2.65	2.28	2.19	1.70	1.85	2.00	1.68	1.84	2.05	2.85	2.18	2.05	3.36	114.0	19 Mar.	7 December.	
Grafton (2) ..	29	33.86	33	4.49	3.87	4.12	2.47	2.23	2.02	2.13	1.50	1.87	2.20	3.19	3.77	3.77	114.0	23 April	17 September.	
Grenfell ..	1238	24.24	36	2.07	1.66	1.91	1.74	1.82	2.73	2.26	2.01	2.07	1.97	1.97	1.54	2.25	109.0	14 "	14 October.	
Gunnedah ..	874	24.23	42	2.39	2.41	2.34	1.60	1.72	1.91	1.90	2.01	1.66	1.96	2.00	2.02	114.0	24.0	7 May	12 "	
Gulgong ..	1476	25.66	40	2.46	1.89	2.24	1.90	1.91	2.51	1.94	1.83	1.90	1.96	1.96	2.16	2.80	169.0	26.9	29 April	14 September.
Hay ..	310	14.26	41	3.85	3.65	3.06	1.07	1.48	1.75	1.18	1.40	1.33	1.19	1.02	1.98	117.3	22.9	9 May	24 October.	
Hobrook ..	858	37.97	37	1.68	1.53	2.04	1.86	2.30	3.78	2.96	2.73	2.53	2.37	2.58	2.67	3.33	107.6	13.4	1 April	29 "
Inverell ..	1980	30.46	47	3.79	2.80	2.92	1.90	2.10	2.34	2.91	1.95	2.07	2.58	2.67	3.33	107.6	13.4	11 March	6 November.	
Jerilderie ..	364	15.18	34	4.97	3.88	1.65	1.07	1.58	1.88	1.90	1.62	1.33	1.29	1.24	1.24	1.78	118.0	19.0	23 May	8 September.
Jerry's Plains	150	25.29	35	2.91	2.38	2.53	1.76	1.72	1.97	2.08	1.95	1.70	1.77	2.33	2.33	111.9	21.0	29 April	9 October.	
Kempsey ..	985	20.41	30	4.28	1.69	1.69	1.49	1.70	2.45	1.85	1.96	1.90	1.91	1.46	1.67	111.9	21.0	31 May	19 July	
Kiama ..	30	41.42	39	4.69	5.04	5.25	3.72	4.01	3.41	2.99	2.70	2.42	2.91	3.19	4.09	113.0	21.0	25 June	21 "	
Kiandra ..	4640	64.42	47	4.12	3.04	4.09	4.13	5.53	8.83	6.36	5.83	3.38	2.74	2.74	2.91	4.26	91.0	4.0	6 January	25 December.
Kurrajong Heights	1870	50.94	50	5.75	6.18	6.23	4.30	4.14	3.63	3.97	2.46	2.93	3.31	4.65	4.65	116.2	23.0	8 May	27 August.	
Lansnore ..	52	51.95	38	5.74	6.62	7.24	4.55	4.69	3.16	3.63	2.90	2.62	2.51	3.57	4.22	114.0	23.0	10 "	28 September.	
Manildra, West	1287	35.06	38	3.29	2.28	2.43	1.81	1.54	2.10	1.54	1.54	1.75	2.19	2.38	3.12	114.0	23.0	24 April	11 October.	
Manilla ..	57	61.74	37	1.74	2.34	2.17	2.22	2.22	2.93	2.26	1.62	2.22	2.23	1.99	2.58	3.02	19.0	1 "	6 November.	
Molong ..	680	33.63	42	2.69	2.76	2.61	1.39	1.79	2.00	1.45	1.42	1.48	1.91	1.97	2.25	117.3	18.0	19 January	12 October.	
Moree ..	55	34.93	46	3.69	3.29	4.13	3.12	2.80	3.04	2.45	1.99	2.74	2.65	2.36	2.67	114.8	22.6	29 May	13 September.	
Moruya Heads	2505	38.37	49	3.71	3.35	3.77	3.12	3.39	3.62	3.85	2.51	2.40	2.95	2.58	3.12	106.0	18.9	19 January	30 November.	
Moss Vale ..	1536	35.75	47	2.17	1.18	1.88	1.76	2.01	2.66	1.95	2.05	2.06	1.90	1.60	1.50	114.9	15.0	22 March	5 "	
Mudgee ..	1268	33.87	37	2.16	1.32	1.98	1.91	1.65	2.74	2.15	2.25	2.06	1.90	2.44	2.37	106.5	20.0	30 February	24 "	
Murrumbarrh	1345	31.21	50	2.98	2.79	2.50	2.14	2.11	3.12	2.45	2.61	2.30	2.44	3.25	4.41	5.48	19.0	8 May	5 October.	
Murrumbidgee	19	67.37	28	10.25	8.72	10.65	5.50	5.77	4.18	3.71	1.62	1.64	1.74	2.63	2.47	117.6	19.0	21 April	13 August.	
Muswellbrook	477	33.76	51	2.38	2.30	2.16	1.64	1.77	2.06	1.92	1.62	1.64	1.64	1.62	1.62	117.6	19.0	21 April	21 October.	
Narandera ..	41	1.37	1.13	1.41	1.29	1.52	2.05	1.38	1.39	1.41	1.61	1.40	1.52	1.52	1.52	114.9	21.0	20 "	16 "	
Narrabri ..	697	36.08	51	2.83	2.79	2.63	1.65	2.02	2.40	1.84	1.71	1.61	1.60	2.19	2.60	119.9	18.4	19 March	17 "	
Narramine ..	783	18.73	29	1.90	1.33	1.67	1.54	1.46	2.02	1.52	1.74	1.26	1.20	1.20	1.40	1.69	119.9	18.4	24 April	26 September.

RAINFALL AND TEMPERATURE TABLE—*continued*.

District.	Altitude above sea level (ft.).	Average Annual Rainfall.	Number of Years' records.	Average Monthly Rainfall.												Extreme Temperatures.		Frosts.	
				Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Max.	Min.	Earliest recorded.	Latest recorded.
Nyngan	581	16.79	39	1.96	1.87	1.50	1.38	1.32	1.15	1.34	1.90	1.00	1.18	1.72	101.0	29.5	— April	21 September.	
Orange	2543	35.25	50	2.16	2.45	2.62	2.43	2.32	4.39	3.22	3.51	3.00	2.69	3.70	101.0	29.5	19 January	16 December.	
Parkes	1065	20.72	32	1.70	1.29	1.84	1.65	2.19	1.80	1.92	1.70	1.59	1.31	1.95	109.0	27.0	28 April	2 October.	
Paramatta	49	36.93	55	3.52	3.68	4.17	3.12	2.98	2.94	3.49	2.22	2.15	2.38	2.42	169.0	56.8	3 May	30 September.	
Perth	89	29.88	55	2.80	2.42	2.83	2.57	2.52	1.90	3.33	1.89	1.39	1.10	2.39	114.9	19.7	15 April	18 October.	
Pietermaritzburg	562	30.65	42	3.38	2.49	3.56	2.90	2.30	2.32	2.56	1.74	1.82	2.32	2.14	114.9	19.7	11 May	23 September.	
Port Macquarie	44	59.93	60	5.72	6.94	6.34	6.03	6.09	4.46	4.33	3.56	3.95	3.41	3.77	106.9	23.9	6 June	5 August.	
Queensland	1899	22.49	51	2.27	1.72	2.11	1.57	1.63	1.96	1.40	1.39	1.32	1.14	2.09	109.4	18.8	18 January	25 December.	
Quirindi	1278	27.83	38	2.97	2.45	2.34	1.76	1.90	2.52	1.86	2.01	1.80	2.13	2.41	107.6	19.0	10 February	6 November.	
Richmond II. A. College.	73	30.25	41	3.36	2.77	3.51	2.38	2.37	2.58	2.37	1.91	1.83	2.01	2.38	113.0	21.0	15 April	1	
Scione	680	24.11	45	2.66	2.55	2.29	1.62	1.39	1.80	1.73	1.78	1.71	1.70	2.09	114.4	19.0	5 May	15 September.	
Singleton	135	28.16	39	2.79	2.54	3.22	2.25	1.35	2.27	2.42	1.63	1.90	2.05	2.45	113.9	22.0	24 April	18 October.	
Taree	968	27.39	41	2.86	2.49	2.19	1.84	1.79	3.37	1.79	1.94	2.18	2.29	2.70	109.0	20.0	24 April	29 September.	
Tamworth	30	45.28	38	4.51	5.06	4.98	4.28	3.33	3.19	3.35	2.61	2.33	2.62	3.02	111.9	25.0	24	Not reported.	
Temora	968	20.34	42	1.69	1.11	1.35	1.38	1.63	2.29	1.69	1.78	1.78	1.93	1.70	1.80	101.0	18.0	23 March	6 November.
Tenterfield	253	32.39	51	3.27	3.16	3.46	1.73	1.82	2.25	2.31	1.72	2.33	2.62	3.18	112.0	18.0	24 April	5 October.	
Tumut	923	29.71	49	3.19	2.39	2.41	2.17	2.32	4.19	3.19	3.18	2.89	2.79	1.98	106.0	19.0	19 January	26	
Uralla	3535	47.27	49	3.19	2.33	2.68	1.62	1.77	2.51	4.19	3.18	2.69	2.36	2.80	106.0	19.0	29 April	26	
Urana	400	47.27	48	1.94	1.36	1.43	1.19	1.83	1.43	1.35	1.33	1.34	1.27	1.11	112.0	28.0	29 April	11 October.	
Wagga	612	21.40	50	1.46	1.30	1.72	1.56	1.86	2.65	1.83	1.93	1.93	2.06	1.37	141.0	18.4	14 February	3 December.	
Walcha	3386	51.34	42	3.46	2.80	2.79	1.86	1.84	2.76	1.97	2.06	2.55	2.68	3.29	104.1	10.0	14 February	9 October.	
Walggett	436	18.36	43	2.14	2.65	1.54	1.40	1.66	1.62	1.33	1.69	1.57	1.50	1.70	122.2	23.2	22	Not reported.	
Warialda	1106	28.69	43	3.47	3.69	2.90	1.64	1.94	2.72	1.76	1.81	1.91	2.17	2.32	111.0	16.0	22	Not reported.	
Warren	645	33.91	52	1.98	1.78	1.65	1.70	1.45	1.71	1.43	1.63	1.12	1.46	1.35	111.0	16.0	22	Not reported.	
Wellington	965	23.01	40	2.02	1.51	1.80	1.68	1.94	2.58	1.92	1.92	1.72	1.82	1.94	112.0	23.3	9 April	1 November.	
Wentworth	1245	75.48	94	8.89	8.28	8.00	7.51	6.59	3.82	1.12	1.21	1.11	1.39	2.81	119.0	21.0	8 May	9 October.	
Werris Creek	36.63	30.63	51	2.92	3.50	3.28	2.56	2.46	2.51	2.01	2.92	1.63	1.93	2.35	107.5	30.0	18	28 September.	
Windsor	38	40.12	52	4.32	4.49	3.58	2.56	2.80	2.76	2.40	1.34	1.54	1.57	2.22	113.1	31.9	25 June	19 July.	
Woolongong	35	17.52	46	1.72	1.45	1.72	4.81	4.38	4.08	3.91	1.98	2.70	2.80	2.67	113.1	31.9	25 February	24 October.	
Wyabong	1374	33.14	51	1.63	1.44	1.11	1.61	1.61	1.37	1.98	1.35	1.42	1.11	1.32	106.0	21.0	25 March	24 November.	
Yass	1116	18.71	50	1.62	1.67	1.61	1.61	1.61	1.61	1.61	2.14	2.69	1.70	1.90	106.0	21.0	25	27 December.	
Young	1010	25.16	50	1.92	1.36	1.88	1.90	2.02	3.02	2.32	2.53	2.24	2.21	1.69	113.9	20.3	21	27	

THE SOILS OF NEW SOUTH WALES.*

The following notes on the characteristics of the soils typical of different districts of the State must be regarded as of a provisional nature. They are based on examination of a large number of soils from the different districts, in some cases forwarded by farmers, and in others collected by ourselves. The soils chosen have in all cases been virgin soils, with the exception of those carrying certain crops, such as lucerne, tobacco, &c., and those which exhibit any peculiar divergence from the type soil have been rejected, so that those on which the following notes are based may be regarded as typical ones. The work is now being carried on more systematically, and for some years one officer was engaged in a systematic collection and examination of soils representative both of different rock formations and also those typically suited to various crops, such as wheat, lucerne, &c. The following notes provide a fairly good idea of the general nature of many of the typical soils, their peculiarities and possibilities.

The table here given shows the average amount of plant food and some of the chief characteristics of some typical New South Wales soils.

TABLE showing Average Composition of Soils from Different Localities in New South Wales.

Locality of Soils.	Capacity for water.	Volatile matter.	Nitrogen.	Lime	Potash.	Phosphoric Acid.
1. County of Cumberland .. .. .	.....	7.4	0.14	0.12	0.10	0.12
2. County of Camden	49.7	11.2	0.23	0.11	0.10	0.17
3. County of Northumberland	45.3	8.0	0.19	0.12	0.10	0.10
4. Richmond River	52.0	16.0	0.30	0.21	0.08	0.3
5. Black Soil Plains	64.0	7.4	0.09	0.67	0.34	0.18
6. Semi-arid Districts	40.0	5.7	0.08	0.44	0.33	0.21
7. Hunter River.. .. .	40.0	6.6	0.12	0.20	0.10	0.10
8. South Coast (Eden District)	41.0	7.3	0.11	0.23	0.04	0.07
9. Myall Creek (Closer Settlement Area).	62.0	10.2	0.14	0.62	0.18	0.22
10. Dorrigo (Closer Settlement Area).. .. .	55.5	18.0	0.25	0.04	0.12	0.14
11. Murrumbidgee Irrigation Areas	40.0	6.5	0.04	0.60	0.45	0.15
12. Pilliga Scrub	34.4	4.0	0.07	0.25	0.09	0.07
13. Peel River Estate	52.5	8.9	0.13	0.77	0.26	0.13

* F. B. Guthrie, Chemist to the Department of Agriculture, New South Wales.

TABLE showing Average Composition of Soils—*continued.*

Locality of Soils.	Capacity for water.	Volatile matter.	Nitrogen.	Lime	Potash.	Phosphoric Acid.
14. Riverina	35.0	4.0	0.10	0.23	0.28	0.11
15. Typical wheat land (Riverina). (Loams to clayey loams.)	37.0	4.5	0.07	0.25	0.28	0.13
16. Typical lucerne land (Hunter River and South Coast). (Heavy loams to clayey loams.)	19.0	9.0	0.21	0.56	0.16	0.24
17. Typical vineyard soils (Albury and Hunter River). (Light sandy loams.)	32.3	5.1	0.15	0.07	0.07	0.13
18. Typical tobacco soils (Tumut) (Light loams.)	48.3	8.5	0.15	0.37	0.15	0.24
19. Typical Citrus soils (County Cumberland). (Friable loam.)	45.1	11.45	0.19	0.46	0.18	0.27
20. Typical granite soils (Loams.)	37.7	5.3	0.10	0.19	0.14	0.11
21. Typical basalt soils	48.0	8.0	0.17	0.56	0.08	0.11

COUNTY CUMBERLAND.

The rocks which form the county of Cumberland belong to what is known as the Hawkesbury series, and may be roughly divided into two portions, the first including those obtained from the area lying between Sydney and Penrith, east and west, and the Kurrajong and Picton, north and south, which rest upon, and are for the most part derived from Wianamatta shale; the second division, including those from the rest of the county of Cumberland, derived principally from the Hawkesbury sandstone. Both the formations from which the Cumberland soils are derived are remarkably poor in constituents suitable for plant-food; it is consequently not to be expected that the derived soils should be rich in fertilising ingredients. Of the ingredients of which the Hawkesbury sandstone is composed, felspar is the only one whose disintegration provides any lime or potash, and we should expect to find very little phosphates, these salts being quite unrepresented in the original rock.

The following analysis of Hawkesbury sandstone represents the average composition of this rock:—

ANALYSIS of Sandstone from Pymont—Representative of the Hawkesbury Sandstone.

Moisture at 100 deg. Cent.	45	Potash	28
Combined water	1.40	Soda	45
Silica	87.60	Phosphoric acid	trace
Alumina	8.53	Sulphuric acid	11
Ferric oxide .. .. .	.03	Chloride of sodium	trace
Ferrous oxide .. .. .	.10	Soluble silica... .. .	40
Manganous oxide	nil.		
Lime .. .. .	.60		100.24
Magnesia .. .. .	.29		

White clay in a very fine state of division is distributed through the sandstone.

The following analysis of a plastic, dark-coloured clay from Cook's River, may, perhaps, be taken as fairly representative of the clays of the Wianamatta shale formation:—

ANALYSIS of Clay from Cook's River—Representative of Wianamatta Shale.

Moisture at 100 deg. Cent. ...	1.47	Lime	absent
Combined water	7.29	Magnesia ... ..	.18
Silica	70.98	Alkalies	1.71
Alumina	18.12	Organic matter	trace
Ferric oxide ... ..	.25		
Manganous oxide	trace		100.00

AVERAGE percentage of fertilising ingredients in Cumberland soils.

	Lime.	Potash.	Phosphoric Acid.	Nitrogen
Average of virgin soils from Wianamatta shale ...	.136	.133	.096	.140
Average of virgin soil from Hawkesbury sandstone	.106	.066	.137	.133
Average of all virgin soils from Cumberland ...	.121	.099	.116	.136

The most striking differences in the two divisions of soils are the much larger proportions of lime and potash, notably potash, in the shale soils and the larger amount of phosphoric acid in the sandstone soils. The slight difference in the nitrogen contents is not in reality due to the nature of the rock, this constituent varying with the amount of organic matter and humus present in the soil, which averages 7.62 in the shale soils, and 7.22 in the sandstone ones.

Physical Characteristics.

The soils examined vary from almost pure sand to stiff clays, and these are fairly equally derived from both divisions of the county. They are, for the most part, deficient in humus, and their capacity for water is low, the soils from the sandstone formation being somewhat better off in this respect than the shale soils. The possession of this property is important in enabling the crop to resist the effects of a drought, and it depends chiefly upon the texture of the soil and its content of humus. It is greatest in soils rich in humus, marls (calcareous soils) coming next, clays, loams, and sandy soils being lowest.

With these exceptions, which are due to deficiency in lime and humus, the physical nature of our soils does not present any feature of particular note.

Defects due to want of Lime.

As has been pointed out above, want of lime is the most serious defect in these soils, and in quite seven cases out of ten of the soils examined, the advisability of liming is strongly insisted upon.

The most apparent result of deficiency in lime is the tendency to sourness. If not actually sour, practically all the soils in this county have a strong tendency to become so after a short time. This may be due in some cases to deficient drainage, but it is also evident in well-drained soils, and in dry weather, and does not appear to be much improved by cultivation as it is usually practised.

General Treatment.

Speaking generally, the defects to be remedied in these soils are sourness, lack of humus, and poverty of plant-food. The remedies for these defects are the following:—

Cultivation.—Deep and frequent cultivation is one of the most important means of ensuring good texture and of sweetening the soil. Its object is to disturb the surface soil, partly to ensure aeration, partly to enable it to absorb rain, and partly to bring it into such a condition that it will draw up water and keep it in circulation. A well-cultivated soil is in a better condition to withstand drought than one where the surface has been allowed to become hard and compact.

Drainage.—The question of drainage is one that must be decided in each instance by the individual conditions. So much has been written on this subject, and the matter has been so well and practically treated of, that I shall not attempt to do more than insist upon its importance in maintaining the texture of the soil. In the case of orchards the best results are practically out of the question unless the land is suitably drained, unless it happens that the natural drainage is sufficient.

Liming is the most important operation on the soils of County Cumberland. They are naturally, as has been several times insisted upon, remarkably deficient in lime, and exhibit all the defects due to this deficiency. Of these, sourness is the most apparent, and perhaps the most disastrous. Now, also, that our farmers have awakened to the importance of using artificial fertilisers, it is important that this fact should not be lost sight of, since a good deal of disappointment has resulted in using fertilisers which are themselves acid, such as superphosphates or mixed fertilisers containing superphosphates, on soil which is itself often quite strongly acid (sour). A previous treatment with lime, or mixing lime with such a fertiliser (provided it contains no ammonium salts), is essential if the manure is to exert its full benefit. For such sour soils the best phosphatic fertiliser is probably Thomas slag, a manure which only requires to be more cheaply obtainable to be largely used.

Green Manuring.—The importance of green manuring and the principles underlying its beneficial action are more fully discussed on page 73.

Too little attention is paid to it in this State, where the soils are on the whole poor in humus, and where farmyard manure is so difficult to obtain. For reasons which will be discussed subsequently, green manuring, besides providing humus and thus improving the texture of the soil and rendering it more suited to withstand drought, possess the additional advantage, if leguminous crops are employed, of enriching the soil in nitrogenous matter, an essential fertiliser, and the most expensive to obtain.

It is, then, by more thorough methods of cultivation, by effective draining, by liming and green manuring, that the fertility of our Cumberland soils may be increased.

By fertility is understood not the actual richness in plant-food, but that condition of the soil which enables the plant-food present to be utilised to the best advantage, and in which any manures added may be most effective.

Of course it may not be necessary to carry out all the operations above mentioned. In some soils nothing may be required to bring them into good condition but deep cultivation, in others a dressing of lime may be sufficient; there are others whose only defect is want of humus; but the principal defects in our Cumberland soils, in addition to their poverty of plant-food.

are want of lime, tendency to sourness, and deficiency in humus, and where all these defects occur in the same soil it may be necessary to have recourse to all the above plans for ameliorating it.

The above remarks apply only to the treatment of the soil preparatory to manuring. The question of the proper manure to apply, and the quantities, depends upon the crop it is required to grow and not upon the soil. But in order to obtain the full benefit from the use of fertilisers it is necessary first that the land should be in good condition.

COUNTY CAMDEN.

The soils of County Camden are for the most part derived from the Hawkesbury sandstone, which forms the country rock over most of the county. To the north of Picton, Wianamatta shale is the prevailing formation, and more or less extensive outcrops of volcanic rocks, chiefly basic, occur in different parts.

Thus the soils about Bowral and Mittagong, Exeter, Wingello, and a few other places are frequently of volcanic origin.

In the south-east portion of the county and more or less along the coast are the Bulli coal measures. Only a few soils, however, have been received for examination which can be regarded as having been derived from Permo-Carboniferous rocks, and these will not be included in the summary.

By far the largest number of the soils examined have been derived from Hawkesbury sandstone, and the following table gives the average chemical composition of such a soil calculated from a large number of soils examined from different parts of County Camden, excluding those derived from volcanic areas or from the coal measures:—

AVERAGE Composition of Virgin Soils from County Camden.

Nature of soil ... ..	...	...	Light sandy loam to clay loam.
Reaction of soil ... ..	..	..	Neutral to strongly acid. (42 per cent. of the soils examined were strongly acid.)
Capacity for water	=	49.73	per cent.
Organic matter	=	11.23	„
Lime	=	.113	„
Potash	=	.102	„
Phosphoric acid	=	.171	„
Nitrogen	=	.231	„

As might have been expected, the soils are very similar to those of County Cumberland derived from the Hawkesbury sandstone, the Camden soils being as a rule better supplied with humus than the Cumberland ones, and possessing consequently more nitrogen and a higher capacity for retaining water. In lime, potash, and phosphates they are also slightly but consistently higher, and, generally speaking, are more fertile soils.

General Treatment.

With regard to the treatment which will bring the land into the best condition and increase its natural fertility, much the same remarks apply as in the case of the Cumberland soils. The first essential is the addition of lime, in which this type of soil is deficient, and the addition of which, besides supplying this ingredient, counteracts the acidity of sour soils, renders certain mineral food-stuff soluble, improves the texture of the soils, and promotes nitrification.

Proper cultivation and drainage are, of course, essential to the maintenance of a fertile soil. Green manuring, in order to supply humus and nitrogenous matter, is also important. The soil-humus is one of the most important ingredients in the soil, not on account of the plant-food it contains, but on account of the way it modifies the texture of the soil, and particularly for the resistance it offers to the evaporation of moisture from the surface—a property of incalculable value in a climate like our own, subject to protracted dry spells. In countries where a more intensive system of farming is carried on this organic material is supplied by means of the straw or litter in the farmyard manure, 10 to 15 tons of manure being an average dressing.

RICHMOND RIVER SOILS.

The virgin soils from this neighbourhood possess certain rather striking features in common, and a sufficient number have been examined to render it possible to strike an average which shall fairly represent a soil typical of the area, which has become one of the principal dairying centres of the State.

The soils under discussion have been taken, for the most part, from the area on the northern side of the river, and are of volcanic origin, mostly overlying basalt, and derived therefrom.

From the analyses of a considerable number of virgin soils from this locality we are able to give the following as the composition of an average soil. They are remarkably uniform in their chemical composition, and vary but little from the average here given:—

COMPOSITION of an average Soil of Volcanic Origin from Richmond River.

Capacity for water	...	...	...	...	=	52	per cent.
Organic matter (humus)	...	...	...	...	=	16	„
Lime	...	...	...	...	=	0.21	„
Potash	...	...	...	...	=	0.08	„
Phosphoric acid	...	...	...	...	=	0.30	„
Nitrogen	...	...	...	...	=	0.30	„

Reaction—Neutral to acid.

The soils vary from light sandy loams to heavy loams, the heavy soils predominating. They are in nearly all cases well supplied with vegetable matter (humus).

Associated with this high humus-content (often over 20 per cent.) are a high percentage of nitrogen and a high capacity for absorbing and retaining water. This latter property is in the highest degree indicative of fertility, soils of this nature being open, readily worked, and favourable to the development of nitrification. The soils examined from this neighbourhood are all exceedingly active, and produce nitrates abundantly. They are also better able to resist dry spells than soils deficient in humus and with a low capacity for retaining water, as the surface evaporation is reduced to a minimum.

With regard to the mineral fertilising constituents, the soils under consideration are uniformly well supplied with phosphates, but poor in lime and potash; and it is in the direction of supplying these ingredients that particular attention must be paid when manuring. The absence of lime, combined with the high proportion of vegetable matter, tends to the production of acidity in these soils; and of the samples examined a large proportion are sour in character.

Speaking generally, they are typically fertile soils, in good mechanical condition, and should provide good pasture, for which purpose they are eminently suitable. There should be no difficulty in raising good crops of every kind suited to the district.

SOILS OF THE BLACK-SOIL PLAINS.

An extensive and typical area of black-soil plain country is that occurring in the north-western portion of the State, in the country watered by the Barwon and its tributaries, the Gwydir, Namoi, and Castlereagh, and lying roughly within a circle bounded by Coonamble, Inverell, Moree, Collarenebri, and Walgett.

These soils are probably of alluvial origin and include some of the richest grazing land in the State. A glance at the tabulated analyses will show that they possess certain well-defined characteristics in common which distinguish them from the soils met with in any other part of New South Wales.

None of them differ in any important particular from the average soil obtained by calculation. Those examined are all either virgin or grazing country.

They are stiff clayey soils, of low capillary power, and highly retentive of water, becoming very sticky when wet, and very hard and cracked when dry. They are not, as a rule, rich in vegetable matter, though their black colour is an indication of the presence of humus. Whether this black colour is due to a peculiar condition of the humus present or to the condition of the iron-salts is a matter for further examination. The nitrogen content is invariably low, but they are very rich in mineral plant-food, particularly lime and potash, and are extremely fertile soils. Even a superficial observation of the nature of the native timbers and the luxuriance of the herbage after rain affords sufficiently convincing proof of their fertility.

They are also deep soils, often of considerable depth, so that they are not likely to be readily exhausted.

From their mechanical constitution they are to be classed as wheat lands. From an agricultural point of view, their principal drawback is the initial difficulty of getting them into good tilth, as, owing to their extreme stickiness when wet, and to their caking hard when dry, tillage operations are always difficult, and, except at the most favourable time—when they are in the right condition as to moisture—ploughing is practically impossible. Once broken up, the surface becomes friable on exposure to air, and their future cultivation presents no difficulties. They are very commonly slightly alkaline in nature, but not sufficiently so to cause any trouble. They are not alkaline soils in the sense of the alkali plains of the Western States of America, which have presented so serious an obstacle to cultivation.

In discussing the question of the use of bore water on these soils, however, this fact must not be lost sight of, as the use of this water for any length of time will, undoubtedly, tend to exaggerate the defects already noticed, namely, their alkalinity, their deficiency in humus, and the sticky nature of the soil when wet, and its tendency to harden and crack when dry. Indeed, the peculiarities are just what one would expect if the soil had been subjected for a length of time to the action of alkaline bore-water.

Locality.	Colour.	Nature of Soil.	Reaction.	Capacity for Water.	Mechanical Analysis.							Chemical Analysis.				
					Root.	Stones.	Coarse Gravel.	Fine Gravel.	Sand.	Clay.	Moisture.	Volatile Matter.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
1. Coonamble	Black	Clay	Slightly acid	77	none	none	none	880	15700	7620	3746	730	116	329	295	178
2. Wee Wee	Black	Heavy loam	Neutral	50	0	0	0.33	333	4691	4883	308	873	132	488	463	187
3. Narrabri	Dark	Loam	Neutral	48	0	0	none	080	1530	5790	683	634	698	725	192	237
4. Inverell	Black	Heavy loam	Neutral	62.6	0.08	0	0.33	108	3266	6785	751	1033	111	160	152	128
5. Myall Creek	Black	Clay	Slightly acid	72	none	0	none	146	1760	8094	1050	1071	126	823	158	380
6. Moree	Black	Very stiff clay	Alkaline	89.5	0	1.06	1.24	656	1190	8011	117	585	671	769	189	986
7. Moree	Black	Clay	Slightly alkaline	63	0	none	0.66	756	1333	7835	970	610	663	640	387	971
8. Moree (cultivated)	Black	Clay	Slightly alkaline	59	0	0	0.93	940	1890	7137	813	529	665	760	350	991
9. Collaredabri	Black	Heavy loam	Alkaline	53.6	0	0	0.25	683	3530	6332	569	617	650	1000	550	940
Average	Black	Heavy loam to clay	Slightly acid to alkaline.	64	0	0	0.3	44	25.5	69.8	670	7.4	689	666	337	179

Geological Notes on the Black-soil Plains.

With regard to the origin and general geological features of black-soil plains, a few notes may be of interest. Black soils may be divided broadly into four classes, namely—(a) Peaty black soils, (b) basaltic black soils, (c) alluvial black soils, (d) black limestone soils. These classes are not sharply differentiated, but intermediate varieties occur.

(a) The peaty black soil occurs in swamps, and owes its dark colour essentially to the presence of organic matter. If such a soil occurs in a sandstone area it may consist almost wholly of quartz sand (silica), and carbonaceous material. On ignition it will, in such a case, become light grey or white in colour. If the soil occurs in any formation abounding in iron-bearing minerals it will, of course, take a red colour on burning.

(b) Basaltic black soils occur on basaltic plains and tablelands, and often cover very extensive areas, as on the Darling Downs of Queensland, and on the Liverpool Plains of New South Wales. The presence of an abundance of lime-bearing minerals in the parent rock has, probably, much to do with the formation of the black colour, since the lime is readily liberated on the weathering of the rock, and its presence in the soil as carbonate would favour nitrification and accelerate plant growth, and the humus formed by decaying vegetation partly tends to blacken the soil in itself, and partly acts so as to reduce iron oxide to the black ferroso-ferric condition (magnetite), and also so as to form black organic salts with iron. Generally basaltic soils tend to possess a brownish colour on hillsides, and a black colour on flats and in valleys, where vegetation is more luxuriant.

(c) Alluvial black soils, comprising those here tabulated and discussed, known in the west as river country, are generally formed of sediments carried hundreds of miles by rivers from various geological formations. Their black colour is probably due to the same cause as in the case of basaltic soils. They differ from the latter in being more loamy in character, and more pervious to water.

West of the Warrumbungle Mountains, at Tundebrine, Tooraweenah, Tenandra, &c., and west of the Nandewar Mountains, near Narrabri, at Maule's Creek, Spring Creek, Bobbiwaa Creek, &c., occur miniature black-soil plains, whose black soils belong to a type intermediate between (b) and (c), although in general appearance and in flora they are very like the typical alluvials (river country) of the Namoi and Castlereagh. These soils are composed mainly of volcanic detritus, which has *not formed* by the decomposition of volcanic rock *in situ*, but which has been carried there by streams from the adjoining volcanic mountains.

(d) Limestone formations are also not infrequently covered with black soil, the colour of which may be due to the causes already mentioned.

In addition to the four classes mentioned, the soils on diorite and gabbro formations are also frequently black loams. They are like the basalt soils—brownish on the hills, becoming black on plains and in valleys, and differ only from basaltic soils in being less clayey.

SOILS FROM THE SEMI-ARID REGION.

In the table on page 34 is given the general characteristics of an average soil (No. 6) from this area, which includes a large portion of the present and the potential wheat-growing area of the State. In the following table the nature of these soils is set forth in more detail.

COMPOSITION OF SOME TYPICAL SOILS FROM THE SEMI-ARID PARTS OF NEW SOUTH WALES.

Locality.	Nature of Soil.	Reaction.	Capacity for Water.	Mechanical Analysis.						Moisture.	Volatile Matter.	Nitrogen.	Soluble in Hydrochloric Acid.		
				Root Fibres.	Stones.	Coarse Gravel.	Fine Gravel.	Sand.	Clay.				Time.	Phosph. Acid.	
Collarendabri	Loam, red-brown	Alkaline	42.6	none	none	none	1.50	57.13	41.37	1.38	6.23	.07	1.15	.57	.19
"	Heavy black loam	"	53.6	"	"	0.25	0.83	35.00	63.32	5.69	6.17	.05	1.00	.55	.04
Menindee (Darling)	Light sandy loam, red	"	21.0	0.04	"	none	7.29	80.54	12.13	0.28	3.44	.04	.23	.29	.28
Moree District	Sandy loam	Slight alkaline	46.0	0.08	"	4.33	7.66	68.54	19.39	4.46	5.31	.07	1.08	.17	.22
Tenandra Bore (average of four soils) .. .. .	.....	Vary from alkali- line to acid.	.....	.....	.....	.....	.....	.....	.....	0.81	5.71	.05	.37	.20	.17
Wantagoong (Nielholson), Lachlan River	Light sandy loam	Acid	28.6	none	none	none	13.15	73.70	12.85	1.93	3.63	.06	.08	.23	.17
Mungindi (Queensland Border)	Chocolate loam	Neutral	46.0	0.04	0.66	0.79	0.83	53.87	13.81	3.56	5.07	.09	.27	.19	.12
Carinda Bore	Light sandy loam	Acid	30.0	0.08	none	one	8.33	74.33	17.24	0.61	3.80	.09	.08	.32	.19
"	Black loam	"	37.5	0.08	"	3.66	3.75	62.12	30.39	1.46	6.63	.10	.07	.29	.30
"	Red loam	Slight alkaline	41.0	0.04	"	0.20	0.41	60.51	32.81	2.39	7.56	.12	.11	.64	.21
Coolabah	Light sandy loam	Neutral	33.0	0.08	"	1.16	9.29	77.25	12.22	2.05	3.56	.01	.13	.23	.22
Alluvial Flats, Bogan River, Coolabah	Light loam	Alkaline	47.0	none	"	1.08	2.50	67.49	28.93	5.31	6.59	.05	.85	.54	.33
Parish Elsmore, County Cunningham, near Condobolin	" colour varies	Acid	40.6	0.16	"	0.25	4.00	66.12	29.47	2.32	6.39	.09	.25	.27	.24
"	Loam, colour varies	"	45.6	0.25	"	0.41	2.91	60.91	35.42	3.17	8.07	.15	.21	.27	.24
Pera Bore	Light sandy loam, red	Very slight alkali- line.	28.3	0.12	"	0.12	0.91	73.94	19.81	3.21	3.94	.03	.13	.36	.25
Eagrowa, Ashburnham (near Parkes)	" loam, red	Acid	37.3	0.04	"	0.87	12.91	61.33	24.85	2.98	5.77	.07	.22	.26	.17
Mingelo (near Parkes)	" gravelly loam, red	Very slight alkali- line.	41.3	none	1.66	14.41	6.25	50.20	21.48	1.79	8.70	.15	.70	.37	.43
"	" loam, red	Slight acid	30.0	"	3.33	1.75	4.58	69.79	20.55	0.60	4.61	.13	.14	.11	.10
Brewarrina	Red loam	" alkaline	50.5	"	none	none	2.33	56.97	40.70	7.65	6.40	.07	1.02	.40	.15

Humus.

In the first place is to be remarked the deficient amount of humus matter. The absence of moisture is equally noticeable, but although the comparative figures given probably represent very nearly the proportionate amounts as compared with other soils, the individual figures are not altogether trustworthy, since the amount found in the soil on arrival in the laboratory is by no means always an indication of its condition *in situ*. The soils were, however, invariably dry, and the average probably very nearly represents the average contents of the soils if determined on the spot. The humus deficiency is, however, a definite one, and has to be taken seriously into account in any scheme for the improvement of these soils. It is due, of course, to the absence of moisture and the burning action of the sun. Moisture is necessary for the decay of vegetable matter. This defect will be remedied by irrigation; firstly, by deposition of the silt which is carried in suspension by even the clearest river water, and which contains a certain amount of organic matter; and, secondly, by supplying the necessary moisture to enable the decay of vegetable matter to proceed.

Capacity for Water.

The next point of importance is the capacity of these soils for water, that is to say, their water-retaining power. These figures represent the percentage amount of water which the soil is capable of holding. This property depends partly upon the amount of humus present, which has a very high capacity for holding water, and partly upon the mechanical condition of the soil, the relative proportions of coarse and fine sand and clay. It is noticeable that the light sandy loams (those soils in which the amount of clay does not exceed 12 or 15 per cent.), have a very low retentive power for water. The average of these soils is, however, about the same as it is for similiar light sandy loams in other parts of the State. This is true, also, of the soils in which the clay content is higher—in the loams and heavy loams. With the increase in decayed vegetable matter, which will be one of the results of irrigation, this retentive power for water will be considerably improved. This is exemplified in the case of the soils from the Richmond River and other places, where the increased humus content has increased the water-holding capacity of the soil enormously, although the proportions of sand and clay are, on the average, the same as in our western soils. This characteristic of the soil to absorb and to retain moisture is one of the very greatest importance in determining their fertility; and although the average of the soils examined from the semi-arid regions is lower in this regard than the average of soils from other parts of the State, it must be borne in mind that these soils are for the most part sandy soils, and only fairly comparable with similar sandy soils from other parts.

The average water-holding capacity of the loams and heavy loams will be found to be quite as high as that of the same class of soils from other places. It is, I think, a matter of congratulation that we are able to assure ourselves that in this important particular the soils in our drier districts are in no way inferior to those of more favoured regions.

Mineral Plant-food.

A second very striking peculiarity in these soils is the large amount of mineral plant-food present. It will be seen, on comparing them with the County of Cumberland soils, for example, that they contain about three times the amount of lime and potash, and twice as much phosphoric acid.

This is, of course, largely to be attributed to the absence of water, which, in more humid regions, carries away a considerable proportion of saline matter into the subsoil. To show that these peculiarities are not abnormal, and that they correspond with what has been observed elsewhere, I quote some figures given by the late F. H. King, Professor of Agricultural Physics at the University of Wisconsin, in his book on "The Soil," contrasting the chemical nature of arid and humid soils. The figures are taken from analyses of Hilgard:—

COMPARISON of Soils from Humid and Arid Regions of the United States.
(From F. H. King, "The Soil.")

	Humus.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
Soils from humid regions	3.04	.13	.11	.22	.11
Soils from arid regions	0.75	.10	1.36	.73	.12

In these figures it will be seen that the difference between the amounts of mineral plant-food are even more strongly marked than is the case with the figures dealing with our own soils. The explanation given by Professor King is the same as I have suggested, namely, "that sufficient water falls for the decomposition of the rock and the formation of alkalis and of zeolitic mineral" (zeolites are soluble in hydrochloric acid), "but not enough to remove these when formed, as is the case in humid regions." The fact that these soils are richer in mineral plant-food is one of considerable importance in relation to their fertility, though it must be remembered that richness in plant-food is only one of the elements of fertility, and that this property alone is not sufficient to render a soil fertile.

Humus in American Soils.

A much more striking difference between our soils and those of similar soils in the United States, as examined by Hilgard, is the relatively large amount of organic matter as compared with the "humus" shown in Hilgard's analyses. It must be explained that the organic or volatile matter in our analyses is not strictly humus only, but includes unchanged vegetable matter, small root-fibres, and so forth, which are sometimes present in these soils in considerable quantities. It also includes water of combination and carbonic acid. The true humus—that is, the decayed vegetable matter—is certainly much smaller in amount, and the very striking peculiarity has been pointed out by Hilgard that the humus in arid regions is very much richer in nitrogen than is the case with the humus in moist regions. So much is this the case that the nitrogen in the humus in arid regions rises as high as 15 per cent., or about three times the amount present in the humus of humid regions, which is about 5 per cent.

Powdery condition of the soil when dry.

A third striking characteristic of these soils, and one not shown in the tables, is their peculiar powdery condition when dry. Everybody who has been in the districts referred to is aware that the surface soil over large areas is often carried away by the wind in the form of a fine dust, which is deposited against outstanding obstacles, or, if unobstructed, is carried enormous distances, to be ultimately deposited when the wind subsides, or carried down in the form of mud by a shower of rain. This phenomenon is noticeable in all

arid regions, and Hilgard attributes it to the larger content of lime which these soils contain. It is well known that the addition of lime to clay renders the clay pulverulent and incoherent on drying. There are, however, reasons which make it difficult to accept this as a complete explanation of the cause of the incoherent nature of our soils. In the first place the quantity of lime, though larger than in the case of the soils from the more humid parts of the State, is not by any means excessive, and it is only exceptionally that they contain as much as is found in the average of the soils examined by Hilgard. In connection with this matter, some experiments were made in our laboratory in regard to the behaviour on drying of clay soils mixed with different quantities of lime. It was found that a clay soil containing 53 per cent. lime (an amount above the average in our soils) when moistened and subsequently dried, became quite hard—as hard as clay which contained no lime—and that the addition of 1.5 per cent., making 2 per cent., in all (an amount which is above the average of the soils quoted by Hilgard), had very little effect indeed upon the texture of the soil when dried. It required the addition of at least 3 per cent. (about 15 tons per acre 1 foot deep) to reduce the soil when dry to the crumbly condition characteristic of the soils of this region. It would seem, therefore, that some other causes, probably the absence of humus, operates in addition to bring about this state of things. This is a subject that will repay further investigation.

Nitrification in soils from arid regions.

The nitrifying power of the soil is one of the most, if not the most, important index of its fertility, since not only does a vigorous nitrifying power ensure to the plant sufficient nitrates, which are essential to its proper development, but the conditions which promote nitrification, namely, aeration, moisture, and warmth, are exactly those which make for fertility.

Nitrifying organisms appear to be present in the soils examined from all parts of the State, with the exception of swamp-soils on which water has lain for some period, and of extremely sandy soils. Sourness of the soil is detrimental to their growth, and, what is of special interest to our purpose, dryness of the soil affects the vitality of these organisms very strongly. In dry soils, such as are met with in the region we are discussing, their vitality is considerably affected, and their development, when placed under favourable conditions, is very slow. When they have once started to develop, however, their further growth proceeds fairly rapidly. It would appear that dry conditions, though they do not actually destroy the nitrifying organisms reduce them to a dormant condition.

The beneficial effects of irrigation were strongly marked in some samples from rice-fields near Bangkok. These were received in small, hermetically-sealed tins, and were quite moist on arrival. The nitrifying organism was present in large quantity, and its development was extraordinarily rapid.

Excessive heat has, of course, also a detrimental effect upon these organisms, and both excessive heat and want of moisture are conditions which prevail in the class of soil under discussion. Hence these soils are characterised by the slowness with which the nitrifying process takes place; but although the vitality of these organisms is impaired; or their condition modified, to the extent that their development is exceedingly slow, in no case are they absent, and when once they commence to develop, the development continues at a normally rapid rate. The conditions which favour their development within the soil, namely, aeration, moisture, and equable temperature, are conditions which will result from properly conducted irrigation. Similarly, the nitrogen-

assimilating organisms which occur in the root-nodules of certain plants depend, of course, upon the vigorous growth of these plants, and, without irrigation, it appears hopeless to attempt to grow leguminous plants in these districts.

Prevention of Loss of Water from Soil.

Even in the absence of irrigation a great deal can be done to ameliorate the conditions of farming in the dry districts. There are large areas in the State where it is out of the question to establish irrigation works—at all events, for many years to come. It then becomes a question of conserving within the soil the moisture present in the soil, and to counteract the continual loss of water which evaporates from the leaves of the plants and from the surface. The planting of belts of trees to break the force of the winds is a very important operation in this connection, since evaporation from both leaves and soil is greatly accelerated by the passage of hot wind over the land. Mulching of the surface soil, liming, thorough tillage, and a proper system of drainage are all operations which result in the production of a fine spongy texture in the soil, increasing its water-holding capacity and reducing the amount of surface evaporation.

The Value of Irrigation.

There is no room for doubt that the soils of our arid districts are admirably adapted for cultivation by means of irrigation; abundance of water, properly applied, being the only thing necessary to render them extraordinarily fertile.

Irrigation fertilises.

Irrigation is of value also on account of its direct fertilising effect, since all water contains more or less saline matter in solution, which is retained by the soil, and acts as plant-food.

Saline Waters.

There are, however, certain waters which contain substances which in quantity are injurious to plant-life, and such waters must be employed with caution. The most commonly occurring of these substances, as far as we are concerned, are common salt and carbonate of soda. These salts have an injurious effect both upon the plant and upon the soil.

We have found by direct experiments in pots that the growth of wheat is affected by quantities as low as .05 per cent. to .15 per cent. of common salt, whilst .2 per cent. prevented germination.*

Carborate of soda (alkali) affects the growth of the plant when present to the extent of .1 per cent.; .3 per cent. prevents germination and growth.

Our own observations on soils which had become charged with alkali from continuous flooding without efficient drainage or correctives, show that such soils are very rich in mineral plant-food, notably in potash, but deficient in humus and in nitrogenous matter. Their capacity for water is reduced. The soils become hard—so hard that some of the samples had to be taken by means of a crowbar. The tendency of continued irrigation with alkaline water is to destroy the organic matter, the soil becoming cemented together so as to render tillage operations difficult, and finally impossible.

A knowledge of the behaviour of these salts is of importance in view of the fact that a large proportion of the water from New South Wales artesian bores is charged with one or other of them.

*F. B. Guthrie and R. Helms—Journ. Roy. Soc. N. S. Wales, XXXVI, p. 191.

The continued use of such water, if allowed to lie on the land, would in course of time prove detrimental, and soils have been examined where the land has been thus flooded without drainage, or any attempt to correct the alkali present, which have shown as much as .9 per cent. alkali, and exhibit all the peculiarities described by American writers as characterising their alkali deserts.

Speaking generally, if this kind of water has to be used, it should be employed with judgment, and care should be taken in the selection of such crops as are most capable of resisting the action of these salts. This, combined with a system of drainage wherever practicable, good tillage, and the use in some cases of substances known to correct the alkali, such as gypsum on the soil or in the water, will probably enable such water to be utilised with advantage on these soils.

Lucerne Soils.

The soils from which the average given in the table on page 33 has been calculated are from the Hunter River district (Maitland and Branxton), from the South Coast (Shoalhaven River Flats, near Nowra, Milton, and Tilba Tilba), and from Bathurst.

They are all good lucerne country on which this crop is successfully cultivated, and may be taken as being representative of the best lucerne land in the State. They are friable clay soils, some containing as much as 80 to 90 per cent. clay, the lowest having 60 per cent. At the same time lucerne can be profitably cultivated on lighter soils, and if irrigation is practised, a much lighter soil is preferable. They are fairly rich in mineral plant-food, particularly in lime, an ingredient which is of the first importance in lucerne-growing. It will be noticed that although the percentage of organic matter (humus) is not particularly high (it is low compared with the soils from Dorrigo and Richmond River) the nitrogen content is good. This is largely due to the faculty possessed by lucerne, in common with other leguminous crops, of obtaining its nitrogen directly from the air, and thus actually enriching the soil in this ingredient.

The growth of lucerne depends less upon the physical and chemical nature of the soil than upon the presence of moisture and room for the development of the root system. The root system of a good, well-established lucerne plant is enormous, and has been traced to a depth of over 30 feet.

The most satisfactory position is, therefore, along watercourses, or on the banks of rivers and creeks, where the roots can extend freely downwards to the water.

In such situations fairly heavy rich soils give the best results, provided they are friable and contain a sufficiency of lime. Under irrigation, as has been said, it will do well in much lighter, even sandy soils.

Wheat Soils.

The soils taken as typical of wheat land (page 35) are from the Riverina district. There is no striking peculiarity about their chemical composition, and they are very similar to other soil samples taken from the Riverina. They are generally fairly heavy loams to clay loams. The most suitable soil for wheat under our climatic conditions, is a free loam overlying a clayey subsoil. Such a soil is easily worked, while the stiff subsoil retains the moisture. Wheat does not require heavy manuring. The usual practice of applying a small quantity of superphosphate with the seed is a sufficient

manuring for the first few years. The extensive use of soluble nitrogenous fertilisers, such as nitrate or sulphate of ammonia, is unnecessary under our conditions, for reasons which are discussed more fully under the heading "The Use of Superphosphates in Manuring Wheat" in another part of this publication. (Page 84, *et seq.*)

Tobacco Soils.

Tobacco is generally regarded as a very exhausting crop, requiring rich land and heavy manuring. The crop itself, as a matter of fact, makes very little more demand upon the land than root crops, such as mangels or turnips, but, from the fact that it occupies the ground for only a short time, it is necessary that it should be provided with plenty of readily-soluble plant food.

A light friable loam, well supplied with lime, and of good water-holding capacity, is the best kind of soil for tobacco. The soils averaged in the table on page 35 are from the Tumut neighbourhood, and are soils which give good results with tobacco. They compare favourably with tobacco-soils from Fiji, the average of a number of which is given below for the sake of comparison.

	Capacity for water	Volatile matter.	Nitrogen.	Lime.	Potash.	Phosphoric Acid.
Typical tobacco soil from Fiji ...	54.2	7.0	0.18	1.34	0.27	0.30
Tumut tobacco soils	48.3	8.5	0.15	0.37	0.15	0.24

Though not as rich as the Fiji soils, it will be seen that with the exception of lime and potash they approach very close to these, and they are of similar mechanical nature and texture, being light friable loam, with a fairly high water-holding capacity.

Vineyard Soils.

The soils taken for the calculation of the typical soil (page 35) for the production of wine are from the principal wine-producing districts of the State—Albury and Hunter River districts. They indicate fairly the characteristics of the kind of soil most suitable for the production of the lighter kinds of wine, and are light loams to light sandy loams, fairly deep and well drained, and easily worked. Heavier soils are more productive of the fuller-bodied type of wine, and are said to be liable to impart a heavy and "earthy" flavour to the wine.

Calcareous soils—soils rich in lime—are particularly regarded in Europe as productive of the best class of wine, and in this respect soils from Hunter River and Albury are exceptional, being deficient in that ingredient, and its application either in the form of freshly slaked or powdered lime or of gypsum will improve the vintage in these districts.

Citrus Soils.

The soils from which the average is calculated (page 35) were collected and examined by Dr. Jensen from a number of good orchards in County Cumberland, between Hornsby and Baulkham Hills. These may be taken as fairly representing the kind of soil suited to citrus fruits. Their present condition is the result of manuring and cultivation extending over many years, and a comparison with the average soil from County Cumberland

quoted in the same table shows how profound have been the changes brought about by cultivation. In addition to the increase in plant food shown in the table there are other changes affecting the mechanical nature of the soils which are not there shown. The capillary power has been reduced in the case of the sandstone soils and increased in the case of the shale soils to about the same figure in each case. In the same way the water-holding power of the sandstone soils has been increased, and that of the shale soils reduced to the figures given in the table.

The original sandstone soils contain, generally speaking, a comparatively small amount of clay, whilst the soils from the shale formation are more clayey in nature. Under cultivation the clay percentage in the sandstone soils has been increased and that of the shale soils reduced to about 72 per cent. on the average. The soils are no longer the poor, rather hungry soils characteristic of these formations, but approach more nearly the composition of a good basalt soil.

FLOOD DEPOSITS.

The silt deposited by floods has a considerable fertilising value, and the extraordinary fertility of many river flats which are subject to periodic floodings is, undoubtedly, largely due to this cause.

An attempt was made to determine the nature and extent of this deposit in the case of floods in the Hunter and Hawkesbury Rivers in 1904.*

In the following tables are given the composition of these flood waters and the amounts of suspended matter (silt), and the chemical composition of the silts:—

ANALYSES OF FLOOD WATERS.

Analysis of Hunter River Water.

	Parts per 1,000.		Grains per gallon.	
Total residue	=	2·463	or	172·4
Volatile on ignition ...	=	0·308	„	21·6
Fixed residue	=	2·155	„	150·8
Matter in suspension ...	=	2·182	„	152·7

Analysis of Hawkesbury River Water.

	Parts per 1,000.		Grains per gallon.	
Total residue	=	·145	or	10·15
Volatile on ignition ...	=	·03	„	2·10
Fixed residue	=	·115	„	8·05
Matter in suspension ...	=	·116	„	8·12

Both waters are slightly acid in reaction.

Analysis of Silt from Hunter River Water.

	Per cent.
In-soluble in hydrochloric acid	= 79·25
Soluble in hydrochloric acid—	
Oxide of iron and alumina (Fe_2O_3 and Al_2O_3)	= 10·02
Lime (CaO)	= 1·55
Potash (K_2O)	= 0·09
Phosphoric acid (P_2O_5)	= 6·18
Volatile matter	= 9·61
Nitrogen	= ·084
Weight per acre, one foot in depth =	3,403,125 lb.

* David and Guthrie—Journ. Roy. Soc. N. S. Wales, Vol. XXXVIII., p. 191.

Analysis of Silt from Hawkesbury River Water.

	Per cent.
Insoluble in hydrochloric acid	= 89.96
Soluble in hydrochloric acid—	
Oxide of iron and alumina (Fe ₂ O ₃ and Al ₂ O ₃)	= 4.77
Lime (CaO)	= 0.49
Potash (K ₂ O)	= 0.12
Phosphoric acid (P ₂ O ₅)	= 0.08
Volatile matter	= 4.68
Nitrogen	= 0.105
Weight per acre, one foot in depth =	3,307,332 lb.

Assuming an average based on local observations of 2 inches of deposit after the subsidence of a flood, the silt left by the Hunter River in flood would amount to 567,186 lb. in weight per acre, and would supply the land with a top-dressing of fertilising constituents to the following amount per acre:—

Lime... ..	8,791 lb.
Potash	510 ,,
Phosphoric acid	1,020 ,,
Nitrogen	476 ,,

—a manuring which contains sufficient of the necessary plant-food to supply the requirements of most crops for nearly ten years.

On the assumption that the same volume of water was flowing for the same length of time at the same rate in both cases, the amount of deposit left by the flood will be proportional to the amount of suspended matter. Taking 2 inches to be the depth of deposit left by the Hunter River, then the Hawkesbury River would deposit under similar conditions as to time, volume and rate of flow $\frac{1}{10}$ -inch silt. The weight of this deposit in the case of the Hawkesbury flood would be 27,561 lb. per acre, or about one-twentieth the weight of that left by the Hunter River flood.

This would provide the land with a top-dressing per acre of the following fertilising constituents:—

Lime	135 lb.
Potash... ..	33 ,,
Phosphoric acid	22 ,,
Nitrogen	29 ,,

All the above estimations as to the amount of fertilising material deposited are based on the assumption that the depth of the deposit in the case of the Hunter River flood averaged 2 inches. This appears a very high average, but there are unfortunately no hydrographical data available by means of which this can be checked. It would be a matter of considerable national importance if further data concerning the rate of flow, volume of water, height of flood, and amount of silt deposited, &c., could be obtained during the period of such floods as those now discussed. This is a matter which might well engage the attention of engineers.

The fact must, of course, not be lost sight of that although such floods are distinctly beneficial in increasing the fertility of land over which they flow, their immediate action is more frequently detrimental than otherwise. Instances have even occurred in which farms have been practically ruined by heavy deposits of sand brought down by flood currents of more than usual strength and volume. In any case floods are uncertain in their coming, and, besides the risk of their destroying growing crops, they render the land unfit for the plough for several weeks, so that a whole season may be lost.

NOTES ON THE WEATHERING OF SOILS.

As a general rule, it is not easy to trace any close relationship between the soil and the rock from which it has been derived. This is especially the case when the soil has been exposed to atmospheric influences for a long period, when vegetation has taken a good hold, and when the land has been under cultivation. The changes brought about by all these processes rendering the mineral matter in the original rock more soluble, and the further action of plant-growth, rain, drainage, &c., remove the more soluble salts from the soil to such an extent as to materially alter the original proportion of the ingredients.

The same thing happens when the soil is transported from its original position, either by rain or wind, or when the original soil is overlaid by transported soil from other rock formation or by flood deposits.

If the weathering or other agents of destruction have been sufficiently active, and have acted for a sufficient length of time, the resulting soil from a pure limestone rock becomes indistinguishable from that derived from sandstone.

Where, however, the rock has weathered *in situ* fairly rapidly, where vegetation has not taken hold and the rainfall is not excessive, it is possible to trace the effects of weathering in the different layers of soil.

This has been shown by Dr. Jensen in the case of samples of granite soil taken from a spot overlying the country rock, where the weathering process could be traced through the different soil-layers right down to the unchanged rock.

The result is given in the accompanying table.

TABLE showing alterations in composition at different depths of a granite soil formed *in situ* (Bathurst Experiment Farm).

Depth and Locality.	Colour.	Reaction.	Water Capacity.	Capillary Power.	Clay.	Lime (CaO).	Potash (K ₂ O).	Phosphoric Acid (P ₂ O ₅)	Nitrogen (N).	Volatile.	Remarks.
No. 1 Near silo—	from decomposition of granite <i>in situ</i> .										
	Per cent.										
0" to 6" ..	light yellow	strongly acid.	25	good	28.8	.160	.111	.072	.140	3.66	
6" to 12" ..	reddish	acid.	27	excellent	51.0	.218	.452	.069	.112	5.83	} Red colour due to ferric oxide.
12" to 18" ..	"	faintly acid.	44½	"	61.8	.349	.559	.063	.112	8.55	
18" to 24" ..	yellowish	"	45	"	44.8	.333	.435	.104	.008	7.72	} Contains lumps of decomposed granite.
24" to 30" ..	light yellow	"	42	"	46.8	.446	.582	.122	.070	6.84	
30" to 36" ..	yellow	"	39	"	34.7	.369	.558	.063	.042	6.07	} Very lumpy with decomposed granite.
No. 2. Near orchard gate—	granite detritus redistributed by water.										
0" to 6" ..	light brown	strongly acid.	42	good	59.2	.249	.184	.004	.154	5.34	
6" to 12" ..	grey	very faintly acid.	26	"	54.2	.184	.103	.012	.070	1.92	
12" to 18" ..	dark grey	neutral	42	fair	79.1	.307	.371	.052	.070	5.95	
18" to 24" ..	} brownish	very weakly	53	poor	85.6	.420	.425	.064	.084	6.09	
24" to 30" ..		alkaline.									
30" to 36" ..											

This table is instructive as showing that the subsoil in granite areas is invariably richer in mineral plant-food, especially potash, than the surface soil. The phosphoric acid gets slightly and the nitrogen considerably less at a depth, but the lime and potash are much higher. It follows from this that when a granite surface soil gets depleted in potash a good supply can be introduced by deeper ploughing. In sandstone country this is not true to nearly the same extent—a fact which makes a poor granite soil an infinitely better asset than a poor sandstone soil.

INJURIOUS SUBSTANCES IN THE SOIL.*

Bare Patches.

It frequently happens that large or small areas of land are found to be unproductive or of poor quality, although from their origin, and the nature of the surrounding country, one would expect them to possess a high degree of fertility. Of such nature are the bare patches often met with in otherwise fertile areas.

Such bare patches may occur in areas of a few feet in diameter, or may be of very considerable extent. The causes of this infertility are various, and it is by no means easy in all cases to determine to what their unproductiveness is due.

The following are some of the instances most commonly met with:—

Shallowness of Surface Soil.

It may happen that the rock from which the soil is derived has weathered unequally in different parts, and that undecomposed rock is found quite close to the surface, thus forming a very shallow surface soil on which nothing but the most shallow-rooted crops will grow, and resting on a hard stratum through which water will not penetrate. Crops or trees growing on such soil may do fairly well until the roots reach the impervious layer, when they begin to wilt.

The same result is produced when a hardpan or layer of impervious material is formed below the surface. This hardpan may be formed mechanically by the plough, either by ploughing stiff clay when it is wet, or by ploughing repeatedly at the same depth. It may also be formed naturally by the cementing together of the particles of sand and gravel of the subsoil by humates and silicates, particularly humates and silicates of iron and lime, and is especially likely to occur in ironstone country. The remedy is to break up the hard layer by deeper ploughing, and to apply slaked lime.

Scalded Plains.

Where conditions are such that a shallow and dry surface soil, or a soil deficient in vegetable matter, is exposed to the action of wind, large areas are frequently denuded. In such cases the top soil is carried away and a hard surface exposed, destitute of vegetable matter, and which is useless for the production of crops, or even of grass, until it has been thoroughly worked and brought under cultivation for some time. These patches form the well-known scalded or scoured plains of greater or less extent occurring in the arid and semi-arid districts, and particularly in thinly-timbered country.

The same thing happens in such parts as have been heavily trampled by stock on stock routes and camping-places. Such lands require only to be well ploughed and exposed to the influence of rain and sun to render them again productive.

* F. B. Guthrie.

Sourness.

This is one of the most common causes of infertility in soils. It is brought about either by the absolute exclusion of air, as in water-logged soils or soils in which the surface has been impacted; or it may also be the result of an excessive amount of organic matter, as in peaty soils. In both cases the result is the formation of organic acids (humic acids, &c.), which, in the absence or deficiency of basic substances, such as lime, to neutralise them, act as plant poisons. They not only affect the growth of the plant, but have a solvent action upon the soil constituents, which are liable to be dissolved out and pass into the subsoil. Soils which are red or chocolate in colour from the presence of oxide of iron, if allowed to become sour, are very frequently bleached in colour. They also exercise a reducing action upon the higher oxides, such as ferric oxide, reducing it to the state of ferrous oxide. It is commonly stated that this latter substance is itself a plant poison, but since this compound would not be present in soils in good tilth, but would be converted into the higher (ferric) oxide, it is probable that the ill effects noted when ferrous oxide is present are in reality due to sourness, and that the presence of ferrous oxide is only one of the results of this condition.

The remedies for sourness are thorough cultivation and turning of the soil and exposing it to the air. In cases where it is the result of accumulation of water (in swampy soils) it will be necessary to have recourse to drainage. The addition of lime to neutralise the acids formed is in all cases beneficial; and by a proper system of drainage, together with thorough cultivation and the addition of lime, it should be possible to reclaim the most sour land. A sour condition of land is usually quite readily recognisable by the experienced farmer from its appearance, the peculiar odour when moist, &c.

As this condition is due to acidity, sour soils have always a strong acid reaction towards litmus; but as this reaction is influenced by other factors, it is not a reliable indication except in experienced hands. It must also be remembered that cultivated soils nearly always possess an acid reaction.

Protoxide of Iron and Pyrites.

The presence of these compounds in the soil is generally an accompaniment of a sour condition of the soil, and is due to the same cause—want of aeration. It is doubtful whether they are themselves active plant poisons, but their presence is always associated with an infertile condition.

The presence of ferrous oxide is indicated by a bluish or greenish colouration in the clay. This colour changes to red or reddish brown when the soil is aerated.

Pyrites and marcasite (sulphide of iron) are commonly occurring minerals, and their presence unchanged is also a sign of deficient aeration.

It is also stated that ferrous sulphate, the substance into which the sulphide is at first converted on oxidation, is itself a plant poison if present in excessive quantities, so that such soils will require very thorough aeration in order to convert the ferrous sulphate into the fully oxidised ferric compound. At the same time it must be remembered that ferrous sulphate is recommended by many writers as a manure. A very effective fertiliser was prepared locally by mixing boiling-down soup with ferrous sulphate. It is

probable that the injurious effects noticed when the compounds under discussion are present are due less to the substances themselves than to the conditions under which they are produced.

The treatment of soil in which these substances are present is the same as in the case of our soils—cultivation, liming, and draining.

Alkalinity.

The reverse condition to that of sourness, and one equally injurious to plant life, is the presence of alkali in the soil. As far as New South Wales is concerned this alkalinity is due to the presence of carbonate of soda, and



A "bare patch" in Mature Wheat at Coolabah Experiment Farm.

is almost exclusively associated with the use of bore water; naturally occurring alkali soils such as are found in other parts of the world are practically non-existent.

The continued use of bore water, especially when used to flood the land, and on dry land which is level and has no adequate natural or artificial system of drainage, results in the accumulation on the surface soil, as the water evaporates, of a white incrustation of carbonate of soda. This substance (alkali) acts injuriously in several ways. It corrodes the stem or crown of the plant or tree with which it comes in contact at the surface; it dissolves out the humus or vegetable matter of the soil, and it combines with the clay, forming a substance which is extremely slimy and sticky when wet, and which dries to a hard mass which it is almost impossible to break up with any agricultural implement. On drying, the surface contracts and opens out in cracks, thus damaging the roots of the crops.

If it is necessary to use this class of water for irrigation, the following precautions must be taken:—

The land must be efficiently drained if there is no natural run-off for the water; the water must be run on in channels and cross-furrows, so that it penetrates the soil laterally; it must be used in moderation, and not allowed to lie on the surface; the surface soil should be continually cultivated with the harrow, and, if possible, kept well mulched with vegetable matter.

Of the substances recommended to neutralise the effect of alkali, gypsum (sulphate of lime), in the form of powder, was first suggested by Professor Hilgard for the alkali lands in the United States, and has been found successful. Its use has not been adopted locally to any extent, but there can be no doubt that it would be effective. It can be applied either directly to the land itself, or placed in the channels or flumes so that the water has to pass over it.

The use of nitric acid has also been suggested; but, unfortunately, the results of the experiments so far carried out locally have not been very definite. The application of an acid naturally suggests itself as the most



The "bare patch" terminates abruptly at the boundary of the plot to which superphosphate has been applied.

obvious means of neutralising an alkaline substance, and nitric acid has the additional advantage that it converts the injurious carbonate of soda into a valuable fertiliser—nitrate of soda. Experiments reported by the Queensland Department of Agriculture indicate that it can be applied with benefit to the bore water in proportions which will depend upon the amount of alkali in the water.

Common Salt (Sodium chloride).

Except in the case of bore water, where its presence no doubt increases the injury done by the alkali, but where its power for evil is insignificant in comparison with that of carbonate of soda, common salt is hardly ever met with in our soils, other than those close to the sea or salt-water creeks, and liable to flooding. Crops vary considerably in regard to their power of tolerating the presence of common salt. Some plants, such as beetroot and

asparagus, benefit from its presence; it is also said to be a good manure for mangels and cabbages; and such plants as saltbushes, &c., contain considerable quantities in their tissues. Most farm crops will stand as much as from 0.1 to 0.2 per cent. salt in the soil, but if the amount exceeds this quantity, crops are likely to be affected.

The action of salt is injurious in several ways. It affects the production of nitrates and the process of nitrification, and also affects the texture of the soil. The addition of salt, in the first instance, flocculates the clay particles, and makes the soil temporarily more friable; but it has a very damaging after-effect, due probably to its combining chemically, with exchange of base, with the silicates, particularly silicate of lime, and forming colloidal silicates, thus rendering the clay slimy.

Manganese.

Although salts of manganese, in small quantities, are found to be beneficial (indeed some chemists go so far as to say necessary) to the growth of crops, they are undoubtedly injurious in larger quantities. Several instances have come under our notice in which small, bare patches occur in a field otherwise fertile; and examinations of these patches and of the surrounding good soil have shown them to be similar in all respects, except that the bare patches contain manganese, whereas the good soil either contains none, or proportionately much smaller quantities.

The action of manganese is peculiar, and extremely interesting. It would appear that certain compounds of manganese are more toxic than others, and that the higher oxides of the metal are more toxic than the lower, so that the process of aeration, usually of benefit in increasing the soil's fertility, has in this case a distinctly prejudicial action. The result is that it may happen that a soil may yield good results for a year or two, and suddenly develop toxic properties, due to the conversion of the more innocuous forms of manganese into higher oxides of greater toxicity. Another point of some interest is that, when the quantity of manganese present is small in amount, it frequently happens that crops suffer during the winter months, and provided the quantity of manganese present is not excessive, recover themselves with the advent of the warm weather, and when their growth is more vigorous. Soils containing excessive quantities of manganese are generally dark in colour, and frequently it is possible to distinguish small particles of manganiferous compounds, black in colour, and very soft.

Generally speaking, manganese poisoning may be suspected when the affected patches are darker in colour than the normal soil, when the bad effects do not appear until the land has been under crop for a year or two, and when the crop suffers in the winter and recovers itself during the summer. It not infrequently happens that these bare patches change their position from year to year; that is to say, an area which was bare one season will resume its normal condition in the next, while other patches in the same paddock will become infertile. Such a condition of affairs will lead one to suspect the presence of manganese.

With regard to remedies, it has been found that the addition of superphosphate has a decidedly beneficial influence on such soils, probably due to the formation of manganese phosphate—a compound of lower toxic action than the oxide. The data so far obtainable are insufficient to justify this being put forward as an infallible remedy, but it has been found to be successful where it has been tried, and is worth further trial.

Magnesia.

Although lime is one of the most important elements of soil fertility, magnesia, which is a very similar compound, and which is frequently found associated with lime, is by no means desirable in any considerable quantity. Although limestone rocks almost invariably produce the most fertile soils, those formed from dolomite (magnesian limestone), which is carbonate of magnesia, are of poor quality, and even the presence of any quantity of magnesia in the limestone renders the soil a poor one.

The general result of experimental work in the field and in pots tends to show that when the magnesia in a soil exceeds the lime the soil is an unproductive one. Loew, who has particularly studied this matter, finds that a certain ratio must be preserved between the lime and the magnesia in the soil. This ratio appears to vary with different crops; some crops do best when the amounts of these compounds are equal, whilst others require about two or three parts of lime to one of magnesia.

The remedy most likely to be effective in the case of soils whose infertility is due to excess of magnesia is the addition of lime, in order to restore the balance, and such soils come under the heading of those which are deficient in lime, although actually the amount of lime salts present might be sufficient provided magnesia was absent.

Toxic Substances Secreted by the Plant.

It is well known that when certain crops are grown continuously on the same ground without fallowing or rotation, the land becomes unsuited to that particular crop. The cause usually assigned to this phenomenon, namely, that the continued growth of the crop in question removes certain elements of plant-food necessary to that crop, requires some modification in view of recent investigations.

The United States Bureau of Soils has advanced the suggestion that the plant during its growth secretes toxic material which is injurious to the succeeding similar crop, though not to crops of a different nature, and a good deal of work has been done in trying to isolate and identify these toxic substances. A corollary of this theory is that the beneficial action of fertilisers is due less to their actual value as plant-food than to the fact that they neutralise or otherwise alter these poisonous substances.

Another theory is that these plant toxins are formed not by the direct secretion of the growing plant, but by the action of bacteria upon the residues left in the soil by the crop. Such a theory would afford an explanation of such phenomena as clover sickness, &c., where it is found that bad results follow the continuous growth of the same crop on the same land, although the soil itself may show no appreciable loss of plant-food.

It must, however, be stated that these theories have not yet advanced much beyond the speculative stage; and that, although a considerable amount of work has been done, and several definite organic substances have been isolated, the toxicity of these substances in the field has not yet been established conclusively.

Whatever may be the real cause of the trouble, whether it is due to soil exhaustion or to the production of toxins, either by the growing plant or by bacterial action on crop residues, or to a combination of these causes, the remedy indicated will in every case be the same, namely, crop rotation or fallowing.

Excessive Concentration of the Soil-water.

Damage may also be done to the growing plant by otherwise harmless or even beneficial ingredients, when the solution in which they are presented to the plant is too concentrated. During dry spells, for example, the soil moisture will contain a relatively larger amount of soluble saline matter than under normal conditions; and it may quite easily happen that a soil on drying out during a dry spell may lose moisture to such an extent that the remaining water may contain an excessive quantity of salts in solution. If the quantity of matter dissolved in the moisture in the soil is in excess of that present in the cell of the plant-roots, the result is that the water will pass out of the cell into the stronger solution outside, with the result that the contents of the cell will shrink and the plant itself wilt.

The ill effects of want of water during a protracted dry spell are thus accentuated by the danger of an over-concentration of mineral matter in the remaining soil moisture. A rich soil, therefore, one well supplied with soluble plant-food, would be expected to show the ill effects of drought even more than a poor one.

This would also account for the fact that heavy manuring with artificial fertilisers is generally found to be rather harmful than beneficial in dry seasons, and that under such conditions light dressings are superior to heavy ones.

Calcium Chloride.

This substance is stated by some authorities to be harmful to the growth of crops, though I am not aware of any exact experiments being recorded which prove its toxicity in the field. We know that chlorides of other metals are frequently injurious. The case of sodium chloride (common salt) has already been dealt with, and certain other chlorides have been found inferior fertilisers for certain crops (such as potatoes and tobacco); it is quite likely that calcium chloride is an undesirable form in which to apply salts of lime.

In certain bare patches at Coolabah Farm were found a considerable concentration of plant-food in the soil moisture, a small proportion of lime and an absence of carbonic acid; and from the fact that the soil from the bad patches was deliquescent, and contained a larger proportion both of lime and chlorine than the good soil, the presence of calcium chloride was suggested.

In such cases, also, the addition of lime is the remedy which suggests itself, so that the crop can be supplied with lime in another form than that of calcium chloride. Here, again, it must be borne in mind that the toxicity of calcium chloride has not been proved by exact experiment.

Alum.

A substance which is frequently accused of causing infertility in soils is alum. Alum is a double sulphate of alumina and potash, and it is not quite obvious why it should have such a bad name. In water cultures of *spirogyra* it has been recently found by M. Fluri (Bied. Centr. 1909, 38, p. 670) that proportions of aluminum salts as low as .003 per cent. deprive the cells of starch. As a matter of fact, of all the soils examined here in which alum is stated to have been the cause of the trouble, none have contained alum; and the infertility has been due either to sourness (in the majority of cases) or to the presence of common salt or alkali.

Samples of incrustation or efflorescence occurring on such soils, and stated to be alum, turn out on examination to be salt or alkali, and the trouble is in all cases due to inefficient drainage, and disappears when the land is properly drained.

Absence of Elements essential to Fertility.

In addition to the presence of the actively injurious substances enumerated above, soil infertility may be caused by the absence or deficiency of certain essential soil ingredients.

Want of lime, for instance, as we have seen, may induce sourness and a disturbance in the ratio between lime and magnesia. Its absence also affects the growth of many crops for which it is an essential plant-food, particularly leguminous crops, lucerne, clovers, &c.

Deficiency in humus is a common cause of infertility. A soil deficient or wanting in humus is less able to withstand droughty conditions, lacks cohesion, and is easily blown or washed away, and is unfavourable to the growth of micro-organisms. The subject is more fully dealt with on page 70.

Absence of bacteria, particularly of the nitrifying organisms, is prejudicial to the satisfactory production of crops. The cause is generally one or other of those discussed above, either want of aeration, lack of lime or vegetable matter, sourness, bad tillage or drainage, &c., and when such soils are restored to good condition the development to the nitrifying organisms will proceed normally.

Want of plant-food is, of course, a common cause of infertility, especially in the case of land which has been exhausted by repeated croppings without manuring or rotation. Proper manuring, having due consideration to the requirements both of the soil and of the crop, is the remedy, provided that the land is in good condition; but the important fact must not be lost sight of that the mere addition of plant-food is not sufficient unless the soil is in such mechanical condition that it can make good use of the manure applied.

Manuring alone is not likely to be of any benefit on land that is badly drained, sour, or in bad tilth.

Presence of Organisms which destroy the Nitrogen-forming Bacteria.

In connection with one of the causes of sterility noted above, namely, the absence or deficiency of bacteria, the results of an investigation of the greatest interest and importance has recently been published by Messrs. Russell and Hutchinson from the Rothamsted Laboratory. These investigators find that probably in all soils the development of these bacteria is kept in check by the presence in soil of certain larger unicellular organisms (Protozoa) which feed on the bacteria concerned in the formation of soluble nitrogen compounds.

If the soil is partially sterilized by heating for a short time to the temperature of boiling-water, or by subjecting it to the action of vapours such as chloroform, bisulphide of carbon, toluene, &c., such vapours being subsequently removed by spreading the soil out in a thin layer and allowing the vapour to evaporate, the effect is to destroy the protozoa and probably most of the bacteria as well, but not the spores of the ammonia-producing bacteria. These spores subsequently develop, and in the absence of the hostile protozoa, their development proceeds with increased activity, the result being a considerable increase in the soluble nitrogenous plant-food and a more vigorous crop growth.

These experiments have so far been carried out in the laboratory. If means are discovered of partially sterilizing the soil in the field a most valuable method of increasing the fertility of the soil will be placed at the disposal of the farmer.

SECTION II.

The Chemistry of the Soil.*

Introductory.

THE essential difference between the new methods of farming and the old is that the old rule-of-thumb methods are being superseded by those which are based on a study of the conditions under which crops grow, and of the relationship of the growing plant to soil and air and water. These new methods have become necessary because of the changed conditions under which farming is carried on. The number of people who have to be supplied with food is continually and rapidly increasing, competition is getting keener, the available land of good quality is diminishing, and poorer land or land in a less favourable climate has to be opened up, and the need has arisen of utilising to the utmost the resources of the soil. This is only possible by the application of principles which science has discovered. This does not mean that the farmer must necessarily be a scientific man, but it is becoming every day more and more necessary that he should understand something of the principles on which farming depends.

Agriculture is an art, and it is an art that was practised centuries before the sciences were born with which it has become associated in modern times.

Man raised corn and made bread and wine thousands of years before he knew anything of the constituents of grain and grape, or the nature of fermentation, and a man can to-day be a thoroughly successful farmer without knowing anything about botany or pathology, or entomology or chemistry.

Nevertheless, the farmer of to-day, working under modern conditions, cannot afford to neglect the teachings of science as far as they affect his own art, and that farmer will be the successful one who is able to understand what science has to tell him, and to utilise the weapons which she puts into his hands. And agriculture is indebted to science not only for the knowledge of useful facts and principles, but in a still higher degree for the scientific method of work, the spirit of inquiry, the patient, accurate, and systematic attention to the minutest details. Without this, the farmer becomes a mere sowing and reaping machine, incapable of progress, and at the mercy of adverse seasons and crop diseases.

The following notes are written with the object of affording some information (avoiding technicalities as far as possible) of the nature and functions of this all-important material—the soil—which, though it is no more than a fine dust-film on the surface of the globe, and is infinitely small compared with the mass of the earth, is nevertheless the substance on whose support all the teeming life of the earth depends.

The point of view from which our study of the soil will proceed will be that of the conditions which make for soil fertility. By a fertile soil is meant one that is most favourable for producing crops, and if we know the factors on which this depends we shall be able to maintain the fertility of a good soil, to restore it to impoverished soils, and to increase it in barren ones.

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Classification of Soils.

The classification which will be adopted in the following pages is that based upon the mechanical condition of the soils and depending upon the proportion of particles of different size. For all practical purposes one based on the proportion of sand and clay is sufficiently close, and the following table gives the standard which is adopted:—

		NATURE OF SOIL.								
		Clay.				Sand, Gravel, &c.				
		Per cent.				Per cent.				
Clay	75	...	90	...	...	...	10	...	25
Heavy loam	60	...	75	..	...	...	25	...	40
Loam	30	...	60	...	...	...	40	..	0
Light loam	20	...	30	...	..	...	70	...	80
Light sandy loam	10	...	20	...	...	..	80	...	90
Sand	0	...	10	...	..	...	90	...	100

Gravelly soils contain over 20 per cent. gravel.

Calcareous soils „ „ 5 per cent. lime.

Peaty soils „ „ 20 per cent. humus.

There are, however, other methods of classification which can be usefully adopted under different circumstances. For instance, the farmer will distinguish between light and heavy soils, plain, timber, and swamp soils, or according to the nature of the vegetation, as pine country, box country, &c., or according to the different crops for which they are particularly suitable, as wheat land, lucerne land, grass land, &c. Another method of classification frequently adopted is one depending upon their manner of formation into sedentary and transported soils, and as these terms are commonly met with in text-books, it will be useful to define them a little more accurately.

Sedentary soils are those which overlie the rocks from which they are formed, and *transported soils* are those which have been carried away by the action of wind or rain, or streams, or by glacial action, from their original positions.

Transported soils are divided into *colluvial soils*, such as are found on hillsides or in undulating country, which have been moved from their original position by the agency of wind or rain, and *alluvial soils* which have been carried away by streams and rivers and deposited often far from their original position by the action of running water.

Sedentary soils are usually met with on upland plateaux and are generally shallow, their depth depending upon the length of time during which denudation has taken place and the amount of transportation which they have undergone. They merge gradually and imperceptibly into the rock from which they are derived, and a knowledge of the nature of the underlying rock is of value in determining the character of the soil.

Colluvial soils—*Drift soils*.—In the case of these soils the surface has been removed from its original position, and has become mixed with soils derived from other rocks, often of quite different character.

Their transportation may have been brought about by a variety of causes, such as the action in remote times of glaciers, or by the action of rain or of wind or running water.

Examples of drift soils blown about by the action of the wind are to be found in the western plains, where the movements of the soil during continued wind-storms have resulted in the transportation of the surface soils to new positions, where they are often piled up to the depth of several feet.

Alluvial soils are found in the beds of old watercourses or on either side of the banks of flowing streams, where they are deposited by the rise and fall of the river, and especially during floods. The Hunter Valley, in New South Wales, where the river is not only subject to periodic floods, but is continually changing its course, affords an excellent example of a large area of country covered by such alluvial soils.

Alluvial soils are also met with in the plain country, where no rivers are to be seen, and occupy the beds of dried-up watercourses, along which they were originally deposited.

Such alluvial soils are generally of great fertility, largely due to the fact that the soil particles are exceedingly fine. Those formed by the deposition of silt in successive floods upon the river banks are often of great depth, and much of the best lucerne land of the State is found in such localities.

Formation of Soils.

Soils are produced in the first instance by the weathering of rocks. By weathering is meant the continued action of wind, water, and changes of temperature upon the rock, and the term includes the mechanical and chemical changes brought about by these agencies, as well as by the action of vegetable and animal life.

The disintegration of rocks to soil is an exceedingly slow process. It has been calculated that the disintegration of limestone rock (one of the most readily-weathered rocks) to the depth of one metre would take over 70,000 years. Syenite would take ten times as long to disintegrate to the same depth.

Weathering of Rock.

Action of Air—(a) Mechanical.—Air acts mechanically by the actual pressure exerted by the wind upon exposed surfaces, and by the bombardment of rock surfaces by wind-borne material such as fragments of rock and pebbles. Its action is also of importance in the removal by wind of the disintegrated rock, leaving fresh surfaces exposed to the other disintegrating agencies. It is also one of the principal factors in the formation of the drift-soils mentioned above.

(b) Chemical.—The chemical disintegration of rock, due to the action of the constituents of the atmosphere, is for the most part brought about by the carbonic acid and oxygen. The action of *carbonic acid* is amongst the most powerful of the agencies at work in the disintegration of rock, and since its action is practically confined to the solution of the gas in water, either in rain or in spring or in river water, it will be better discussed later under the heading of water.

The action of *oxygen* is practically confined to the further oxidation of lower oxides of such metals as iron and manganese. A large number of minerals contain ferrous oxide, to which they owe their dark colour. This oxide really absorbs oxygen, being converted into ferric oxide (rust), the change being accompanied by an increase in bulk which assists in shattering the rock in which these minerals occur.

Changes of Temperature.

The mechanical effects of alternate heat and cold are potent factors in the disintegration of rocks, which, with few exceptions (such as limestone, quartzite, &c.), are made up of a mixture of different minerals. These

minerals expand and contract unequally when subject to variations in temperature, and their alternate contraction and expansion is an important factor in the slow breaking down of rocks.

The daily alteration of temperature between night and day is capable of effecting the disintegration of the hardest rocks. This disintegration is accelerated by the fact that into the minute crevices so formed, water, dust, plant-roots, &c., are carried, themselves acting as further disintegrating agents.

On mountain ranges and over extensive plains, where frosts occur, and the air is clear and dry, the action is yet more marked. The surface soil in the deserts of Central Asia and other parts of the world, including the interior of our own continent, has been formed in this way, aided, of course, by the other weathering agencies.

Water.

The effect of water, and especially of water containing carbonic acid in solution, as is the case with rain-water and most spring and river water, has a most far-reaching influence in the disintegration of rocks and their conversion into soil.

(a) *Mechanical Action of Water.*—Water acts mechanically in several ways. The actual bombardment of exposed surfaces of rock by rain results in its slow attrition. Running water traversing rock surfaces exerts a very considerable erosive action apart from its solvent action. The action is further hastened by the removal to lower levels of the particles thus torn away and the exposure of fresh surfaces of rock to the weather.

Running water also plays an important part in the transport of soils from one part to another, from higher to lower levels, and in the formation of alluvial soils by the deposition of mud and fine silt during flood. Such alluvial soils occur along the banks of all our rivers for some distance from the river banks, and in the case of rivers which wind tortuously through level country and are subject to frequent floodings the extent of the alluvial deposit is very considerable. When such a river, as is the case with the Hunter, frequently changes its course, the extent of the alluvial deposit becomes still greater.

The alternate freezing and melting of water plays an important part in mechanical rock disintegration. Even the most compact rocks are not entirely impervious to water, and contain a small amount of moisture, known to quarrymen as "quarry water." Water in freezing expands about one-tenth of its bulk, so that in situations exposed to alternate frosts and thaws, the amount of disintegration brought about by this means is very considerable, particularly when the alterations are rapid, say, warm days followed by frosty nights. During periods of prolonged frost this action does not proceed.

Connected with the action of moving water, we must also take into account the action of glaciers, which, though it takes no present part in the formation of soils on the Australian continent, has undoubtedly been an active agent in the past in the disintegration of mountain ranges and the transport of the debris to form soils in the valleys.

(b) *Chemical Action of Water.*—The chemical action of water, and especially of the dissolved substances, is undoubtedly the most extensive agent in the denudation of rocks.

Water acts on the soil constituents in two ways—

- (a) By combining chemically with the ingredients to form hydrates;
- and (b) by its solvent action.

(a) A large proportion of the minerals which form rocks are hydrated silicates, containing a certain proportion of combined water. The hydration of these minerals is accompanied by considerable increase in bulk, which assists in the disintegration of the rock-mass, and also produces a substance which is more readily attacked than the original silicate. A good example of the expansion of rock on hydration is met with in the well-known operation of taking a cast in plaster of Paris, which is burnt gypsum, a substance which frequently occurs in rock-masses. When plaster of Paris is moistened with water it absorbs the water and becomes a hydrate, and in so doing expands so that if a mould is made round a coin or medal and filled with moistened plaster, this will expand in drying out and setting, and force itself into the irregularities of the surface, forming a reproduction of the original medal.

(b) It is, however, the solvent action of water which plays the most important part in the breaking up of rocks. Even pure water exercises a slight solvent action on the minerals of which rocks are composed. If a little finely-powdered felspar be shaken up with water, the water will show an alkaline reaction, and turn red litmus paper blue—showing that something has been dissolved from the water. The same thing happens with powdered glass. Absolutely pure water is, however, not met with in nature. Natural water contains appreciable quantities of dissolved materials, some of which, such as carbonic acid, ammonia, nitric acid, exert a very considerable solvent action upon rock particles.

Carbonic acid is present in all natural waters to a greater or less extent. Even in rain-water the quantity, though small and very variable, is appreciable, and amounts to as much as 1 per cent. The solvent action of waters holding carbonic acid in solution is very considerable. Some rocks, such as limestone, are completely soluble in such a solvent. On this account waters flowing over limestone rocks are invariably hard owing to their containing carbonate of lime in solution.

Ordinary spring and river waters do not, indeed, contain very much carbonic acid, but some springs contain a very considerable quantity of the gas dissolved under pressure, and the effervescence of many mineral waters is due to the escape of this gas when the pressure is released on reaching the surface.

Other rocks and minerals are not so readily dissolved as is carbonate of lime, but all are very much more soluble in water containing this gas than in pure water. Felspar, for example, is very readily attacked, the carbonic acid removing the potash (or other base) and leaving a residue consisting of pure clay. Even silica is attacked by it, and the minerals composed of hydrated silica—such as flint, jasper, and even quartz—are sensibly attacked by it. Quartzite is the only rock that may be regarded as practically unattacked by carbonic acid.

The *ammonia* contained in rain-water has also a very powerful solvent action upon silicates. Finely-powdered glass is quite readily soluble in ammonia; and the windows of stables, where organic matter is undergoing decay and ammonia is evolved, are frequently frosted by the action of this latter substance.

Nitric acid in the air also aids in the solvent action of rain-water.

The dissolved saline matter in rain-water also helps in the disintegration of rocks, both by its chemical action and by its mechanical. In the neighbourhood of the sea especially the air contains particles of salt which are dissolved by the rain and carried into the minute abrasions and crevices

formed in the rock by the mechanical action of wind and rain. As the water evaporates the salt crystallises out, expanding in the process, and thus aiding the work of disintegration.

The Action of Vegetation.

As soon as a very small quantity of disintegrated soil is produced, it becomes at once the medium for the germination of small seeds, wind-blown or dropped by birds. As these seeds germinate and grow they assist in the disintegration of the rock below, mechanically by forcing their roots into its mass, and chemically by the solvent action possessed by their roots. Even on the solid rock vegetation can gain a foothold. The first forms of vegetation are the lichens which cover the surface of the rock in moist and sheltered places. These plants secrete oxalic acid—a much stronger acid than carbonic acid—which attacks the lime in the rock. Crystals of oxalate of lime are frequently found in lichens. By their growth they exclude light and air, and help to keep the rock moist, thus favouring its further denudation.

When a certain amount of soil has been produced by the growth and decay of these lichens other forms of vegetation can obtain a foothold—mosses, ferns, stone-crops, and saxifrages, followed by other shallow-rooted plants. By the decay of these and the continued disintegration of the rock, the soil gradually increases in depth until higher plants and trees are able to find support and nourishment.

Bacteria.

Bacteria and micro-organisms generally play a highly important part, not only in the transformation of organic material within the soil (which will be discussed more fully under the heading "The Plant's Supply of Nitrogen" (page 75. *et seq.*), but also in the formation of soil from the disintegration of rocks. The bare surfaces of rocks contain large quantities of organisms which, with the aid of the oxygen, ammonia, watery vapour, and carbonic acid of the air, are capable of decomposing the rock and of forming nitrates and accumulating carbon.

Factors which determine Fertility.

The fertility of a soil depends only partly on its contents of plant-food (potash, lime, phosphoric acid, and nitrogen), and partly on the power the soil possesses of making use of these compounds. We have to take into account the other characteristics which conduce to fertility, especially the power possessed by the soil of changing the condition of the plant-food.

The soil is not an inert mass of material, out of which the plant picks whatever material is present for its nourishment, and, having exhausted that, dies. When we talk of changes that take place in the soil, we must realise that the changes are constantly going on, that the material of which the soil is composed is continually altering, that the growth and decay of plants, the movements of underground animals and of minute organisms, the fall of rain, the evaporation of moisture, alternations of temperature, of night and day, of summer and winter, even alterations of atmospheric pressure, the passing of clouds, and countless other phenomena of which we take no heed, or whose action we do not yet fully understand, all these agencies produce an incessant series of changes within the soil. When we add to these the changes produced by human agencies—by cultivation, by ploughing, liming, manuring, &c., &c.—it will be seen at once that a mere statement of the

amount of fertilising material in the soil, even if we could say how much was actually available for any particular crop, is not all that is wanted if we are to judge of the soil's fertility.

The fertility of a soil depends, then, in the first place, upon the presence of a sufficiency of plant-food, and, secondly, upon certain physical characteristics, possessed more or less by all soils, which effect the splitting up of the mineral ingredients and nitrogenous matter in such a way as to render them available to plants, as well as regulating the supply of water, warmth, &c.

Of these physical characteristics the most important are—

The texture or porosity of the soil.—On this characteristic depends a large number of the properties conducive to fertility.

By the porosity of the soil is meant the fineness and the number of its pores. We must distinguish between this and permeability to water; a coarse sand, for example, is permeable to water, but possesses properties exactly opposed to those of a porous soil. Humus soils are especially porous. On the fineness of texture depend the following characteristics:—

The capillary power, by which is understood the power of imbibing water. This property maintains a continual circulation of water within the soil, and consequent aeration. It is, moreover, largely through the agency of this circulating water, which is charged with carbonic acid and different salts, that the mineral and, in a less degree, the organic matter of the soil is rendered available for plant-food, and presented in solution to the plant.

The capillary power of a soil depends very largely upon the fineness of its texture. The nearer the texture approaches that of a sponge the greater will be its capillarity.

Humus has a very high capillary power, which is not possessed to any extent by either coarse sand or clay.

The capacity of the soil for water is also of special interest, and depends partly upon its porosity and partly on its content of organic matter. Peaty and humus soils, other things being equal, have the highest capacity for water, followed in order by marls, clays, loams, and sand.

The hygroscopic power—that is, the power of attracting water vapour—is of practical importance, in that it prevents undue evaporation, and prevents the soil from becoming parched up. It also serves as a guide to the absorptive power for other gases. This property, like capillarity, is due entirely to the fineness of texture, and the order is the same—humus, clay, loam, marl, sand, and coarse sand.

The absorptive power of the soil for salts is another factor of very great importance in determining the fertility of a soil. This power which soils possess of removing saline matter from solution, and retaining it within their pores, is due partly to the chemical nature of the soil, resulting in a chemical interchange of basic constituents, and partly to its mechanical structure, the fineness of its texture, substances such as humus and clay possessing the power in a remarkable degree.

Nitrification.

We now come to the most important property possessed by soils as affecting their fertility, and, at the same time, the most obscure, namely, their power of nitrification. This property depends upon a number of points on some of which our information is not very clear.

From what we know of the process of nitrification, we can lay down with tolerable certainty the following conditions as being favourable to the process:—

We must have free access of air and moisture, a certain degree of warmth, and the presence of nitrogenous organic matter prone to oxidation (represented by humus). The presence of reducible mineral matter, such as sesquioxide of iron or metallic sulphates, is also favourable. A sufficiency of basic substances to combine with the nitric acid appears to be advantageous to nitrification.

Putting on one side the bacteriological aspect of the phenomena involved, we shall find that the formation of nitrates within the soil is due primarily to oxidation, and that within certain limits the power of oxidation which the soil possesses is also the measure of its nitrifying power.

We are, therefore, justified in assuming that a soil will be most favourable to the development of the nitric ferment which combines the following characteristics:—

- 1st. A proportion of humus.
- 2nd. Warmth.
- 3rd. Provision for free access of air and of moisture (these depend upon its porosity, and are determined by its capillary power).
- 4th. Good drainage, to prevent stagnant water accumulating.
- 5th. A certain proportion of basic substances.

These conditions are more fully discussed on page 76, but it will be seen that, beyond the presence of certain mineral and organic matter, the conditions favourable to nitrification are those whose presence otherwise indicates fertility—namely, fineness of texture and absence of excessive water. If the capillary power of the soil is low, it indicates an unfavourable condition for nitrification.

It has been stated that the presence of nitrates in the soil assists in rendering soluble the potash in such insoluble combinations as felspar, which is an additional mode by which the nitric organism promotes fertility.

Provided then, that the condition of the soil, as indicated by the physical properties above enumerated, is favourable to the metabolism of plant-food, its fertility will depend upon the amount of that plant-food, and it is immaterial whether that food be now in a soluble state or not. If the mineral and nitrogenous matters are present in sufficient quantity, and the soil possesses high absorptive capacity, high capillary power—in short, is of good texture, and possesses the conditions conducive to nitrification—it may be fairly expected to prove a fertile soil; and, in cases where one or more of the conditions conducive to fertility are absent, we may look to improved methods of cultivation to attain that fertility.

The above considerations lead us to attach special importance to two factors in particular besides the chemical nature of the soil. One factor is the texture of the soil, its porosity, and the second is the amount of humus or decaying organic matter it contains.

It may be worth while to study these two points a little more in detail.

Texture of Soil.

We have seen that the texture is of first importance in determining the fertility of the soil. We will now discuss some of the conditions which affect the texture and some of the means to be adopted to promote the desired porosity of texture.

Relation of Texture to Moisture.

The ideal condition of the soil as regards moisture is obtained when the soil contains about half the amount of water which it is capable of holding.

For example, a fairly heavy clay soil will have on the average a capacity for water of about 40 per cent.—that is to say, 100 lb. of such soil will contain, when fully saturated with moisture, about 40 lb. of water. It is generally agreed that the amount of moisture most favourable to plant growth is something under half this amount, namely, about 18 per cent. If a much larger proportion of water exists than this, the interstices of the soil are filled with water instead of air, consequently there is a deficiency of oxygen, which we have seen is one of the prime agents in promoting chemical action within the soil. The soil becomes what is called water-logged, and the chemical action which we have recognised as essential to fertility is at a standstill. The roots of the plants, moreover, are immersed in water.

The condition of things in a soil containing the proper amount of water, and in good tilth, is pretty much as follows:—The minute grains of which the soil is composed do not form a compact mass, but the intervening spaces are so small that they act as capillary tubes, of the same nature as the pores of a sponge or the little tubes of an ordinary wick, and their effect upon the water present is exactly the same as the bundles of hollow tubes in the wick—that is to say, they draw the water up by the attraction of the sides of the tubes. Each grain of the soil will be then surrounded by a thin film of water, which in its turn encloses and surrounds small bubbles of air. (In the case of a waterlogged soil, these bubbles are driven out, and there is little or no air in the soil.) In and out amongst the grains of soil the plant pushes its roots and its root-hairs in search of food and moisture. If the above rough description is at all clear it is obvious that the water in the soil is *continuous*—that is to say, a sufficiently minute organism could pass through the entire soil in the water, without ever having to touch a particle of soil, or pass through a bubble of air. The result of this is that, supposing a particle of water to be removed at any point, either by evaporation at the surface or by absorption by means of the root-hairs, its place is at once taken by adjacent water, and the whole of the water in the soil is at once set in motion until equilibrium is again restored. It follows from this that a crop with well-developed roots is itself an important factor in retaining moisture within the soil, for, as the water is absorbed by the root-hairs at any point and circulates through the plant, its place is taken by adjacent particles of water, so that a steady flow of water is set up towards that point.

The evil effects of too much moisture, which cannot get away, have been already mentioned. In addition, it is to be noted that this is one of the most common causes of sourness in the soil. Sourness—that is, the formation of certain acids within the soil—is directly due to the absence of air and oxygen, and can be remedied by the free admission of air, as by turning over and exposing to the atmosphere.

To prevent this accumulation of water, the remedy is to drain. In many cases where it is due to the presence of a stiff clay subsoil, through which the water cannot penetrate, subsoiling is resorted to; but it is also possible to have too little water in the soil, with the result that the crops wither and die, and this takes place when the evaporation equals or exceeds the absorption by the roots. Plants absorb water only through their roots and root-hairs.

Evaporation.

The soil-water evaporates in two ways. The water absorbed by the root diffuses throughout the cell-system of stems and leaves, and evaporates through the breathing-pores of the leaf. Water is also lost by evaporation from the surface of the soil.

Both kinds of evaporation are increased by high temperature, dryness of the atmosphere, or a high wind—that is to say, evaporation is most rapid in hot, dry weather and a windy day; it is slowest in cool, moist weather and calm air.

The advantage of shelter in the shape of trees is, therefore, quite obvious as a means of cooling and moistening the air and breaking its force, and thus preventing too rapid evaporation. It is, unfortunately, largely ignored in New South Wales, where most of the trees are religiously “cleared,” and the crops protect themselves against drought as best they can.

I do not know of any other method for checking the evaporation from the leaves which has been successful, though one or two have been suggested.

With regard to the evaporation from the surface-soil, the case is different. Evaporation from the surface can be checked by mulching. A covering of leaves or farmyard manure, or any other form of mulch, protects the surface-soil from the heat and the dry winds which cause rapid evaporation, and thus prevents the too great loss of moisture; or the same result can be obtained by hoeing or stirring the surface-soil, which has the effect of breaking or widening the capillary tubes at the surface, and by this means preventing the upward motion of the water, for a time at least, and until the water has found out the new channels. Hoeing, therefore, which is generally practised for the removal of weeds, has another equally beneficial action, and it should be done, even where there are no weeds.

The above remarks show how important a matter is the texture of a soil in its relation to moisture, the ideal soil being one of a fine tilth, from which excessive moisture drains readily away, in which there is free movement of air and water, and in which too rapid evaporation is checked.

Humus.

Closely connected with the soil's texture and its consequent relation to moisture is its content of humus. Humus is the black or brownish matter in the soil produced by the slow decay of organic matter, whether of animal or vegetable origin. It is not a definite chemical compound, but a mixture of a number of different compounds, the nature of which varies, both with the original matter and with the age of the product.

Over that considerable portion of the State's arable land on which the rainfall is limited or uneven, the need of retaining within the soil whatever moisture is received as rain is one of paramount importance in the treatment of the land. The maintenance of the soil's fertility in these areas becomes largely a question of conserving this sometimes scanty supply, and soil-treatment having for its object suitable means of maintaining the most favourable conditions as to moisture will claim the most serious consideration of the farmer.

As the land taken into cultivation gradually extends so as to include more and more of the area within the belt of reduced rainfall and approaching to semi-arid conditions, this question of the conservation of soil moisture becomes of increasing importance.

It far exceeds in importance the question of manuring, and it is safe to say that unless the conditions as to moisture are satisfactory, the application of manures is not likely to be of any benefit, and the money expended on their use is practically thrown away.

Apart from the question of cultivation and drainage, the maintenance of the best conditions as to water within the soil depends to a very large extent upon the presence of humus. Humus, which is derived from the gradual decay of animal or vegetable matter within the soil, is one of the most important of the soil's constituents, and any great variation in its amount affects profoundly the value of the soil for agricultural purposes.

Functions of Humus.

The presence of humus in the soil increases the fertility in the following ways:—

In the first place it absorbs and retains moisture in the soil, and prevents surface evaporation. A surface soil, fairly rich in humus, exercises much the same influence on the underlying soil as does a mulch of dead leaves or other vegetable matter. During dry spells, and under the influence of hot winds usually prevalent under such conditions, the loss of moisture from the soil by surface evaporation is enormous, and in soils destitute of humus this loss is so rapid as to result in the drying up of the soil and the wilting of the crops. The final result of such conditions is the formation of scalded spots and the complete removal of the fine surface soil by the wind in the form of dust.

The humus in the soil is the ingredient which is most subject to alteration and destruction, and under dry conditions it is more or less rapidly destroyed. As soon as it has lost its moisture and become dry it is rapidly burnt out by the combined action of sun and air. So that it is exactly in those circumstances where its presence is most essential that it is most liable to destruction, and the necessity for renewing it most urgent.

The presence of humus in the soil tends to improve its texture, lightening and loosening it, and preventing compaction of the surface, so that it is of special value in the amelioration of stiff soils.

It is the principal source of nitrogen in the soil, and by its decay under the influence of soil organisms, ammonium salts and nitrates are produced, which are the forms in which this important element is assimilated by the plant. It is of interest to remember that the humus of arid or semi-arid regions is richer in nitrogen than that of the moister districts. This is a point of great importance with reference to the potential fertility of these soils. In point of fact, from a variety of causes acting together, the soils of the dry climates are richer in plant-food of all kinds than are the soils in regions of greater rainfall, consequently nothing but the absence of water prevents these from being extremely reproductive. There is, therefore, no problem which exceeds in importance that of retaining in the soil the little moisture that it receives, and any operation that succeeds in arresting even partially the unavoidable loss of that moisture deserves the highest consideration.

Methods of supplying Humus.

There are three ways of supplying humus to soils in need of this constituent, namely, by the application of generous additions of farmyard manure (in cases where this is available), by the application of compost manure, and by green-manuring, or the ploughing under of a quickly-growing green crop (leguminous for choice).

(a).—Farmyard Manure.

Except in some dairies or such farms on which the animals are stall-fed the material known as farmyard manure is nothing more than the solid excrements of animals, and does not contain either the urine or the vegetable matter used as bedding which is the characteristic of farmyard manure made and used in Europe and colder countries.

Owing to the absence of vegetable matter such manure has very little value in the formation of humus, and it is probably most economically used in the compost heap.

(b).—The Compost Heap.

The compost heap is a most valuable adjunct to the farm, and it is a very great pity that it is not more frequently to be found.

A heap or pit can be made very economically, and is of special value in that it utilises all sorts of vegetable and animal refuse, which would otherwise be wasted, and converts it into a valuable manure, rich in organic matter, and eminently suited for soils low in humus or subject to droughty conditions.

The principle of the compost heap is the fermentation of easily-decomposed vegetable matter in the presence of earth and lime. It is not only substances like peat and straw, which form the usual basis of compost heaps, that are thus decomposable, but almost every kind of organic substance, both of vegetable and animal origin, can be thus composted. Dead leaves, bush scrapings, sawdust, weeds, tops and stalks of vegetables, as well as bone and animal refuse, can be treated in this manner. In the case of animal refuse, the operation is much slower, and substances like bones should be first crushed. It is also important to be sure that animal refuse so treated is not derived from a diseased source.

The best way of making and maintaining the compost heap will depend largely upon local surroundings.

As a general method of procedure the following will be found satisfactory:—Make a heap with alternate layers of earth, refuse, and lime. Under the term refuse is included all the refuse material of animal or vegetable material mentioned above. Cover the whole with a layer of earth. When a sufficient quantity of refuse is again collected, place it on top of the heap and cover with a layer of lime, and lastly of earth, until the heap is 3 or 4 feet high. The heap should be kept moist, and for this purpose all refuse water from the house, slops, urine, &c., should be added. The heap may be conveniently watered by making a hole into the interior and pouring the liquid in. The outer covering of earth has the object of absorbing any ammonia which is evolved in the process of fermentation and by the action of the lime.

When the heap has been prepared it must be left to itself to ferment for some time. Probably a few months will be sufficient unless very refractory substances, such as bone, &c., are present. In a few months' time it should be well forked over and another layer of lime, and finally of earth, should be added. In the course of another month or two it should be ready for use, and you will have provided yourself at a very slight cost with an excellent manure, rich in humus, and will have utilised for the purpose a great amount of refuse material which would otherwise have been lost or burnt. When refuse material is burnt, the ashes, though still possessing manurial value on account of the lime and potash and phosphates they contain, are of

incomparably less value than the original substance out of which they are derived, owing to the absence of humus material and nitrogen, both of which have been lost in the process of burning.

Instead of a heap the compost may be conveniently prepared in a pit. In either case the bottom should be cemented, or so drained that the liquid escaping from the mass can be collected and returned to the compost.

It will be found advantageous to prepare a second heap while the first one is ripening and being used. It will also be found that if it is desired to use more concentrated fertilisers, such as superphosphate, potash, and ammonium salts, these can be mixed with advantage with the compost manure before being applied to the land. Used in this way they will be in less danger of leaching away, and will be of greater benefit than if applied directly to the land.

(c).—*Green Manuring.*

Amongst the most effective methods of supplying humus to the soil and increasing its fertility is the practice of green-manuring—that is, the ploughing under of a green crop. The beneficial action of this operation is a twofold one: it enriches the soil, in the first place, by supplying it with a considerable proportion of readily-available plant-food; and in the second place, by adding humus, and thus improving the soil's texture and its power of absorbing and retaining moisture. When such a crop is buried, the surface soil becomes enriched by the nourishing materials which the crop, during the period of its growth, has drawn from the air and from the lower portions of the subsoil, and this material is now placed within the reach of the succeeding crop.

During the growth of the plant the soil has, in addition, been stirred up and disintegrated by the development of the roots. When ploughed under, provided that sufficient moisture and warmth are present, the buried mass decomposes with more or less rapidity, and the succeeding crop gets the benefit of the fertilising ingredients contained in the decaying mass of vegetation in a readily-available form. The resulting humus is of the greatest value, not only as a source of plant-food, but in improving the soil's texture, in preventing too rapid evaporation, and in enabling the soil to absorb and retain water, thus rendering it less liable to suffer during dry spells.

A further important result is the formation of carbonic acid by the decomposition of the buried crop. Carbonic acid is given off abundantly in the fermentation of the mass and assists in the disintegration of the soil and in rendering available the plant-food contained in it.

Green-manuring is effective both in sandy and in heavy clay soils, and, indeed, on all soils deficient in humus. On sandy soils the effect of green-manuring is to consolidate the soil, the humus formed binding the particles together. On clay soils, the effect of the addition of humus and the production of carbonic acid is to loosen and aerate them. When conditions as to warmth and moisture are favourable, and the crop decomposes fairly rapidly, the production of soluble plant-food proceeds with considerable rapidity. This is especially the case in respect of nitrogen, which is the principal manurial ingredient. Nitrification (that is, the conversion of the nitrogenous material of the plant into soluble nitrates) takes place quite rapidly. In sandy soils, green manure nitrifies more rapidly than manures like dried blood, bone-dust, &c., and only less slowly than ammonium sulphate; while in stiff clay soils the green crop nitrifies very much more rapidly than either sulphate of ammonia or animal manures.

With regard to the kind of crop to be used for the purpose of green-manuring, a good deal of latitude is permissible. Any crop that is rapid and luxuriant in growth, and that can be readily turned under, is suitable for the purpose, and the selection will be guided by considerations such as the time of year at which it is to be grown, its suitability to soil and district, &c. Amongst the most effective class of crops for the purpose are leguminous plants, such as clover, cowpeas, &c., since these are specially valuable on account of their power of obtaining their nitrogen from the air. They are, therefore, especially suitable for soils poor in nitrogen, and are of high value in enriching the soil with this ingredient. There are, however, many other crops which are suitable for the purpose, and frequently used, such as oats, rye, &c. These are all rapid growers, and can be grown as catch-crops—that is to say, after the main crop has been harvested and before the succeeding one is sown. The practice of growing a crop of tares or vetches after the wheat crop has been harvested is very common in Europe, and can be followed successfully here in districts where the autumn rainfall is sufficient. Such a catch crop occupies the ground only at a time when it would be otherwise unoccupied, and, during its growth, is collecting plant-food from air and soil, which is utilised for manuring the succeeding crop.

The practice of green-manuring is of special value in orchard work, where the green crop can be grown and ploughed under between the rows.

It must be borne in mind, in all cases, that green-manuring depends for its success upon conditions favourable to the decomposition of the buried green crop, namely, sufficient warmth and moisture. A crop ploughed under in the late autumn or winter will nitrify only slightly, and the same applies to ploughing under a crop in a dry season. If the land is quite dry the crop will remain buried without decomposition for a considerable period, and its benefit is lost.

Proportion of Nitrogen supplied to Soil by Green Manuring.

With regard to the actual amount of material supplied to the land by ploughing under a green crop, some experiments were carried out at the suggestion of Mr. W. J. Allen, the Fruit Expert of the Department.

The produce of one square yard of crops of vetches, at Wagga, Bathurst, and Hawkesbury College, was harvested carefully, tops and roots, and forwarded for analysis. In the case of the Wagga sample, the roots were obtained by washing away the soil, and the Manager calculated that he succeeded in obtaining 95 per cent. of the total weight of roots in the soil. The produce of tops from one square yard was 4 lb. 14½ oz., or 10 tons 12 cwt. per acre; and of roots, 1 lb. 9 oz. per square yard, or 3 tons 7 cwt. per acre. Analysis showed that the tops contained 87 per cent. water (13 per cent. dry matter) and .506 per cent. nitrogen; the roots contained 83 per cent. water (17 per cent. dry matter) and .213 per cent. nitrogen.

When, therefore, this crop was ploughed under, it added to each acre of the soil, in the shape of dry matter, 1 ton 7 cwt. tops, and 11½ cwt. roots, including 120 lb. nitrogen from the tops and 16 lb. nitrogen from the roots; a total of 136 lb. nitrogen per acre. Assuming that conditions were favourable for nitrification, this would be equivalent to a dressing of nearly 7 cwt. sulphate of ammonia per acre, or over 11 cwt. dried blood—an enormous dressing.

The soil in which this crop was grown was a light loam with about 25 per cent. clay. The clay is of a tenacious character, and has a tendency to cake hard on drying. The soil is low in humus, containing only about 4 per cent. of this ingredient. It is fairly rich in potash and satisfactorily supplied with lime, but rather low in nitrogen and phosphates. It is, consequently, just the type of soil in which green-manuring should be effective, as the effect of ploughing under the crop will be to break it up and render it more friable, and to supply the deficiencies in humus and nitrogen. Its efficacy is, of course, dependent upon conditions as to rainfall being favourable to its decomposition in the soil. The climate of Wagga is not very favourable to the growth of these crops.

At Bathurst, and at the Hawkesbury College, where conditions are more favourable, the benefits of green-manuring were even more striking. Mr. Allen obtained similar samples of tops and roots, representing the produce of one square yard from crops grown at these places, and they gave the following figures:—

At Bathurst, the tops weighed 17 lb. and the roots 2 lb. 5 oz. per square yard, or 36 tons 14 cwt. tops and 5 tons of roots per acre, giving a total of dry matter to be ploughed under of 4 tons 15 cwt. from the tops and 16 cwt. from the roots. Assuming the same nitrogen content in tops and roots as was found in the Wagga plants, this would give when ploughed under 411 lb. nitrogen per acre from the tops and 22 lb. nitrogen from the roots.

At Hawkesbury the produce was 21 tons 12 cwt. tops and 4 tons 14 cwt. roots per acre. When ploughed under, this would yield 2 tons 16 cwt. dry matter from the tops and 16 cwt. dry matter from the roots. With .5 per cent. nitrogen in the tops and .2 per cent. in the roots, the soil would be enriched in nitrogen by 242 lb. per acre from the tops and 22 lb. from the roots.

The Plant's Supply of Nitrogen.

The question of the plant's supply of nitrogen is one of the most interesting of the problems presented to the agriculturist; it is also one of the most obscure and least understood. A large proportion of the dry matter of all plants consists of nitrogenous material, and this portion of its structure is of fundamental importance to the plant. Further, it is upon the nitrogenous matter of plants that animals depend for their proteid material—blood, flesh, &c.—since animals can only utilise for this purpose nitrogenous material already elaborated in the tissues of plants or other animals.

The ultimate source of all this nitrogenous matter is the free nitrogen in the atmosphere. It is the study of the different methods by which this element is brought (naturally or artificially) into combinations in which it can be utilised by the plant that will form the subject of the present discussion.

The plant may absorb its nitrogen in two ways, either by means of its leaves from the free nitrogen or from the ammonia or the nitric acid in the air, or by means of its roots.

With regard to the first of these, the absorption of nitrogen by means of the leaf, the question cannot be said to be definitely settled at the present time; the consensus of opinion, however, is that if such absorption takes place, it does so to a very limited extent, and is insufficient to constitute part of the economic functions of the plant.

By means of its roots, however, the plant absorbs nitrogen, in the form of either nitrates, nitrites, or ammonium salts dissolved in the water of the soil.

It appears probable that the nitrogenous material taken up by the plant from the soil by means of its roots enters the plant in the form of nitrates. In the case of leguminous plants, as we shall see later on, the free nitrogen contained in the air imprisoned in the soil can be made use of under certain conditions by the roots of these plants.

Formation of Nitrates in the Soil.

It has long been known that the addition to a sterile soil of a quantity of a more fertile one rendered the sterile one fertile; and the operation of top-dressing poor soils in this manner was a common one amongst the nations of antiquity.

When the subject was approached in the light of more recent advance in scientific knowledge, it was shown that this increase in fertility was accompanied by an increase in the quantity of nitrates in the soil. How it was that the addition of so small a proportion of a soil containing nitrates could bring about the large increase of nitrates observed was a problem which remained unsolved until the discovery by Pasteur of organisms capable of inducing fermentation and of producing certain chemical substances as by-products, paved the way for a rational explanation of the process. Pasteur himself surmised that this gain in nitrates was due to bacterial activity.

(a).—From Nitrogenous Organic Matter.

In 1877, it was shown by Schloessing and Muntz that the formation of nitrates (nitrification) only took place within certain temperatures, and that it could be entirely stopped by antiseptics—such as chloroform vapour—showing that nitrification was brought about by the action of organisms.

We know now that quite a number of different organisms take part in the conversion of organic nitrogenous material into nitrates. In the first stage of the process, the nitrogenous matter in vegetable or animal refuse is converted by putrefaction into humus, carbonic acid being evolved and the nitrogen converted into simpler forms such as amides (*asparagin, urea*) and ammonium carbonate; the familiar odour of stables and dung-heaps being due to the ammonia evolved. Quite a number of bacteria and moulds possess this power of converting albuminoid matter into ammonium salts. In ordinary manure heaps moulds produce this decomposition; in arable soils it is brought about by the action of bacteria (particularly by *Bacillus mycoides*, which is widely distributed in the surface-soils, air, and water). The further nitrification of ammonium salts is the work of yet other bacteria.

Warington first showed that there were two distinct stages in the conversion of ammonium salts into nitrates, and that nitrites were formed as an intermediate oxidation. Consequently, there must be two distinct organisms involved.

In 1890 these were isolated by Winogradsky, who found two distinct organisms capable of converting ammonium salts into nitrites—namely, *Nitrosomonas europea*, occurring in soils of the Old World, and a nitrococcus, which he found in American and Australian soils.

The further conversion of nitrites into nitrates is the work of another organism, of the genus nitro-bacter.

Frapps has identified a fourth organism, which it is stated converts nitrogenous organic matter directly into nitrites and nitrates. The process takes place, more or less vigorously, in all soils not absolutely destitute of organic matter, but there are certain conditions which are more particularly favourable to the process. They are—

1. The presence of organic matter prone to oxidation, represented by humus.
2. The presence of suitable food for the growth and development of the organisms, such as lime, potash, sulphates, and phosphates, and free carbonic acid.
3. Suitable temperature. The optimum temperature being about 35° to 36° C. Nitrification is stopped at temperatures over 50° to 55° C., or at 0° C.
4. The presence of a base to combine with the free nitrous and nitric acid formed. Carbonate of lime is the most suitable. The presence of free acid prevents nitrification, so does excessive amount of alkali (carbonate of soda).
5. Moisture.
6. Absence of too strong light.
7. Presence of sufficiency of oxygen (the process is essentially one of oxidation).
8. Good drainage.

(b).—*From the Nitrogen of the Air.*

We have, so far, discussed the question of the plants' supply of nitrates (which are the principal source of the plants' nitrogen), and we have seen that these are derived from the decomposition of animal and vegetable nitrogenous matter within the soil. How is this material, in its turn, derived from the free nitrogen of the air, for that must be its ultimate source? Atmospheric nitrogen is converted into organic material in nature in several ways.

Quite a number of free-living organisms have been isolated during recent years which have the power of fixing the free nitrogen of the air, and thereby enriching the soil in nitrogenous material and nitrates.

The *Azotobacter chromococcum* (for example) of Baeyerink is capable of fixing atmospheric nitrogen in a medium in which nitrogenous matter is absent, the fixation being due to the presence of lime, and is much more active in soils rich in lime.

These free-living organisms do best in soils containing organic matter, but poor in nitrogen. Hall thinks that, as in the case of the nitrifying organisms, the fixation depends upon the oxidation of carbohydrates, which supplies the energy.

Henry has found that decaying leaves of forest trees, such as oak or beech, possess the power of fixing free atmospheric nitrogen in considerable quantities. The fallen foliage on the surface of the ground in an oak-forest accumulates 13 kilogrammes of nitrogen per hectare annually (11½ lb. per acre). In the case of beech leaves, 22 kilogrammes is annually accumulated per hectare (19¼ lb. per acre).

(c).—*By the Root-nodules of Leguminous Plants.*

An extremely interesting instance of the absorption of free nitrogen by a certain class of plants was first observed by Hellriegel and Willfarth.

The roots of leguminous plants when vigorously growing develop small nodules or excrescences, which contain bacteria capable of fixing the free nitrogen in the interstitial atmosphere of the soil, and of handing it over to

the plant in a form in which it can be readily assimilated. The process is either symbiotic or parasitic, and is quite distinct from the fixation of nitrogen by the free-growing organisms, and explains the enormous gain in nitrogen found to result by the growing of a crop of clover or peas. The growth of such a crop, even if not turned under, enriches the soil in nitrogen by the production of these nitrogen-fixing bacteria.

Pure Cultures of Nodule Organisms for Use.

Many attempts have been made to prepare cultures of these organisms, for use in directly inoculating either the seed or the soil. The best-known of these was a preparation originally prepared by Professor Nobbe, and known as "Nitragin," which has been in use for many years, and which consisted of gelatine cultures of these organisms. Its use was not attended by universal success, and many attempts have been made to prepare by other methods cultures of these organisms which shall possess greater vitality and be of more universal practical application. The best known of these in recent years have been prepared by Professor Hiltner, in Germany, by Dr. Moore, of the United States Department of Agriculture, and by Professor Bottomley, of London.

Reports of exact experiments conducted with these cultures in England, Canada, and South Africa, show that it is premature to claim for them anything like certainty in ordinary farm practice. Our own experiments with Dr. Moore's cultures, both in pots and in the field, have likewise yielded disappointing results, and the fact is forced upon us that the reports of the remarkable results alleged by the American magazines to have resulted from their use have been much exaggerated. It is always quite possible that some method of preparing these cultures will be devised by which the vitality of these organisms may be retained and their use made of practical value for farm-work.

Artificial Fixation of Atmospheric Nitrogen.

The free nitrogen of the air can then be utilised in the manner above noted by plants for their growth, principally by means of free-living organisms within the soil and by the bacteria in the root-nodules of leguminous plants. A point of the very greatest importance to us is, can we produce artificially this nitrogen absorption? Can we convert atmospheric nitrogen into a form in which it can be utilised by the plant? The importance of this point is enormous, for nitrogen is one of the essential constituents of the food of plants, and owing to the soluble nature of the nitrates produced by the soil, it is continually being washed out by rain into the subsoil beyond the reach of the plant-roots. Consequently, it is necessary to constantly replenish it, and this is done by manuring.

Manures such as blood, bone-dust, stable manure, nitrate of soda, and sulphate of ammonia, owe their value to the nitrogen they contain, and enormous quantities of the more concentrated manures, such as nitrate of soda and sulphate of ammonia, are used for this purpose. Nitrate of soda is at present exported from a narrow strip of land east of the Andes. The present export is about 1,500,000 tons per annum, equal to £16,000,000. It is expected that the deposits will be exhausted in 1950. It is not only the most important, but the most expensive of the fertilising ingredients, costing about 9½d. per lb., potash costing about 6¼d., and phosphoric acid about 1½d. to 2¾d., according to its solubility. Latterly various methods of fixing the nitrogen of the air have been devised, and the development may have the most important results in the increase of the yield of farm crops. Nitrogen is one of the most difficult elements to force into combination; it combines directly with only a few elements.

The text-books tell us that nitrogen is the most inert of elements. It would, however, be fairer to say that it is characterised by a highly aristocratic exclusiveness. So strongly marked is this characteristic, that even when it has been coaxed into certain combinations (such as nitro-glycerine, picric acid, nitrogen chloride, &c.), it sets itself free on the slightest provocation, and with explosive violence. On account of this aloofness, it has only recently been possible to devise means whereby atmospheric nitrogen can be made to combine in such a form as to be available for plant-food when applied to the soil. Recently, however, experiments have been carried out in several directions which contain considerable promise of success, and the future developments of these processes will be watched with extreme interest.

Calcium Cyanamide.

When air from which the oxygen has been removed, and which is practically pure nitrogen, is passed over calcium carbide at a white heat, it combines, forming a compound known as calcium cyanamide, CaCN_2 , in the form of a fine black powder. This is readily converted by water into ammonia, and the crude cyanamide has been found to possess manurial value, due, no doubt, to the production of ammonia. The results of trials with it at Rothamsted and several of the German experiment stations show that while it has a distinct manurial value, there is nothing to show that it has a higher manurial value than sulphate of ammonia, with which it cannot compete in price, at least at present. There are certain disadvantages connected with its use; for instance, it must not be used as a top-dressing, as loss of ammonia results; nor must it be mixed with superphosphate, as the mixture becomes hot. It is most efficient when sown about ten days before the seed, as when sown with the seed it has a markedly injurious effect upon the germinating power. It is most effective when mixed with peat, or applied to peaty soils, the peat no doubt acting as an absorbent for the ammonia. It may be said that its future success depends upon whether it can be produced at a cost which will enable it to compete with ammonium sulphate or nitrate of soda.

Production of Nitrogen by Electricity.

Another, and apparently more promising, method of utilising atmospheric nitrogen, has been rendered possible by later developments in electricity. When air is sparked, the nitrogen and oxygen combine to form nitric oxide, which in the presence of water becomes nitric acid. This happens always in the neighbourhood of electrical machines, and the lightning flashes during thunderstorms also produce the same result, so that the air during thunderstorms always contains small quantities of nitric acid. Many attempts have been made to utilise this action on the manufacturing scale. Amongst the earliest of these which had any measure of practical success was Bradley and Lovejoy's, which was in operation at Niagara Falls until 1904. One of the most successful of these processes is that patented by Birkland and Eyde in 1903 (see *Journal of Society of Chemical Investigation*, 1905). This is being carried out at Savelgfors, in Norway, where works have been erected utilising 30,000 horse-power and producing large quantities of calcium nitrate for use as a manure. The several features of the process are the following:—Air is led into a specially-constructed electric furnace, where it is heated to a very high temperature by an electric arc, spread out into a fan-shape under the influence of powerful electro-magnets. The oxides of nitrogen formed are passed into towers, where they are dissolved in water and concentrated. The whole of the gases are not, how-

ever, absorbed by the water, as it is so diluted with the air which passes over with it that at least half escapes absorption. This is passed into a tower charged with milk of lime, where it is converted into nitrite and nitrate of calcium. By further treatment with nitric acid, a calcium nitrate, containing about 13.2 per cent. nitrogen, is formed (pure $\text{Ca}(\text{NO}_3)_2 = 17$ per cent. nitrogen). It is placed in the market, either in this form (either fused or in crystals), or, preferably, by converting it (Messel's process) into a basic salt by calcining it with lime, this product being non-hygroscopic, whereas ordinary calcium nitrate absorbs water from the air and becomes moist. This is a point of considerable importance in determining its value as a manure.

Calcium nitrate appears to be just as effective as sodium nitrate containing the same amount of nitrogen. The determining factor is, of course, the cheapening of the unit-cost of the current, by the provision, for example, of water supply adequate to produce the requisite power at a cheap rate.

More Recent Processes.

Instead of combining atmospheric nitrogen with oxygen to form nitric acid, as in the above processes, it may be combined directly with hydrogen to form ammonia.

Haber Process.—This process, or some modifications of it, has been the basis of most of the recent processes for the fixation of atmospheric nitrogen. Hydrogen, obtained from water by the decomposition of steam by iron or coal or coke, is directly combined with the nitrogen of the air under the influence of a catalyst, such as finely-divided iron. The ammonia thus obtained can be converted into sulphate of ammonia or oxidized to nitric acid.

Oxidation of Ammonia to Nitric Acid.—The ammonia produced by the Haber process or its modifications, or by any other process, such as the destructive distillation of coal in the manufacture of coal-gas, can be converted directly into nitric acid. A mixture of air and ammonia can be so oxidized in contact with metallic platinum, the platinum acting as a catalyser.

Recent Developments brought about by the War.—The need for nitric acid nitrates in the manufacture of high explosives, brought about by the war, caused a rapid development of methods for extracting nitrogen cheaply from the air. When Germany declared war she was in a position to be independent of the Chilean nitrate supplies. She was in possession of the Haber process for the production of ammonia and the Ostwald process for its oxidation to nitric acid, and these processes were heavily subsidised by the Government.

The world's consumption of fixed nitrogen went up rapidly and enormously. Germany alone, for example, which consumed about 250,000 tons nitrogen in 1913, consumed 400,000 in 1917. Many modifications of the Haber process for the production of ammonia and its subsequent oxidation to nitric acid have been introduced, and the cost of production of both fertilisers and explosives from the air very considerably reduced.

Cyanide Process.—This has been developed principally in the United States. In this process sodium cyanide is produced from carbonate of soda, coke, iron, and atmospheric nitrogen, a process which does not involve the use of electricity. The cyanide can be converted into ammonia and this in turn, as with the processes referred to above, into ammonium sulphate or nitric acid.

MANURES AND MANURING.

In order to understand properly the action of the different substances used as manures, it is necessary to study in some detail the food requirements of the different crops and the manner in which these are satisfied.

The Chemical Composition of the Plant.

This subject will be dealt with as broadly and generally as possible, so as to avoid technical language, and to bring into prominence only those essential points which will enable us to understand the connection between the chemical requirements of the plants and the part played by the soil and by manures for their provision.

We shall not go far wrong if we assume that all plants are built up of the same elements combined together in different proportions. These elements are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, silicon, chlorine, potash, and about half-a-dozen metals in combination. It is to the relative proportion of these elements and their compounds that the great differences in the chemical composition of the various plants are due.

Different combinations of carbon, hydrogen, and oxygen give us the large class of bodies known as carbohydrates, including such dissimilar substances as starch, sugar, the woody structure, cellulose, gum, &c. Hydrogen and oxygen combined give us water; nitrogen, united with the above elements and sulphur, forms the nitrogenous constituents of the plant, such as the gluten in wheat. Little is known regarding the manner of formation of these substances in the living plant. Still less is known of the metals—their disposition in the plant, and the changes they undergo. We are able to detect their presence in the ash, in combination with oxygen, phosphorus, sulphur, and chlorine.

Not only do the quantities of the different elements vary in different plants, but in the same plant some elements are present in quantities out of all proportion to the others. Over one-half of the bulk of most growing plants consists of water. In watery fruit, such as the melon or cucumber, the percentage of water is as high as 90 to 96. Of the remaining portion of the plant the compounds of the metals rarely exceed 2 per cent., and are more often about 1 per cent. This you may readily prove by burning a weighed quantity of any green crop until a white ash, or nearly so, is left. The ash from every pound of such crop will not weigh more than 100 grains.

The point of importance for us to keep in mind is that each of these plant-constituents is as necessary for the well-being, even for the existence, of the plant as any other, whether that constituent be present in large or small quantities. The substances found in the ash, though present in minute proportions, are as indispensable to the well-being of the plant as the elements found in large quantities. Not only that, but if any single one of the ash-constituents is insufficiently supplied—if the potash is deficient or the iron—the plant suffers, although the amount of such element does not in many cases amount to more than a fraction of 1 per cent.

The volatile portion of the plant—that is, the water and the carbohydrates—is for the most part abundantly supplied to it by air and rain (with the exception of nitrogen in some plants)—that is to say, about 98 per cent. of the food of the entire plant is derived from air and water. From the soil it extracts the remaining 2 per cent., consisting for the most part of iron, lime, magnesia, potash, and soda, combined with sulphuric, hydrochloric, and phosphoric acids, together with the nitrogen as already

stated. These substances it is the function of the soil to supply, and where the soil, by reason of its nature, or from having been exhausted, is unable to meet the demand, we have to assist it by means of manure.

The object, then, of manuring is to assist the soil in presenting to the plant a portion of the food necessary for its growth; and though the food-stuff thus supplied is extremely minute in comparison with what the plant derives from other sources, it is nevertheless of the greatest importance, and its absence or insufficiency will affect the health of the plant quite as much as will the absence of air or of sunlight or of water.

Ingredients to be supplemented by Manure.

Of these ash ingredients, the greater portion is found in all soils in quantities more than sufficient for the requirements of any number of crops; thus, iron, magnesium, sodium, manganese, chlorine, sulphuric acid, silica, are present in nearly all soils in greater quantities than the plant requires, so that there is little danger of the soil becoming exhausted as far as they are concerned. The ingredients, therefore, that we have to supplement by means of manure are reduced to three or four, viz., lime, potash, phosphoric acid, and nitrogen.

Lime is probably present in most soils in quantities sufficient for the purposes of plant-food, and it is seldom necessary to supply it with that object. Its principal functions when applied to land are, firstly, a mechanical one, in modifying the physical character of the soil; and, secondly, a chemical one in rendering available certain insoluble plant-foods. (See pages 88 to 92.) Lime acts, however, also directly as a plant-food, and the different classes of artificial manures fall under one or other of the above headings, according as they supply lime, potash, phosphoric acid, or nitrogen.

The food thus supplied by the soil is taken up in solution by a peculiar process by means of the roots. It is necessary, therefore, that such food should be in a soluble form to be of any use to the plant, which is unable to utilise insoluble material. By soluble we mean soluble in water or in the weak acids present in the soil or secreted by the plant-roots.

Insoluble and Soluble Plant-food.

This is what is meant by the constituents being "available for plant-food," and when the terms "latent" or "dormant" and "active" are employed, they simply mean insoluble or soluble in the water imbibed by the root. Those manures which are known as quick-acting manures are such as contain their potash, phosphoric acid, and nitrogen in a soluble form at once available for the plant; those which are slow-acting contain these substances in a more or less insoluble condition.

In these latter cases a gradual decomposition takes place in the soil, due to the action of chemical agencies within the soil and assisted by the action of the roots of the plant, by which the insoluble compounds are converted into soluble ones, and so become gradually available, the beneficial action extending over a long period of time.

A good example of these two conditions is found in the state of the phosphoric acid in bone-meal and in superphosphate respectively. Bone-meal consists of bones ground to a powder, and the compound of phosphoric acid and lime which it contains is insoluble in water to any appreciable extent. In course of time the agencies at work in the soil render it soluble. Superphosphate is a compound manufactured by treating bones or mineral phosphates with strong oil of vitriol, by which treatment a different compound of phosphoric acid and lime is produced. This, being readily soluble, is at once made use of by the plant.

Crop Requirements.

From the preceding considerations, which I have endeavoured to make as clear and as general as possible without going into precise details, we shall have realised that a definite relationship exists between the requirements of the plant and the nature of the food with which we have to supply it. All plants do not take up the constituents presented by the soil in the same proportion, and are consequently benefited differently by different manures. Whilst all crops will benefit from the application of a complete manure containing all the elements of plant-food, there is in each case a special ingredient or ingredients which the crop more particularly requires. Some require potash, others nitrogen, whilst others do not thrive unless there is abundance of phosphoric acid.

What these special requirements are, and the nature of the different manures by means of which they are satisfied, we are now in a position to inquire into.

We know that in the selection of the proper manure for use in any special case we have, in the first place, to consider the requirements of the crop in question, and, secondly, how far the soil can supply those requirements.

In connection with the rational application of artificial manures, we have therefore the following points to consider:—

1. What are the chemical requirements of the different crops?
2. How far does the soil supply these requirements?
3. In what direction is it to be assisted by manure?

I do not propose to touch upon the question of tillage or of general farming operations, except in so far as they may produce chemical changes in the soil constituents. The action of the different manures will be regarded entirely from a chemical point of view as plant-food.

In the first place, with regard to the requirements of the different cultivated crops, a very superficial observation is enough to show us that the food required by different plants must vary considerably. Plants vary enormously in character, and every plant requires one or more special sorts of food, and exercises a power of selection in regard to such food. Some crops cannot make use of the soil-ingredients to the same extent as others do.

Some crops also occupy the ground for a longer period than others; those that come rapidly to maturity will require a larger store of food which is immediately available. Again, their requirements vary in many cases at different stages of their growth. What these special requirements are we will proceed to examine more in detail for each class of crop.

The Requirements of Wheat.

Wheat thrives best in free loamy soil, with a dry subsoil about 9 to 12 inches below the surface. A good subsoil is of great importance in the dry districts, as it retains the moisture and enables good crops to be grown where otherwise the crop would fail through the drying out of the soil.

The quantities of the different fertilising ingredients removed from the soil by the wheat crop are as follows:—

A wheat crop of 30 bushels grain to the acre weighs about 5,000 lb., or something over 2 tons of grain and straw, and removes from the soil during the period of its growth 48 lb. nitrogen, 21 lb. phosphoric acid, and 29 lb. potash.

The wheat crop depends practically entirely upon the soil for its nitrogen, so that for the whole of the above quantities of food the wheat is dependent upon the supplies existing in the soil. Now, 48 lb. nitrogen is equivalent roughly to about .003 per cent., as indicated by analysis in a soil of average weight 6 inches deep. This quantity is very much less than the average percentage of nitrogen in our soils, which is quite .1 per cent. In the same way 21 lb. phosphoric acid represents about .001 per cent. phosphoric acid in a soil of average weight and depth. This quantity is present ten times over, even in poor soils, as is also .002 per cent. potash, the quantity represented by 29 lb. potash, required by the 30-bushel crop. If, then, it were possible to convert the plant-food in the soil into an available form at the times that the plant could make use of them, the necessity for manuring of any sort would be done away with and the poorest soil would contain abundance of plant-food for a succession of several crops. But wheat does not appear to be capable of utilising the soil-ingredients to their full extent, consequently the application of soluble manures is particularly beneficial to it and the other cereals.

The Use of Superphosphate in Manuring Wheat.

In the great majority of cases the manuring of wheat lands resolves itself into the application of a small quantity of superphosphate, either applied broadcast on the land or drilled in with the seed when sown. In this respect the practice is opposed to that which prevails in the older wheat-growing countries of the European Continent and in England and America, where the application of nitrate of soda is almost universal. With the application of nitrate of soda (or of ammonium salts) by itself is found to be of little or no benefit, whereas in most cases the addition of a small proportion of superphosphate in the early stages of the plant's growth insures an increased harvest. The soundness of this view has been confirmed by exact experiments carried out in all the Australian States, including our own. The reason of this want of response to nitrogen in the wheat crop is, I think, to be found in the different conditions as to rainfall under which the crop is grown, and the effect thereby produced in the natural formation of nitrates within the soil.

In Europe the grain sown in autumn remains dormant after germination for four to five months during the late autumn and winter, its period of active growth being practically confined to the months of April, May, and June, and being particularly active in May and June. It is during this dormant period that the greatest fall of rain takes place. The ground is covered with snow during the winter months, so that during the thaws, when the frost breaks up in February and March, the soil is subjected to a very heavy leaching. This applies more particularly to Northern Europe and America, where there is little thawing during the actual winter, and the whole of the accumulated snow melts in a comparatively short time, flooding the land, and leaching out the nitrates which have been produced during the previous summer and autumn. The leaching process is continued by the spring rains—which are usually fairly heavy—of March and April, so that when the plant enters upon the period of its most active growth in May, the soil's store of nitrates is removed beyond the reach of the roots, and the addition of readily available nitrogenous manures such as nitrate of soda or sulphate of ammonia is essential for a satisfactory harvest.

The Rothamsted experiments show that nitrification is most active during summer and autumn, the formation of nitrates increasing from July to October. When wheat was grown at Rothamsted after fallow the increased yield was found to be almost wholly due to the retention in the soil of the

nitrates thus formed in the summer, and depended upon whether the fallow was succeeded by a wet or comparatively dry autumn. Should a wet autumn and early winter succeed, the nitrates are washed so far down into the subsoil as to be out of the reach of the crop, which then shows a very small return for the previous summer fallow.

The Rothamsted experiments also show that there is little or no nitrification going on during the three months preceding harvest—that is during the period of the plant's most active growth. The period of active nitrification begins about midsummer, and continues with increased activity during late summer and after the grain is harvested. The nitrates thus formed are to a greater or less degree washed down into the subsoil during the rains of autumn and the thaws and rains of late winter and early spring. Hence the great importance of the use of nitrogenous manures in these countries. The Rothamsted experiments show, further, that practically the whole of the nitrogen supplied as ammonium salts is nitrified during the season of growth of the wheat, and whatever is not removed by the plant gets washed down as nitrate into the subsoil.

With us the condition of things is very different. During our mild winter the wheat plant, once well started, is making steady and continuous growth the whole time, from April or May, when the seed is sown, till December. The months succeeding harvest are usually comparatively dry and warm, and favourable to nitrification. The seed is thus sown, and the plant germinates in land in which nitrates are abundantly present; and as there is practically no dormant period the plant gets the full benefit of this, at least during the early stages of its growth, until it is well established. The greater portion of the rain falls (at least in the principal wheat-growing districts) during the winter months—June, July, and August—when it is of the greatest benefit. If these months are dry, a failure in the harvest is almost certain, unless rain falls in September or October. Nitrogenous manuring alone is, therefore, of little benefit under our conditions. What the wheat crop appears to need is an application of fertiliser to enable it to make a vigorous growth at the outset, and to develop the root-system, which latter property is possessed in a high degree by superphosphate, and this is supplied by the application of readily available phosphatic fertiliser.

The principle adopted by most of our farmers of applying with the seed a small quantity of superphosphate is therefore a perfectly sound one, and while applications of a complete manure may increase the yield as compared with superphosphate alone, the value of the increase is not commensurate with the additional expense involved in the other fertilisers.

Other Cereals.

Maize grows best on alluvial soils of good depth. Deep sandy or medium loams with a clay subsoil retain moisture better than heavy soils, and are also easier to cultivate. Heavy volcanic soils of basaltic origin are, however, better than the lighter volcanic (granite) formations on account of their greater fertility.

Rye accommodates itself to lighter and drier soils—in fact, the poorest soil is usually considered good enough for rye.

Barley requires a light fertile soil, warm and friable, and grows most strongly and produces the largest crops on land well tilled and heavily manured. If, however, the grain is grown for malting purposes, the application of excessive quantities of nitrogenous manures is to be avoided, as the

grain produced by such treatment contains a large proportion of nitrogenous matter, which is said to injure the keeping qualities of the beer, the starch in the grain being likewise diminished.

Oats thrive best in a damp climate and moist soil, with a moderate summer temperature. They contain considerably more potash in the straw than the other cereals.

More specific recommendations for the manuring of the cereals will be found on page 112 of this Handbook.

Grass.

A crop of $1\frac{1}{2}$ tons of meadow hay per acre contains on the average 49 lb. nitrogen, 51 lb. potash, and $12\frac{1}{2}$ lb. phosphoric acid.

The question of the appropriate manuring of grass-lands is complicated by the questions as to whether it is intended for permanent pasture or to be cut for hay, and whether grass or clover is to predominate. It may be stated generally that the proportion of clover is increased by the application of manures containing potash and phosphoric acid, and diminished by the application of nitrogenous manures.

Too heavy manuring of any kind, especially nitrogenous, tends to the growth of coarse grass. Manures containing lime, such as plaster, also promote the growth of clovers.

For grass the best results have been obtained by the application of mineral manures (superphosphate and potash salts) together with sulphate of ammonia. Heavy grass crops were obtained to the almost total exclusion of clover. To promote the growth of clovers, omit the ammonium salts from the above mixture, and manure with mineral fertilisers alone.

Stable manure and compost is an excellent manure for grass lands, especially when mixed with sulphate of ammonia.

Root Crops.

These exhibit a greater variety in their food requirements than the cereals, and differ more amongst themselves. In all cases the crops contain a larger proportion of nitrogen than the cereals, but they appear to possess to a far greater degree the power of assimilating the nitrogen as it exists in the soil; consequently the application of nitrogenous manure alone is, as a rule, without much benefit, the exception being the mangold crop, for which purely nitrogenous manures are distinctly beneficial. They all produce far more bulky crops than the cereals, and remove proportionately larger quantities of the soil ingredients. They, therefore, require liberal manuring, and are especially benefited by the application of potash.

Potatoes.—A crop of 6 tons of potatoes weighs about 18,000 lb. of tubers and haulm, and removes from the soil 67 lb. nitrogen, 80 lb. potash, and 24 lb. phosphoric acid. As in the case of the cereals, these quantities are abundantly present in the poorest land, and it is only a question of the power of the crop to assimilate them. Potatoes do well in most soils—best in loose, mellow soils. Virgin soil appears particularly well adapted to their growth. This may be partly due to the manuring of potash the soil receives from the clearing and burning away of the timber. The subsoil should be porous, the tubers being liable to rot in land with stiff subsoil, or in very retentive soils. The soil should not be too stiff, otherwise there is not room for the roots to develop. They are surface feeders, and, as might be expected from the preponderance of potash in their composition, the

application of potash manures is often beneficial. The addition of potash salts alone is, however, not usually of much benefit, and they are generally applied together with superphosphate. (See page 114.)

Turnips.—A crop of 17 tons roots per acre contains 49,000 lb. of root and leaf, and removes from the soil 112 lb. nitrogen, 149 lb. potash, and 33 lb. phosphoric acid, in round numbers. They thrive best on light loams, loose and open. The land for the turnip crop requires more thorough tillage and previous preparation than for most other crops; but this question is outside the scope of the present discussion. They are a crop that requires heavy manuring, and a liberal dressing of farmyard manure is favourable to their successful cultivation. Though the quantity of potash is larger than in the potato crop, potash manures have not the same marked benefit. Their weak point appears to be their inability to make use of the phosphoric acid in the state in which it exists in the soil; hence the manures from which they derive especial benefit are those containing phosphoric acid, such as superphosphate or bone-dust; $\frac{1}{2}$ cwt. to 1 cwt. superphosphate per acre is the average proportion.

Mangolds.—A mangold crop of 22 tons weighs 67,000 lb. roots and leaves, and removes 147 lb. nitrogen, 300 lb. potash, and 53 lb. phosphoric acid. Mangolds are deep feeders, and require a deep and well-tilled soil. They form an exception to most root crops in that they are capable of utilising the phosphoric acid and potash present in the soil, and the manures that specially benefit them are those containing nitrogen. On a rich land, or one already well-manured with farmyard manure, the application of a soluble nitrogenous manure alone is of marked benefit, though, as a rule, it is added together with superphosphate.

Beetroot is also a crop that requires nitrogenous manures in conjunction with bone-dust or superphosphate.

Leguminous Crops.

Crops such as the pea, bean, lupin, lucerne, clover, vetch, &c., stand midway between the cereals and root-crops in regard to the amount of fertilising materials they contain. The following figures show the composition of beans and of red clover.

Beans.—A crop of 30 bushels grain consists of 2,000 lb. grain and 2,200 lb. straw, and contains 99 lb. nitrogen, 67 lb. potash, and 29 lb. phosphoric acid.

A *Red Clover* crop of 2 tons contains 102 lb. nitrogen, 83 $\frac{1}{2}$ lb. potash, and 25 lb. phosphoric acid.

In addition to the above, leguminous crops contain a large proportion of lime, amounting in the clover crop to 90 lb. None of the cereals contain more than 10 lb. lime in the entire crop. Potatoes contain about 27; mangolds, 43; and turnips 70; so that it will be seen that the proportion of lime in the leguminous crop is considerable.

They thrive best on calcareous soils, and derive special benefit from the addition of lime as a manure.

But the most striking peculiarity about this class of plants lies in the fact that they are practically independent of the soil for their supply of nitrogen. It has long been a vexed question, and is still undecided, whether plants are able to utilise the nitrogen of the air by means of their leaves. There is no satisfactory evidence hitherto of this fixation of nitrogen by the leaves of growing plants, and it is quite certain that the amount thus obtained is inconsiderable, and not sufficient to enable them to thrive independently of the soil-nitrogen.

The case of legumes is, however, quite different, and may be referred to more fully. It appears from experiments of Hellriegel and Willfarth, and later, of Lawes and Gilbert, on peas, lupins, vetches, and lucerne, that there exist in the root-nodules, or small excrescences which are found on the roots of these plants, certain minute organisms, which are capable of assimilating free nitrogen and of rendering it in an available form to the plant. These organisms act therefore, as carriers of nitrogen between the air and the plant, and the root-nodules become a store-house from which the leguminous crop derives its nitrogenous food. The air from which the nitrogen is thus withdrawn is the air in the interstices of the soil, and as this is continually renewed, especially in the case of a porous soil, from the outside air, the supply of nitrogen is practically an inexhaustible one. The form and appearance of those nodules vary somewhat in the different plants, being generally large or small swellings on the root or root-fibres, sometimes single and sometimes agglomerated. Though leguminous plants exhibit this peculiarity in a special degree, there is reason to believe that other plants are able to fix nitrogen from the air in a similar manner, though in a much smaller degree.

On account of this property possessed by leguminous plants, such plants derive little or no benefit from the application of nitrogenous manures—in fact, it has been observed that the formation of root-tubercles is reduced, or even stopped entirely by the addition of much nitrate.

The manures that particularly benefit leguminous crops are such as contain potash and phosphoric acid. The latter especially seems to have a most favorable effect, and hence superphosphate, both when sowing and as a top-dressing during the life of the stand, has proved most beneficial.

Composition and Action of Manures.

We have now to consider the composition and the specific action of the several substances used as manures; and for this purpose it will be convenient to classify them according as lime, phosphoric acid, nitrogen, or potash is their dominant constituent.

MANURES CONTAINING LIME.

The manures which depend for their action upon the presence of lime are (a) burnt-lime, (b) carbonate of lime, and (c) gypsum.

(a)—*Burnt-lime, quicklime, or stone-lime.*

When liming is recommended for a soil, it is always either burnt-lime (powdered or freshly slaked), that is intended or else carbonate of lime. The following remarks apply to burnt-lime or quicklime. Many substances used as manures contain lime, but in these cases the lime is in combination with other substances, and has not the same action on the soil as burnt-lime. For example, bone-dust and superphosphate both contain considerable proportions of lime in combination with phosphoric acid as phosphate of lime. Neither of these substances, however, has any effect in lightening clay soils, or in sweetening sour ones. In the same way gypsum (sulphate of lime) is a substance rich in lime, and a valuable addition to the land in certain cases, but its action is not that of burnt-lime, and it is not to be used when liming is recommended. Wood-ashes also contain carbonate of lime and have a considerable value as fertilisers. Thomas' phosphate contains free lime, and there is no doubt that it has a considerable effect in altering the texture of heavy clay-soils, but none of these substances are to be substituted for burnt-lime.

There are few soils which will not derive benefit from the application of lime, even when this substance is present in fair proportion. A. D. Hall, the late Director of the Rothamsted Station, states that English experience shows that soils containing less than 1 per cent. carbonate of lime require liming. This represents about $\frac{1}{2}$ per cent. lime, and there are not a great number of soils in New South Wales which contain as much as this, whereas the bulk of our soils contain considerably less. Liming is beneficial on a great variety of soils, and is to be regarded rather as a means of improving the land than as a direct plant-food. The soils on which it is particularly beneficial are the following:—

1. Soils deficient in lime.
2. Sour soils, on which it acts as a sweetening agent, neutralising the soil-acidity. On land which is newly opened up, or land which is being reclaimed from swamps, the addition of lime is an essential.
3. On stiff clay soils. The action of lime on this class of soils is to lighten them and render them more friable and amenable to tillage operations.
4. On sandy soils, lime acts in an opposite manner, as will be shortly explained, consolidating them and increasing the cohesive and capillary power of the soil.
5. On land which is destined for leguminous crops, or such crops as are specially benefited by the presence of lime, such as sugar-cane, maize, &c. Where a green crop is sown to be ploughed under (green-manuring) the previous application of lime to the soil is of the greatest benefit in promoting the growth of the green crop.

Nature of Lime.

Burnt-lime, stone-lime, or quicklime is obtained by burning limestone (carbonate of lime) in kilns of special construction. In the process of burning or calcining, carbonic acid and water are driven off, and the burnt product is pure lime (calcium oxide) of greater or less purity according to the purity of the original stone. Other substances, having the same composition as limestone, also yield lime on being burnt, such as chalk, marble, shells, &c. If the lime has been properly burnt it forms a very hard, stony substance, nearly white, which slakes, or combines with water, with great avidity, crumbling to a fine white powder, and evolving sufficient heat to convert a part of the water into steam. In slaking, it combines with the water, slaked lime being a hydrate of lime. As its function in the soil is principally mechanical, a test of its goodness lies in the readiness and completeness with which it slakes. Both under-burnt and over-burnt lime slake badly, though from different causes.

Burning Limestone on a Small Scale.

If only small quantities are to be burnt at a time, the use of a kiln may be dispensed with and the lime burnt in the open or in an excavation on the side of a hill. This is best done by placing the wood and limestone in alternate layers. About 1 ton of wood is required to 2 tons limestone.

A method reported as successful by the General Manager of the State Brick and Lime Works is as follows:—He excavates about 10 feet into a bank, thus making the sides of the excavation act as the three sides of a kiln, and then lays about 18 inches of timber on the bottom; then 18 inches limestone on the top of this, filling up the excavation with alternate layers of wood and limestone; he then lights the timber at the bottom, and the fire burns through the lot. The lime produced is quite good enough for agricultural purposes.

In a note in the *Agricultural Gazette of New South Wales*, vol. XXIV (1913), page 601, Mr. A. J. Wilson describes a method adopted in South Australia, on the Murray, which is as follows:—

“A 12 to 14 feet cube is excavated, with a trench 2 feet wide slanting to the bottom for lighting purposes. Pieces of thick wood are laid at intervals of about 3 feet, and in between are put dry boughs, &c., for lighting. The fire can then spread all over almost immediately, and the lime will be evenly burnt. The first layer of wood is put crosswise on the bottom pieces, and then alternate layers of stone and wood not more than 18 inches thick, finishing with a layer of wood. This ensures the top stone being burnt.”

In places where limestone occurs and wood or other fuel is abundant, one or other of the above methods, or a similar method, will give satisfactory results, while avoiding the expense of the construction of a kiln.

Action of Lime on Different Soils.

The action of lime in the first place is a mechanical one, in altering the texture of the soil, and with it those properties which depend upon its texture, such as its absorptive power for water, its amenability to tillage operations, &c. The action of lime upon a clay soil may be illustrated by the following experiment:—If a small quantity of a heavy clay be mixed with water in any suitable vessel, it will form a muddy liquid. If a little lime be added to this, and the mixture well shaken, it will be noticed that the solid matters sink to the bottom in a loose powder, and in a short space of time, if the water is poured off and the soil dried, it can be readily broken up by the fingers. If no lime had been previously added, the clay, on drying, would form a hard mass, difficult to break up. This action, which is due to the power that the lime has of coagulating the fine particles of the clay, is identical with what takes place on the larger scale when lime is added to the field.

The presence of lime also prevents the shrinkage which wet clay soils undergo on drying, and which causes the cracks and fissures seen on the parched clay soil. The admixture of lime to a clay, therefore, prevents the formation of a sticky mass when wet, and a cracked, parched appearance when dry.

Limed land is drier and warmer, more friable, and consequently more readily cultivated than unlimed land. Land which has been limed is ready for the plough sooner than unlimed land.

On light, sandy soils, the action of lime is also strikingly beneficial in binding the particles of sand together, and increasing the cohesive and capillary power of the soil. Its action is, in fact, exactly that of lime on sand in the mixing of mortars, only on a much modified scale, since for making mortar the proportions are one part of lime to three or four parts of sand, whereas the addition of a ton of lime per acre represents one part of lime to nearly 20,000 parts of sand. The action of the lime is the same in both cases—on drying it absorbs carbonic acid from the air, forming carbonate of lime, which cements the particles of sand together; forming, in the proportions used in making mortar, a hard compact mass, and, in the case of the soil, increasing its cohesiveness and its power of retaining water.

Lime, therefore, lessens the cohesiveness of clay soils, and increases that of sandy soils—two properties which are apparently opposed to one another—in fact, there are few soils the mechanical texture of which is not improved by liming.

The action of slaked lime is exactly the same as that of stone or quicklime, but not so pronounced, and it is generally preferable to use the lime powdered and unslaked, or only slightly and freshly slaked.

Chemical Action of Lime.

Apart from the above mechanical property of lime in improving the texture of the soil, it has also a chemical action, and though this is not thoroughly understood, it may be classed under the following headings:—

Firstly, it neutralises the acids sometimes present in soils. Sour soils in particular, contain free acids present in such quantities as to be injurious to plant life, and such soils are “sweetened” by the application of lime—that is to say, the free humic and similar acids are neutralised.

Secondly, it attacks the inert organic matters in the soil and promotes fermentation—one of the most active agents in the production of available plant-food. It is, of course, possible to have too much of a good thing, and an excessive dressing of lime would tend to burn up the vegetable matter of the soil, and do as much harm as good: but in the moderate dressings recommended, it will be found beneficial even on land which has recently been green-manured. It must not be forgotten, however, that the action due to caustic lime soon ceases, for it is very rapidly converted into carbonate of lime within the soil, which has no such action on organic matter.

Thirdly, it attacks the insoluble mineral constituents of the soil to some extent. Phosphoric acid enters into combination with lime, and is in this form more readily utilised by the plant than in its insoluble combinations with iron and alumina, with which it is associated in the soil. Owing to the tendency of lime to burn up a portion of the organic matter, its benefit is more marked on soils rich in organic matter.

Fourthly, carbonate of lime (into which we have seen the lime is soon converted in the soil) is beneficial, if not necessary, to the process of nitrification, the peculiar ferment action by which the inert soil-nitrogen is converted into nitrates.

Fifthly, whilst it promotes certain ferment action, such as the above, it hinders the active growth of many fungoid diseases like rust and smut, and is said to be often a cure for such diseases.

Methods of Application.

‡ Lime may be applied in two ways—either as ground lime or freshly slaked. As ground burnt-lime, it is applied at the rate of 5 to 6 cwt. per acre in a manure-distributor and lightly scattered over the surface. If freshly-slaked lime is used it is applied in somewhat larger quantities up to $\frac{1}{2}$ ton per acre, or even more in the case of very stiff clays. The heavy dressings once employed are found to be less beneficial than smaller applications more frequently applied.

Liming with freshly-slaked lime is best carried out as follows:—The quick-lime (stone-lime) is broken up into small lumps and placed in heaps about the field covered with moist loam. It is left exposed to the air and moisture until it begins to crumble to powder. As soon as this happens the heaps are scattered with a shovel as evenly as possible over the surface of the field, and harrowed or ploughed in very lightly. Liming is most effectively done in the autumn or winter, but whenever it is done the land should be left alone for two or three weeks after the application, and no seed sown nor any manures (especially such as contain nitrogen or superphosphate) used during that period.

Lime-content of the Ash of some Native Timbers and Plants.

The following are a few examples of the lime-content of the ash of some individual timbers, and of wood-ashes from mixed sources examined in the laboratory :—

Ash.	Lime, calculated as Carbonate of Lime. per cent.	Ash.	Lime, calculated as Carbonate of Lime. per cent.
Gidgea acacia ...	95	Mixed wood-ashes ...	43·0
She-oak ..	75·6	„ „ ...	26·0
Red-apple ...	60	„ „ (hardwoods) ...	24·0
Grass-tree ...	44·5	Mixed wood-ashes (principally box)	12·3
Red-gum ...	23·4	Tobacco leaves ...	76·0
Bloodwood ...	15	„ stalks ...	40·0
Blackbutt ...	13	From sawmill ...	28·0
Mixed wood-ashes ...	85·4	Seaweed ash ...	17·0
„ „ ...	73·8	Vine cuttings ...	20·0

The composition of these mixed ashes will be seen to vary very considerably. This will always be the case, both on account of the nature of the timber from which they are derived and also the length of time to which they have been subjected to the weather and the amount of leaching they have undergone.

Other Lime Compounds.

(b)—*Carbonate of Lime.*

Carbonate of Lime is used in several forms—such as chalk, ground lime stone or shells, and “mild” or “agricultural” lime, which latter is old burnt lime which has been exposed to the air and become converted into carbonate by absorption of carbonic acid. The term “agricultural lime” is also applied to the screenings from builder’s lime, or to lime rejected by the mortar makers. Its addition to the soil promotes nitrification, sweetens sour soils, and prevents clay soils from puddling, though it is less powerful in the latter respect than burnt-lime. It is milder in its action and, as a rule, burnt-lime is to be preferred for lightening stiff soils, though for sweetening sour soils or for supplying lime to soils deficient in that ingredient, it is equally effective. It should be applied in quantities of not less than 1 ton per acre.

(c)—*Gypsum.*

Gypsum or *plaster* (sulphate of lime) may also be sometimes used to advantage. Its action is principally that of a direct plant-food on soils poor in lime; hence it is most useful for such crops as clover, and other leguminous crops on soils poor in lime. It is best applied moist, or in wet weather, at the rate of 2 to 3 cwt. per acre. Gypsum is also often used as a “fixer”—that is to say, when added to dung or urine or decaying animal and vegetable matter, it decomposes the carbonate of ammonia which is being continually evolved from such substances, and converts it into sulphate of ammonia, in which form ammonia does not escape into the air. If a heap of dung from which the odour of ammonia is perceptible, be covered with a few shovelfuls of moist gypsum, the smell will be found to have disappeared—in other words, the ammonia is “fixed,” and its loss prevented.

Gypsum is also of great value in lands which are charged with alkali, or irrigated by alkaline water. For this purpose it is either sown on the land in proportions depending on the amount of alkali in the soil, or it may be introduced in boxes in the irrigation sluices, or added to the tanks if the water is stored.

For a fuller description of the uses of lime, see Farmers’ Bulletin, No. 115, “Lime on the Farm.”

MANURES CONTAINING PHOSPHORIC ACID.

Phosphoric acid is applied to the soil almost exclusively in the form of phosphate of lime, and its sources are bones, rock-phosphates, and guanos.

Bones and Bone-products.

Bones vary very slightly in composition from whatever source they are drawn, or from whatever part of the animal they are taken, though as a rule the thigh-bones and the bones that have to bear the greatest mechanical strain are the richest in phosphate of lime. Bones are composed chemically of water, ossein or collagen, fat, and mineral salts. The last-named, which are left behind as ash when the bones are burnt, consist principally of phosphate of lime. Bone-ash contains about 83 per cent. of this substance, together with about 10 per cent. carbonate of lime, and in much smaller quantities magnesium compounds, and fluoride and chloride of calcium.

The ossein of the bones is the substance which is converted into gelatine by boiling with water, and is an albuminoid containing about 16 per cent. nitrogen. Bones are, therefore, a nitrogenous, as well as a phosphatic, manure. An average sample, reduced to powder as bone-meal, contains about 45 per cent. phosphate of lime, and a trifle under 4 per cent. nitrogen.

Bones are used in a variety of ways. They may be used whole or broken, or reduced to powder (as bone-meal, bonedust, or ground bones); or they may be boiled or steamed, fermented, calcined (bone-ash), charred (bone-black), or converted into superphosphate.

We shall now see how these different methods of treatment affect their composition and action.

Bone-meal.

When simply broken or crushed their chemical composition is, of course, unaltered, and the principal advantage derived from their finer mechanical condition is the greater rapidity of their action. Whole bones resist decomposition within the soil for a considerable length of time, and it is very doubtful if their use is in any sense economical; in fact, as the object of artificial manuring is to feed the crop rather than the soil, it is doubtful whether slow-acting manures are in any case economical. The case of lime, which we have just considered, stands on a different footing. Lime is seldom applied as a direct plant-food. Its action is practically confined to the soil. The substances we have now to consider are valuable only when they are available as plant-food. They produce little or no permanent benefit to the soil, and if their decomposition is slow the plant receives its nourishment in small dribbles, inadequate to its needs.

Bones are, therefore, most efficacious when crushed, and, within certain limits, the finer the powder the better the product as a manure. An additional advantage of fineness of division lies in the ease and evenness with which it can be distributed on the land or mixed with other manures.

Bone-meal is decomposed in the earth, the nitrogen in the ossein being converted by putrefaction into ammonia, and the phosphate of lime rendered soluble by the action of carbonic acid and the vegetable acids. It is particularly suited to turnips and root crops generally, grass, tobacco, fruit-trees, and in fact is a manure of almost universal application. It is applied in some countries at 3 to 5 cwt. per acre, and if mixed with a manure containing potash, forms a complete manure, and an excellent substitute for stable

manure. It is more particularly adapted to light soils, and is sometimes disappointing on heavy clays, the probable reason for which is that in stiff clay soils it is more or less protected from putrefaction (which we have seen is the cause of its efficacy) by the absence of air and moisture.

Boiled or steamed bones or bone-meal.—When bones or bone-meal are boiled, and more effectually when they are subjected to steam, the ossein of the bone is gelatinised, and more or less removed, whilst the fat is also removed, the resulting compound being, therefore, poorer in nitrogen, but richer in phosphoric acid. The treatment renders them more friable, and they are easily reduced to fine powder. The removal of the fatty matter also renders them more easily decomposed in the soil, as fresh bones are more or less protected from external action by the presence of the fat. Not only is the proportion of phosphoric acid increased, but the rapidity of action of the product, and its consequent effectiveness as a manure, is increased, at the expense, of course, of the nitrogen, which may be reduced 1 or 2 per cent., as is shown in the table below.

Bone-ash.—The residue left after the calcination of bones consists, as we have seen, mainly of phosphate of lime, and contains no nitrogen. It is not largely used as a manure. It is dissolved in the soil by carbonic acid, and conveyed thus directly to the plant.

Bone-black is the product of charring bones. The broken bones are subjected to strong heat in closed iron cylinders, whereby they are converted into bone-charcoal, on exactly the same principle that wood is converted into wood-charcoal. The volatile matter of the bones is driven off in the form of gas, water, oil, and tar, and the carbon present is for the most part left mixed as charcoal with the mineral matter of the bones. This product is largely used by sugar-refiners for removing the colouring matter from raw syrups. After it has been used for this purpose a certain number of times it becomes unserviceable, and can be obtained at a cheap rate for manurial purposes. It may be applied directly to the soil as a phosphatic manure or better converted into superphosphates by treatment with acid.

The following table shows the alteration in composition which bones undergo when subjected to the above methods of treatment. The analyses are not analyses of the same sample but represent fairly the average composition of the several products. The analyses of bone-black were kindly supplied by the Colonial Sugar Company, and represent their "char" before and after it had been used for the purpose of refining:—

	Bone-meal.	Boiled bones.	Steamed bone-meal.	Fermented bones.	Bone-ash.	Fresh bone charcoal.	Spent charcoal.
Water	10.43	10.61	11.57	12.02	1.86	.....	2.0
*Organic matter, including 10% carbon in the case of charcoal ...	32.30	21.55	19.01	28.71	.....	13.5	18.0
Calcium phosphate ...	48.40	60.19	60.02	49.28	86.34	76.0	74.0
Calcium carbonate, alkalis, &c.	7.20	5.81	8.54	8.92	11.20	7.0	5.5
Insoluble	1.67	1.84	0.86	1.07	0.51	1.0	1.5
	100.	100.	100.	100.	100.	.....	.....
*Containing nitrogen .	3.71	1.76	1.60	3.47	.....	0.7	0.7

Utilising Waste Bones on the Farm.

The following are amongst the best methods of utilising waste bones on the farm, and converting them into manure when it is not feasible to grind them:—

1. *Fermented Bones.*—Bones may be decomposed and rendered more active by mixing them with about one-fourth of their weight of loam, and keeping the heap moist with stable-liquor or urine. The heap should be protected from rain. By this process also there is a loss of nitrogen, but the phosphate is rendered more readily available and proportionately increased. This is a method that deserves to be made use of where bones are plentiful, and there is no means of reducing them to powder. Thirty to forty bushels per acre is the proportion recommended for grass lands.

2. Another method of fermenting bones, which I have taken from the late Mr. J. L. Thompson's notes in the *Agricultural Gazette*, is the following:—Bones may be softened by mixing in heaps with quicklime and loam. A layer 6 inches deep of bones, then a layer 3 inches deep of lime, and then a layer about 4 inches deep of loam, and so on, repeating until the heap is made of convenient height, when it is to be covered up with a thick layer of earth. Holes are then bored into the heap from the top, and water poured in to slake the lime. The mass will become hot, and remain so for two or three months, after which the bones will be found very friable, and the whole heap may be mixed together, and is ready for applying to the ground.

3. By conversion into superphosphate (see pages 96 and 97).

Other Sources of Phosphoric Acid.

Mineral phosphates are little used in the raw state as a manure; but as they form the basis of the bulk of the superphosphates and mixed manures on the market, a short account of them will not be out of place here.

The mineral known as apatite is a crystalline form of phosphate of lime, and phosphorite a non-crystalline form. These occur as rock-masses or in nodules embedded in rocks of sedimentary origin in many parts of the world, notably Canada, South Carolina, Florida, England, Spain, and Norway. The Canadian phosphate is a crystalline rock, the English coprolites are for the most part spherical nodules found in the green-sand and chalk.

Rock phosphates are found in considerable quantities in the islands in the Pacific, whence they are imported to the mainland and used in the manufacture of superphosphates.

Ground phosphate is the name usually given to the above compounds when finely ground. They are not much used in this condition, but if so employed it is essential that they should be as finely ground as possible. They are non-nitrogenous.

Guano, in its original signification, is the name applied to the dried dung of fish-eating sea-birds, and is obtained principally from the rocky islands in the Pacific and Atlantic Oceans. Guanos are either nitrogenous or contain little or no nitrogen, the amount of this ingredient decreasing with the age of the deposit. Guano was at one time very extensively used as a manure, but it is being largely superseded by cheaper and more concentrated forms of phosphoric acid and nitrogen. Nevertheless, it should not be overlooked, in view of the quantity of it existing in the islands of the Pacific Ocean off our own coasts.

The term is used locally to include a much more extensive class of substance. The dung of bats, flying-foxes, and marsupials goes under this name. A large number of artificial fertilisers are also sold as guanos.

The nitrogen exists often in the three forms of organic nitrogen, ammonium salts, and nitrates, the last form being the most soluble form in which nitrogen can be applied to the soil. They are excellent manures for cereals, especially as a top-dressing in the spring.

They likewise contain an appreciable percentage, 2 to 3 per cent., of potash.

The bulk, however, of the mineral phosphates and of phosphatic guanos is converted by treatment with sulphuric acid into superphosphate.

Superphosphates.—When bones, bone-ash, or any of the substances mentioned in the previous paragraphs are acted upon by oil of vitriol (sulphuric acid), the phosphate of lime which they contain, and which exists in the form of tri-calcium phosphate, is converted into a different lime compound, known as mono-calcium phosphate, or superphosphate. This substance differs from the original phosphate in being readily soluble in water. We have already seen that the availability of a manure as plant-food depends largely upon its ready solubility: consequently a phosphate of lime soluble in water is the most available form of this substance. Plants, however, are not dependent for their food-supply only upon such compounds as are soluble in water, but are able, by means of the acid juices secreted in the roots and root-hairs, to avail themselves of a class of compounds soluble in vegetable acids. It is, indeed, very improbable that superphosphate remains in the soil for any length of time in that condition, for it is readily decomposed, both by carbonate of lime and by the iron and alumina salts present in the soil. Carbonate of lime converts it into a third compound of lime and phosphoric acid, known as bi-calcium phosphate. This substance is insoluble in water, but being in a very finely-divided state is readily dissolved by the plant-acids. Iron and alumina attack the superphosphate even more rapidly, converting it into phosphates of iron and alumina, to which the same remarks apply.

This point is of further importance in reference to the composition of the superphosphates sold as manures, for they also usually contain a considerable quantity of the bi-phosphate in question.

In the valuation of fertilisers the term "citrate-soluble phosphate," sometimes employed, is just this bi-calcium phosphate, which is formed to a greater or less extent in superphosphates by the inter-action of the superphosphate and unchanged tri-calcium phosphate. In a superphosphate, therefore, as usually purchased, there will be not only the water-soluble superphosphate, but also a certain quantity of the reverted phosphate, which is insoluble in water, but which is, nevertheless, available for plant-food, and of only slightly lower fertilising value than the water-soluble phosphate.

Superphosphate is essentially the manure for wheat, cereals, and root-crops, and in all cases where a rapid return is wanted. For autumn manuring and for the manuring of permanent pasture, bone-dust is equally effective; and the conditions under which it will be advisable to use the one or the other form of phosphate will vary with circumstances.

Superphosphates are more specially beneficial on soils of medium nature and such as contain lime. Indeed, in sandy soils poor in lime it has been found to be of very little benefit. It must not be forgotten that it is an acid manure, and in the absence of lime to neutralise it, may even prove injurious.

It is applied usually at the rate of $\frac{1}{2}$ to 2 cwt. per acre, the amount varying with the nature of the soil and with the quantities of the other manures used in conjunction with it. It is of especial value in the case of wheat and root crops, and it forms the basis of the "general" manures, special manures, mixed fertilisers, &c., on the market, such manures being usually prepared from superphosphates by mixing it with sulphate of ammonia or nitrate of soda and potash salts.

Superphosphate obtained from mineral phosphate contains no nitrogen; that obtained from bones usually contains 2 or 3 per cent., a portion of the nitrogen having been lost in the process of manufacture.

The following table will serve to convey an idea of the result of the action of sulphuric acid upon mineral phosphates and upon bone-meal respectively:—

	Superphosphate from Mineral Phosphate.	Superphosphate from Bone-meal.
Water	16.00	10.00
*Volatile and combustible matter	9.50	33.00
Phosphate of lime (soluble in water)	28.00	31.50
Insoluble phosphate of lime	6.00	2.00
Sand and insoluble matter	5.00	3.00
<hr/>		
*Containing nitrogen... .. .	.....	3.00
Equal to ammonia .. .. .	.....	3.60

The tendency to revert is greater in those superphosphates which contain iron and alumina, and in such manures a portion of the soluble phosphoric acid often reverts to the citrate-soluble condition on keeping for a length of time.

Dissolved bones is the name applied to superphosphate prepared from bones.

Dissolved guano is superphosphate obtained from guano.

Fish guano is not a guano, but fish offal.

Thomas' phosphate, or *Basic slag*, must also be mentioned amongst phosphatic fertilisers. It is a waste product of the manufacture of steel by the Thomas-Gilchrist, or basic process, and contains, in the form of a phosphate of lime, the phosphorus existing in the original impure pig-iron. In Germany and England enormous quantities have been consumed, it having proved a very valuable and cheap form of phosphoric acid. Its great weight and the consequent cost of transport has, no doubt, prevented its economical use in this country. Recent changes in the steel-making processes, however, are affecting the supply, and European farmers are likely to be dependent on slags of rather less uniform and somewhat inferior qualities.

Manufacture of Superphosphate on a Small Scale.

The following directions for making this invaluable fertiliser on a small scale may prove useful on farms where bones accumulate, and the question arises how to deal with them most economically.

It will be found most satisfactory in the first instance to burn the bones, and convert them into what is known as bone-ash, since fresh bones or bone-meal produce, on treatment with acid, a slimy mass, which is exceedingly difficult to dry.

To prepare the superphosphate from bone-ash, it is necessary to provide a receptacle for mixing the ingredients which is not attacked by sulphuric acid. A wooden trough lined with lead (a sheet of lead hammered to fit the trough) is about the best; but a wooden trough, pitched inside, will answer the purpose, or a hole in the ground lined with cement. In this receptacle the ingredients are mixed in the following proportions:—For every 40 lb. of bone-ash add 1 gallon of water and 15 lb. strong sulphuric acid (commercial oil of vitriol). Pour the whole of the water into the empty tank, then add *gradually*, stirring constantly with a wooden pole, the sulphuric acid. The acid combines very violently with the water, and unless it be added as directed above, an explosion may result. Now add gradually, a little at a time, the bone-ash, stirring constantly with a stout pole or hoe.

The above proportions should yield a mass possessing the consistency of a stiff dough. If it is not stiff enough, some more bone-ash may be added. Leave it to itself for a few hours, when it will dry to a friable mass, easily broken, and in a fine state of division. Protect from rain whilst drying. The manure is now ready for use. The acid does not actually *dissolve* the bone-ash, and the resulting superphosphate is very similar in appearance to the original bone-ash, nor is it visibly soluble in water, that is, a large quantity of sulphate of lime is formed which is insoluble. The resulting superphosphate is acid in character. Although burning the bones destroys the organic matter and diminishes the proportion of nitrogen, this loss is more than compensated for by the ease with which the product can be dried and handled. If fresh bones or bone-meal be used, the fat which they contain prevents the complete action of the acid, and the resulting product is so slimy as to be unmanageable in many cases, and much difficulty will be experienced in getting it to run through the drill.

If it is preferred to use fresh bones or meal, the following proportions are said to be the best:—

Dilute every $\frac{1}{2}$ gallon of acid with 1 gallon of water as directed above—that is, add the acid to the water, stirring all the time. Never, on any account, add water to the strong acid. Pour this diluted acid upon 20 lb. of the bone-meal in the trough, taking care to pour slowly, stirring all the while. The sticky mass must now be mixed with loam, wood-ashes, peat, or gypsum, in order to dry it.

Instead of burning the bones, the oil may be removed by steaming them, but this is rather a troublesome process, though a smaller proportion of nitrogen is lost by this means. Simple boiling with water is better than nothing, but in no case is the product so satisfactory as that prepared from burnt bones.

In order to avoid disappointment, it must be remembered that superphosphate is not entirely soluble in water. It is known as soluble phosphate, but the solubility only refers to the phosphate of lime. A large proportion consists of sulphate of lime (gypsum) produced by the action of the sulphuric acid on the bonedust, and this is insoluble in water. Further, it is an acid manure—that is, it turns blue litmus paper red.

Instead of using acid, bones may be rendered soluble by allowing them to ferment (see page 95). The following is also a good plan:—

Dig a trench, and fill it with alternate layers of wood ashes and bones, beginning and ending with wood-ashes. Moisten each layer of ashes when laid, and keep the whole moist by watering from time to time. In a few months the heap may be turned over.

Bones can also be dissolved by placing them in a pit, and drenching with a hot solution of lye—1 lb. of potash lye to every 4 lb. of bones. Cover with earth, and stir occasionally for two or three weeks, when the mixture may be turned out to dry.

It will be seen that treatment with acid is the most rapid, and the product is more satisfactory, but a little caution is required in mixing the ingredients.

MANURES CONTAINING NITROGEN.

Nitrogenous manures fall under three heads, according as the nitrogen they contain is combined with organic matter or exists in the form of ammonium compounds, or of nitrates. In the two latter forms it is soluble in water, and immediately available as plant-food. Most of the quick-acting concentrated fertilisers contain one or other of these compounds, usually sulphate of ammonia or nitrate of soda. What is known as organic nitrogen is contained in animal products, refuse, and excreta, such as blood, bones, hair, meat, guano, farmyard manure, &c.

The nitrogen in these latter products is not in a state in which it can be immediately utilised by the plant, but requires first to undergo fermentation within the soil, resulting in the first instance in the formation of ammonium compounds before it is available as plant-food. Although the nitrogen in these different substances is usually classified for the sake of convenience under the one heading of "organic" nitrogen, it occurs therein in a variety of combinations, some of which are more susceptible to fermentation than others, and consequently more rapid in their action. The smell of ammonia is soon noticeable from such products as urine and farmyard manure, which contain a large proportion of their nitrogen in the form of urea, whereas hair, wool, &c., resist decomposition for a considerable length of time.

The following list shows the order of solubility of the most commonly occurring of these products, the most soluble standing at the head:—

Fresh urine.	Fine bone-meal.	Coarse bone-meal.
Dried blood.	Oil-cake.	Horn-meal.
Dried and pounded flesh.	Fish scrap.	Dung.
Guano.	Dried offal.	Hair and wool.

This list is of course only intended to show the relative solubility of the nitrogen in the different substances named. It is not meant to apply rigidly in all cases, nor is it possible to draw any such rigid comparison, for the solubility will vary according to the fineness of division of the material, to some extent also with the nature of the soil, and with the substances with which the manures in question are mixed. The list will serve its purpose if it makes clear the fact that some of these nitrogenous products are more soluble than others, just as we have seen that some forms of phosphoric acid are more soluble than others, and that the percentage of nitrogen alone is not always a sufficient indication of the value of such manure, unless the source of the nitrogen is also known.

Those products containing their nitrogen in the most inert form, such as hides, horn, hair, &c., are generally utilised by the manure-makers by treatment with sulphuric acid as in the manufacture of superphosphate. Their rapidity of decomposition is greatly increased by this means, just as mineral phosphates are rendered soluble by treatment with acid. They may also be

mixed with lime, under which treatment they swell, become soft, and decompose far more readily. They may also be usefully added to the compost heap.

The most important and most commonly used of these products are :—

Dried blood and dried flesh.—These substances are produced in considerable quantity in slaughter-houses and boiling-down works, and are dried by means of steam. They are almost identical in chemical composition, and contain on the average 11 to 13 per cent. nitrogen. They are specially beneficial on grass lands (about 30 bushels per acre), for turnips, and in fact all crops that require nitrogenous manures. They are less soluble than such manures as sulphate of ammonia and nitrate of soda, and are more applicable as an autumn manuring than as a top-dressing. With superphosphate and kaimit they form a complete manure, suitable for fruit-trees, vines, potatoes, tobacco, and such crops.

Sulphate of ammonia is a manure of very great value, and being a waste product in the purification of coal-gas, it can be produced more cheaply than other soluble forms of nitrogen. It is obtained by treating the ammoniacal liquor of the gasworks with lime, which drives off the ammonia. The ammonia is absorbed by sulphuric acid and forms sulphate of ammonia. The ammoniacal liquor is a mixture of different ammonium compounds produced in the purification of coal-gas. Sulphate of ammonia is a white crystalline powder when pure. It is the most concentrated form of nitrogen we possess, containing about 20 per cent. of this element in combination. It is readily soluble and immediately available, and specially valuable as a top-dressing to the young crop.

For gardening purposes it may be dissolved in water (about $\frac{1}{2}$ oz. to 1 oz. to the gallon), and will be found effective for most pot plants and flowers. It is more particularly adapted for clay soils. It is stated to be ineffective on strong calcareous soils—that is, soils which contain over 8 or 9 per cent. of carbonate of lime; but as the cultivated soils of the State average something under 1 per cent., there is not much to be feared on this score. Sulphate of ammonia, or manures containing sulphate of ammonia, should not be mixed with lime, nor applied to land which has been recently limed. A still more effective form of available nitrogen exists in—

Nitrate of soda, the principal source of which is the nitre-beds of Chili and Peru. Enormous quantities are exported to England and the European continent, and it is largely used both in the imported and locally-made fertilisers.

It contains about 16 per cent. nitrogen, as against 20 per cent. in the case of sulphate of ammonia, and the unit value for the nitrogen is higher than in the case of sulphate of ammonia. Its local use is consequently limited.

Of other forms of nitrogen may be mentioned—

Soot, which contains from 1 to 2 per cent. of nitrogen, principally in the form of ammonium compounds. It is fairly quick in its action, and at the rate of about 33 bushels per acre will be found useful for grass and vegetables.

Calcium cyanamide or *Nitrolim* is a product obtained by passing nitrogen over calcium carbide at a high temperature. It is lower in nitrogen than sulphate of ammonia, and does not appear to possess any higher manurial value, and it cannot at present compete with the latter locally in cost. It is consequently not on the local market to any extent.

Calcium nitrate is the manurial product obtained by the electric process for the manufacture of nitric acid from the atmosphere. It contains about 13 per cent. of nitrogen, and appears to have the same manurial value as nitrate of soda that contains the same amount of nitrogen. Like cyanamide it is not on the local market at present. Like this, also, its future success depends upon its production at a rate enabling it to compete with sulphate of ammonia.

Humus and Green Manuring.

Amongst the most effective means of adding nitrogen to the soil is the application of vegetable matter in the form of farmyard or compost manures, and the ploughing under of a green crop or green manuring.

We have seen in the case of many leguminous crops (page 87) that they are not only independent of the soil for their supply of nitrogen, but that their growth actually enriches the soil in this ingredient. The land on which such a crop has been grown contains a larger proportion of nitrogen than before. This property is turned into account in rotating crops, and also suggests a means of supplying nitrogen to the soil without the addition of nitrogenous manures. If a leguminous crop is grown, and is ploughed into the land just before it reaches maturity, a manure is thereby added to the land containing 100 lb. or more of nitrogen to the acre—that is to say, the land receives a manuring of nitrogen equivalent to that produced by the addition of over 4 cwt. sulphate of ammonia or of 8 cwt. of dried blood per acre. The crops suitable for green manuring are those that mature most rapidly and occupy the ground for the shortest time. The value of green manuring to the physical nature of the soil is mentioned on page 70.

AMOUNT of fertilising ingredients added to the soil by ploughing under certain green crops.

	Average yield per acre.	Percentage composition of whole plant.				Amount of fertilising ingredients added to the soil in pounds per acre.		
		Tons.	Water.	Nitrogen.	Phosphoric Acid.	Potash.	Nitrogen.	Phosphoric Acid.	Potash.
Cow peas ...	7½	84.4	0.63	0.13	0.46	106	22	77½
Oats ...	8	75.0	0.72	0.19	0.56	129	34	100½
Rye ...	8	81.9	0.32	0.17	0.60	57½	30½	107½
Red Clover ...	2	70.8	0.54	0.12	0.67	24	5½	30
White clover..	2	80.0	0.43	0.12	0.40	19½	5½	18
Lucerne ...	3	77.5	0.58	0.12	0.50	39	8	33½
Vetches ..	4-6	85.0	0.36	0.10	0.45	40	11½	50½
Rape ...	2-4	85.7	0.35	0.12	0.62	23½	8	41½

Inoculation of the Soil for Leguminous Crops.

Attempts have been made in the preparation of pure cultures of the organisms occurring in the roots of leguminous plants for the purpose of inoculating the soil with these organisms.

Several preparations have been made under different names, and by different investigators, the idea being that the introduction of the organisms into the soil would favour the growth of the particular crop on the roots of which they had been growing, just as soil from a clover-field is known to favour the growth of clover in other land if used as a top-dressing. So far the results obtained have not been entirely satisfactory; and although numerous carefully-conducted experiments have been carried out with these preparations, their use has not spread to any extent as a practical application.

MANURES CONTAINING POTASH.

With the exception of wood-ashes, we have been dependent in the past upon the German potash depots for our supplies of this invaluable manure, but during the war it was unobtainable. With the opening up of the Alsatian deposits the supply of this fertiliser is now almost normal again, though the price is considerably higher than in pre-war times.

Kainit is a mixture of the sulphates of potash and lime, together with chlorides of magnesium and sodium. It is of value principally on account of its potash, of which there is about 12 per cent. For leguminous crops, root-crops, fruit, vines, &c., it is a valuable manure. It is usually mixed with other manures, especially phosphatic manures, about 2 cwt. mixed with 3 cwt. superphosphate, and 1 or $1\frac{1}{2}$ cwt. sulphate of ammonia per acre being about the best proportion for potatoes. This substance is, however, not obtainable at the present time.

Sulphate of potash is also obtained from the same source as the above, and is a very concentrated form of potash, of which it contains over 50 per cent. As it contains no chlorine, it is preferable to kainit for such crops as tobacco. It is more economical than kainit on account of its concentrated nature, 1 cwt. of it containing as much potash as 4 cwt. of kainit. This has also been replaced since the war by the chloride or muriate.

Potassium chloride or muriate is the potash salt obtained from the Alsatian mines which has replaced the sulphate on the local market, and is at present the only potash-salt obtainable. It contains the same proportion of potash, and can be used to replace the sulphate in equal quantities.

Wood-ashes.

The value of wood-ashes as a fertilising material is not as widely known as it deserves to be. In newly-cleared country this valuable substance is produced in large quantities, and it will be found to more than repay the trouble of returning to the land. It is a matter of common observation that after a bush fire the vegetation is particularly strong and luxuriant, and the effect is due largely to the lime, potash, and phosphoric acid thus returned to the soil. The household wood-fires also furnish a small but continual supply of ashes which should be all kept and made use of. They may be utilised, either by themselves or mixed with other manures, or added to the compost heap—a valuable adjunct to the economy of the farm. (See page 72).

The ash of the different woods contains the mineral portion of the wood from which it has been obtained. Of these ingredients the substances possessing fertilising value are lime, potash, and phosphoric acid. Their potash and phosphoric acid are, moreover, in an exceedingly soluble condition, and are in such a state as to be readily assimilated by most plants. The value of the ash of the different varieties of European trees has been long well known and their constitution established by numerous exact analyses. The composition of the ash of our own trees has not as yet been studied systematically, but from the following analyses made in the Department it will be seen that they are likely to be quite as valuable:—

	Phosphoric Acid.	Potash.
Spotted-gum	·10	·69
Red-gum	·38	4·17
Bloodwood	·27	5·25
Box	·67	1·65
Blackbutt	·04	2·02
Ironbark	·82	1·53
Red-apple	·47	6·00
Grape-vine	1·85	3·76
She-oak	8·85	2·19
Grass-tree	3·07	5·30

The following figures indicate the content of potash (K_2O) of samples of wood-ashes from mixed timbers (varieties unknown) made at different times in the Laboratory for individuals:—3·46, 1·57, 0·06, 5·04, 4·65, 0·27, 0·83, and 0·30 per cent.

The following analyses recently made of wood-ashes from various timbers specially burnt for the purpose by the Forestry Department will serve further to show the variations to be expected in the potash-contents of the same timbers, and even of individual specimens of the same timber:—

Tree.	Unburnt Carbon.	Potash (K_2O).	Tree.	Unburnt Carbon.	Potash (K_2O).
	per cent.	per cent.		per cent.	per cent.
Myall	17·10	1·36	Mountain Ash	20·02	9·23
Yellow Box	16·74	0·28	Blue Gum	26·14	5·17
Mountain Gum	30·60	6·88	Grey Box	24·80	2·95
Mountain Ash	30·57	5·57	Grey Ironbark	22·89	0·13
Woollybutt	17·60	6·36	Red Ironbark	21·32	1·02
Yellow Stringybark	9·70	5·59	Forest Red Gum	47·03	1·58
Brush Box	24·14	1·78	Grey Gum	24·66	0·26
Spotted Gum	20·02	4·70	Blackbutt	40·31	2·04
Forest Oak	27·45	5·02	Turpentine	22·17	1·88
			Mixed North Coast Hardwoods.	11·63	1·34

None of the figures here quoted can be accepted as representative of the timbers specified, as the burning has not been conducted uniformly; the variations in the unburnt carbon are considerable, the temperatures at which the wood was burnt vary, also the exposure of flame.

Exceptionally high figures for potash were obtained in a sample of the ash of *Pinus insignis* (from the Forestry Department), which gave 18·67 per cent. potash, and from the ash of bracken fern, which contained 16·71 per cent.

The process of burning converts the potash salts into carbonate of potash for the most part. The lime is present in the form of oxide and carbonate, and the phosphoric acid partly as calcium phosphate, and partly as alkaline phosphates. Now, carbonate of potash and alkaline phosphates are particularly soluble forms of potash and phosphoric acid respectively; the beneficial action of lime, both in the form of oxide (quicklime) and of carbonate (chalk), is well known. It will, therefore, readily be seen what a valuable manurial substance we have got here. In addition to their direct action as plant-food, wood-ashes act beneficially in improving the quality of stiff clay-lands, and equally so in binding light sandy soils; in fact, they benefit the soil mechanically exactly in the same way that lime does, though to a lesser extent. With the exception of nitrogen, which, of course, has been burnt off, they contain all the ingredients of a complete manure, and in a particularly serviceable form.

It might, therefore, be expected that the addition of a nitrogenous substance would make a complete manure of them; but such addition must be made with caution, as the presence of free lime and alkalies in the wood-ashes is liable to decompose the nitrogen in such a mixture, driving it off in the form of ammonia, the smell of which will be apparent when sulphate of ammonia and wood-ashes are mixed together.

The ash of young wood is especially rich in potash, and, generally speaking, the ash of young and small wood, as young boughs, twigs, &c., is more valuable than that obtained from the trunk or heart of an old tree.

The following are the best means of utilising wood-ashes:—

- (a) They may be used alone as a top-dressing to grass and pasture, and for leguminous plants, but are of benefit to nearly all crops, potatoes and roots, fruit and vines being specially benefited. They are applied at the rate of from 25 to 30 bushels per acre.
- (b) A mixture of wood-ashes and bone-meal in the proportion of 5 cwt. bone-meal to 25 bushels ashes is said to be an excellent substitute for farmyard manure. Such a mixture should be made as required—not kept mixed.
- (c) They may be used instead of loam or earth for mixing with superphosphate and other chemical fertilisers when these are applied to the land. Ammonium salts must not, however, be mixed with wood-ashes.
- (d) One of the best ways to utilise wood-ashes is in the compost heap.

The best material with which to compost it is undoubtedly peat, but other decayed or decaying vegetable matter is nearly as good, such as straw, dead leaves, and refuse of this sort generally. Such substances are fermented in contact with wood-ashes, and their nitrogen rendered available. On farms where the compost heap is an institution, it should not be forgotten that the addition of wood-ashes forms the best method of utilising this product and improves the value of the compost heap. Where such a system of utilisation of waste matter is not practised, the following method of composting ashes

will be found useful:—Make a heap of alternate layers of peat or peaty loam, or vegetable refuse, and wood-ashes, or make a hole and fill it with these substances in alternate layers, moisten the heap with urine or slop-water, and allow to ferment for a few months, when it may be turned over. The addition of stable-manure, dung, and in fact all refuse matter of the farm, will benefit such a heap, which may be thus made the means of utilising a great deal of valuable fertilising material which would otherwise be thrown away.

The above remarks apply to unleached ashes, such as are obtained from the burning of timber.

Leached ashes contain practically little but lime and carbonate of lime, as the potash and phosphoric acid are for the most part leached out. Their use and action are similar to those described under the heading of carbonate of lime. They may be sometimes economically used instead of this substance, but in no case will the farmer derive any benefit from leaching his own ashes. As the above analyses will show, it is chiefly for the sake of their potash that wood-ashes are used, and they may be regarded as potash manures. They are not nearly so concentrated a form of this substance as potash salts, and if substituted for kainit it is well to remember that 1 cwt. sulphate or muriate of potash contains about the same quantity of potash as 12 or 13 cwt. wood-ashes.

The fertilising value of wood ashes is, for the reasons referred to in the preceding paragraphs, very variable, even ashes from the same timber giving different figures according to the way they are burnt and the amount of weathering or leaching they have undergone. The potash content is especially liable to variation, as potash salts are volatile to some extent, and when the wood is burnt in contact with a hot bright flame, a considerable quantity is lost by volatilization, whereas when the timber smoulders away, little, if any, is so lost.

Sea-weed as a Manure.

Sea-weed is not at a first glance a very promising fertilising material. It has, when fresh, a fertilising value somewhat lower than that of farmyard manure, and its large content of water prevents its carriage in a fresh state to any distance with economy. Even at the distance of a few miles from the coast the cost and labour of transport places it out of court as a fertiliser. Its use is, therefore, limited to farms situated immediately upon an accessible coast; but in such cases there is no doubt that it might be applied with advantage more frequently than at present.

In the coastal districts of Great Britain (especially of Scotland and Ireland), France, Norway, and the United States, sea-weed is largely used as manure. The general custom is to fork it straight into the land like dung, and this is the best method for such sea-weeds as decompose rapidly, and can be easily distributed, such as the different varieties of kelp and ribbon-weed. These may be strewn over the land or ploughed lightly in, and rapidly decompose and disappear. For the tougher kinds, such as eel-grass, it is usually recommended to compost with lime. This is done by building a stack of alternate layers of sea-weed and lime, the layers of sea-weed being about 6 inches deep, and covered with lime. The whole stack may be conveniently covered with gypsum to prevent loss of ammonia. The heap is left for two or three months, and then turned over at intervals until well rotted. It is doubtful whether composting is economical in the case of the more readily decomposed varieties above mentioned.

Though a poor manure, it is fairly rich in nitrogen and potash, its weak point being its phosphoric acid. For this reason a previous dressing of the soil with superphosphate or bone-dust is stated to be beneficial. Its use must be avoided on certain crops, such as tobacco, which is injuriously affected by chlorides, which are present in sea-weed in considerable quantities in the form of common salt. For the same reason, plants such as asparagus, and small fruit, such as raspberries, which require much saline matter, are benefited by its use. Potatoes are said to contain less starch when manured with sea-weed, and to acquire in consequence a somewhat soapy taste; at the same time, in many parts of the coast of Ireland, sea-weed is almost the only manure used by the peasant for his potato crop.

It must be carefully spread, especially if used as a top-dressing for meadows, as it is otherwise liable to destroy the grass when used in large quantities.

Storer, in his work on "Agriculture," points out that it is entirely free from seeds of weeds, spores of fungi, and eggs of insects; consequently it is a comparatively easy matter to keep the land clean where it is used.

The ash of sea-weed contains a considerable quantity of fertilising materials, potash, and phosphoric acid, and in some cases it may be found economical to utilise sea-weed in this form. The nitrogenous matter is, of course, thereby lost. The ash is richer in fertilising substances than wood-ashes—the potash varies in the different varieties from 4 to as high as 20 per cent.

Except for the larger amount of water contained in it, sea-weed compares favourably with farmyard manure.

The average composition of cow-manure is roughly:—

Water	77·0 per cent.
Nitrogen	·5 ..
Potash	·6 ..
Phosphoric acid	·15 ..

The following table shows the composition of the most abundant species of sea-weeds, determined by Messrs. Wheeler and Hartwell, of the Rhode Island Experiment Station, who have also collected a large amount of valuable information as to the use of these plants:—

	Water.	Nitrogen.	Potash.	Phosphoric Acid.
Ribbon-weed, Kelp, Tangle (<i>Laminaria saccharina</i>)	87·99	·17	·16	·05
Broad-ribbon weed, Broad-leaved Kelp, Devil's apron Tangle (<i>Laminaria digitata</i>)	87·50	·23	·31	·06
Dulse, Dilisk (<i>Rhodomenia palmata</i>)	86·25	·37	1·07	·09
Round-stalked rock-weed, <i>Ascophyllum (Fucus) nodosum</i>	77·26	·24	·64	·08
Flat-stalked rock-weed (<i>Fucus vesiculosus</i>)	76·55	·38	·65	·12
Irish or Carragheen Moss (<i>Chondrus crispus</i>)	76·03	·57	1·02	·13
Eel-grass, grass-wrack (<i>Zostera marina</i>)	81·19	·35	·3	·07

Analyses of Local Sea-weeds.

The following analyses of local products, including fresh sea-weed, dried sea-weed and ash, have been made in the laboratory of the Department at different times, and are appended as representing local weeds. The variations in composition are very considerable, especially in the ash, and are due partly to the varying composition of the sea-weeds themselves, and (in the case of the ash particularly) to the way the fresh stuff has been dried and burnt and the amount of weathering it has undergone. The samples in the majority of cases were sent direct by the correspondent, and there is no means of ascertaining the botanical names. Only in two or three cases have these been known.

FRESH SEA-WEED.

	Water.	Ash.	Nitrogen.	Lime.	Phosphoric Acid.	Potash.
Sample unnamed.....	80.0	1.18	0.16	0.41	0.09	...
" "	41.03	16.48	0.14	...	0.21	0.60

DRIED SEA-WEED.

Sample unnamed.....	13.3	29.3	0.72	1.83	0.37	5.11
" "	18.9	15.44	1.64	3.44	0.14	0.14
<i>Phyllospora comosa</i>	11.57	21.6	0.91	...	...	5.84
<i>Hermosira banksii</i>	13.91	29.7	0.91	..	...	5.37
<i>Ulva lacti irrens</i> (air-dried)	30.52	12.9	2.94	...	...	1.08

SEA-WEED ASH.

	Lime.	Phosphoric Acid.	Potash.
	6.52	0.91	13.98
	9.27	0.49	0.59
	6.29	1.27	17.55
	0.53	0.19	34.30
	.....	1.28	3.65
	9.39	0.47	2.26
	22.3	0.92	0.93
Name of original sea-weed unknown.....	4.22	3.26	0.22
	4.03	1.0	31.41
	.....	.....	10.0
	.....	.....	35.5
	.....	.....	38.0
	.....	.....	32.1
	7.5	0.95	1.30
	.....	.....	2.93
	6.64	0.41	1.02
<i>Phyllospora comosa</i> .....	.....	.....	27.06
<i>Hermosira banksii</i> .....	.....	.....	18.09
<i>Ulva lacti irrens</i>.....	.....	.....	8.35

A Few Simple Hints for Detecting Adulteration in Artificial Manures.

It must be premised that it is of no use attempting the roughest *analysis* of a manure without a fairly accurate balance. The substances likely to be added as adulterants, or whose presence in quantity lowers the value of the manure, are not foreign matters, but those like sand, which already exist in most manures: therefore, all attempts to decide the value of a fertiliser must depend upon an estimation of the quantities of the ingredients present, and these cannot be estimated without a balance which must be capable of weighing at least half a grain.

In the absence of a balance, however, the following rough tests may be found useful in giving an approximate idea of the purity of a few of the simple fertilisers:—

Bonedust.—A good sample of bonedust, however fine, shows the bony structure in some of the larger pieces. It should be as dry as possible, and in a fairly fine state of division. It should have the characteristic smell, though there is no need that the smell should be offensive. It does not follow that bone-meal is necessarily good because the odour is disgusting.

Take about 100 grains in a small iron spoon or ladle; heat it strongly in a brisk fire. The heat should be applied cautiously at first to avoid loss by spurning, after which it may be applied as strongly as possible. Any moisture present, all the organic matter and carbonic acid are driven off by this means, and the "ash" left behind contains phosphate and oxide of lime, and magnesia, with a small quantity of alkalis. The ash should be quite white if the bone-dust is pure, although it may require some patience and a pretty hot fire to get it white. This ash is now allowed to cool, and emptied into a glass beaker or a basin which will stand heat. If such a vessel is not at hand, a small enamelled saucepan may be pressed into the service. Pour on to the ash in this vessel about half a pint of water and a few ounces of hydrochloric acid, and boil well for about five minutes. The substance should dissolve completely in the acid, or leave only a very small residue. If there is any considerable residue left undissolved, the presumption is that sand has been mixed either purposely or accidentally. Allow this acid liquid to cool; pour it off from the sand into a tumbler or glass jar. A rough indication of the quantity of phosphate of lime present may be gained as follows:—Add dilute solution of ammonia until the liquid smells of ammonia. This will form a dense white precipitate of phosphate of lime, and a little practice will enable you to judge from the bulk of the precipitate after it has stood for two hours of the relative proportion of this ingredient in the manure. If the same quantity (100 grains) be taken in each case, you will know what quantity to expect from a good sample. If no precipitate, or only a slight one is formed, the manure may be discarded. I know of no method by which even an approximation of the nitrogen can be made without apparatus. As sand is the most likely adulterant, it will generally be sufficient to test for it as above. This method will detect sand in bonedust, dried blood, offal, and such products.

Sulphate of ammonia should be a whitish crystalline powder, fairly dry and friable. It should dissolve completely in water without leaving any residue, and on placing some in the iron spoon used in the test for bone-dust, and heating it strongly in the fire, it should completely volatilise, leaving no residue. A fair idea of its purity may be inferred from the quantity of the

residue thus left. A perfectly pure sample should volatilise completely, leaving the spoon perfectly clean. If a little of the powder be mixed with slaked lime, and heated in the spoon, a strong smell of ammonia will be given off. If there is none, the substance is not sulphate of ammonia at all, nor any ammonium compound.

Dissolve a little of the salt in water, and add a few drops of ferric chloride, which can be prepared by dissolving a little iron rust, scraped off a rusty iron implement, in hydrochloric acid. If a deep blood-red colour is produced by this reagent, the manure should not be used, as it contains a compound which is injurious to plants, namely, ammonium sulphocyanide. The solution of sulphate of ammonia should not alter the colour of blue litmus paper; if it turns red, the salt contains free acid and should not be used.

Kainit should be a crystalline powder, resembling common salt, more or less white, often of a reddish or darkish tinge, generally damp to the touch. It should dissolve almost entirely in water, and should be completely soluble in water to which a little hydrochloric acid has been added. The potash cannot be estimated by any simple method with any degree of accuracy.



The above tests require no other reagent than a little hydrochloric acid and ammonia, and though they are not, in any sense of the word, accurate analyses, still they may prove useful when there is any doubt about the purity of any of the substances in question.

With the help of a balance which will indicate half a grain, such as any druggist possesses, the following scheme will enable a fairly close estimation of bonedust to be made:—

The following articles and chemicals will be required:—A balance (turning to $\frac{1}{2}$ grain), pure hydrochloric acid, pure ammonia, a packet of cut filter papers, glass beaker, pestle and mortar, a sieve of eighty meshes to the linear inch, a porcelain basin, a glass funnel, some strips of litmus paper. These can all be obtained at the local druggists.

It is very important to obtain an average sample of the bonedust. To do this, if the sample is contained in one bag, empty it out upon a clean board or floor, and mix it well with the shovel. If in two or more bags, take a sample from the middle of each bag, and mix them as above. From the mixture take about a spadeful and grind it thoroughly in the mortar until the whole of it has passed through the sieve. The sifted sample is again mixed and is ready for analysis.

A piece of glazed writing-paper is placed on one of the pans of the balance, and exactly counterpoised by placing a similar piece of paper in the other pan. Weigh out exactly 200 grains of the finely-powdered manure upon the paper, introduce it without loss into the iron spoon, heat very gently at first and then gradually more strongly until the ash is white. Care must be taken not to lose any by spurling. Allow to cool; empty back again upon the paper without loss of substance. The weight should not now much exceed 80 grains. This is now emptied again into the porcelain basin, about half a pint of water added, and about 3 ounces of strong hydrochloric acid. Boil well for about five minutes, add a little more water, and filter.

Filtering is done as follows:—Fold one of the round papers in half , now fold again in half at right-angles to the first fold . On opening this out it will be found to fit exactly into the funnel. The funnel with the filter paper is now supported over a beaker. The liquid in the dish is poured

through the filter, rinsing it out with water so as to get all the sand on the paper. The paper with the sand is now placed in the oven until quite dry, and weighed. If a second filter-paper of the same size as the first be placed in the other scale the weight obtained will represent the weight of sand. This should not be more than 3 or 4 grains in a pure bonedust. This number divided by two will give the percentage of sand and insoluble matter in the bone-dust.

The filtered liquid is now neutralised with ammonia—that is to say, ammonia is added till the solution turns red litmus paper blue. Allow the precipitate which is formed to settle and filter again in the same way as the sand; dry and weigh as before. The weight of this precipitate divided by 2 gives the percentage of phosphate of lime in the bonedust. This should not be less than 40 per cent.—that is, the precipitate should weigh at least 80 grains. The above scheme does not pretend to scientific accuracy, but it will give a fair approximation to the actual composition.

As the efficiency of a bonedust depends much upon the fineness of division, it is as well to grade it roughly by passing it through a sieve with twenty-four meshes to the linear inch. Three-quarters of the weight of the manure (75 per cent.) should pass through the sieve.

It must be thoroughly understood that the above tests are only intended as a rough guide as to the purity of a manure. If the quantity of impurity is found to be excessive a sample should be forwarded to a qualified analyst for report.

General Remarks on Artificial Manures.

Manure the crop, not the land.

Never purchase a manure without a guarantee of its composition as determined by analysis.

In the case of complete fertilisers, it must not be forgotten that you have to pay for getting them mixed; consequently it is often a question whether it would not be cheaper to buy the simple manures and mix them yourself. On the other hand the mixing (especially in the case of large quantities) can be much more thoroughly done by the manufacturer.

The simple manures are bonedust and superphosphates, containing nitrogen and phosphoric acid (superphosphates from mineral phosphates contain no nitrogen); dried blood, sulphate of ammonia, and nitrate of soda, containing principally nitrogen; sulphate of potash, and wood-ashes, containing potash; and lime, gypsum, &c., containing lime. As these fertilisers are seldom used in greater quantities than can be mixed by hand, the trouble involved is very small.

A further advantage is that you can vary the proportions to suit your own particular requirements in different cases, whilst in purchasing a complete fertiliser you nearly always pay for a quantity of some ingredient which you do not require.

It will be found more convenient to mix them with about three times their weight of dry loam, and distribute evenly. The advantages of such a course are obvious. Lime should not be added to ammonium sulphate, or dried blood, or bonedust, as it drives off ammonia. It is safer not to add lime to any nitrogenous manure; hence, when the land has been limed, it is better not to manure it for two or three weeks.

Comparative Value of Farmyard Manure and Artificial Manures.

The following comparison of the relative manurial value of farmyard manure and a typical complete artificial fertiliser on the market may be found useful.

One ton of farmyard manure contains, roughly, the following quantities of fertilising ingredients :—

Nitrogen	8 lb.
Potash	6 lb.
Phosphoric acid	6 lb.

In 3 cwt. of the artificial fertiliser there are of—

Nitrogen	9 lb.
Potash	6 lb.
Phosphoric acid	42 lb.

That is to say, 3 cwt. of the fertiliser contains about the same quantities of nitrogen and of potash, and seven times the quantity of phosphoric acid, as 1 ton of farmyard manure.

The manurial ingredients in the artificial products are in a very soluble form and their effect is more rapid. On the other hand, they contain no vegetable matter like the litter in farmyard manure.

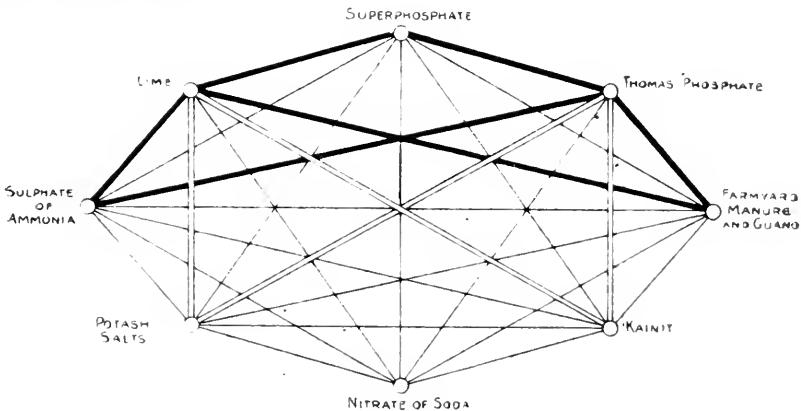
A Few General Hints.

When purchasing a manure, always insist on a guarantee of its composition as determined by analysis.

Artificial manures should be mixed with about three times their weight of dry loam, and distributed evenly.

Never add lime to a manure containing sulphate of ammonia or blood and bone manures, as in these cases loss of nitrogen results; and when lime has been applied to the land, do not use manures until about three weeks afterwards.

The accompanying fertiliser diagram, which represents in a graphic manner the points to be taken into consideration in the mixing of different manures, is reproduced in the hope that it will be found useful to farmers who make up their own mixtures.



Substances connected by thick line must not be mixed together.
 Substances connected by double line must only be mixed immediately before use.
 Substances connected by single thin line may be mixed together at any time.

FERTILISER RECOMMENDATIONS FOR DIFFERENT CROPS.*

In the following pages are given manurial recommendations for different crops. These recommendations are based on actual field experience on the Department's farms and orchards, farmers' experiment plots, and elsewhere.

Cereal Crops.

Wheat.—Experience has shown that there is only one fertiliser that wheat-growers in New South Wales need consider, and that is superphosphate. Although differing local conditions may make advisable some variation from the quantities recommended, and although it is well worth any grower's while to ascertain by experiment what such variation (if any) should be, it may be said that in the Riverina and on the South-western Slopes growers should never fail to sow about 56 lb. of superphosphate per acre with the seed. In the central-western districts the most satisfactory amount has been found to be somewhere between 40 and 56 lb. In the north-west district manuring with superphosphate is not so essential.

Oats.—Oats, like wheat, require manuring under most conditions, and respond bountifully to the application of superphosphate. On most soils, from 40 to 56 lb. per acre will be found sufficient; but on poorer lands the quantity can be increased up to $\frac{3}{4}$ cwt. with beneficial results.

They appear to respond much more to heavy manuring than wheat. When sown early in the season $\frac{1}{2}$ cwt. of superphosphate is ample; but as the sowing season advances, the quantity can be slightly increased. In coastal districts, where there are practically no drills, and the manure (if used) has to be broadcasted, the quantity per acre should be increased to double that recommended for sowing with the drill.

Maize.—It is almost impossible to make the soil too rich for maize. Unlike the other cereals, maize requires not only various quantities, but different kinds of manures, according to the district in which the crop is to be grown. There is no doubt that farmyard or stable manure, if readily available, is the most desirable manure for this crop. It not only gives a substantial increase in the immediate yield, but the beneficial effect on the soil of a single application lasts for several years.

Leguminous crops (peas, beans, vetches, clovers, &c.), the roots of which have the capacity of living in association with certain bacteria that fix the free nitrogen of the atmosphere in small nodules or excrescences on the roots, are the cheapest and best means of supplying nitrogen to maize soils.

The best fertiliser for the grain crop differs from that for a green fodder crop. The various applications that have been found most profitable for grain and for fodder in the different parts of the State are given below:—

NORTH COAST	...	...	Grain. Equal parts of bonedust and superphosphate at the rate of 2 cwt. of the mixture per acre, or 2 cwt. superphosphate alone.
			Fodder.—A mixture of 2 cwt. superphosphate and $\frac{1}{2}$ cwt. sulphate of ammonia per acre.
SOUTH COAST	...	...	Grain.—Equal parts of superphosphate and bonedust at the rate of 2 cwt. per acre, or 2 cwt. of superphosphate alone.
			Fodder.—1 cwt. superphosphate per acre.

* Compiled by the Field and Chemist's Branches.

NORTHERN TABLELAND	...	Grain or Fodder.— $\frac{1}{2}$ cwt. superphosphate and $\frac{1}{2}$ cwt. sulphate of ammonia or nitrate of soda per acre.
SOUTHERN TABLELAND	...	Fodder.—2 cwt. superphosphate per acre.
NORTH WESTERN SLOPES	...	Grain.—1 cwt. superphosphate per acre.
TUMUT AND DISTRICT	..	Grain.—1 to 2 cwt. superphosphate and $\frac{1}{2}$ cwt. sulphate of ammonia or nitrate of soda per acre.

Millet (Broom).—Such crops as cowpeas, field-peas, vetches, and clovers are suitable for green manuring for this crop and may be ploughed under when they have reached the blooming stage or have been grazed off by stock. This latter system works well when mixed farming is carried out, and stock of different kinds are kept. Any vegetable matter should be ploughed under early, to give it ample time to decompose before sowing. Farmyard manure, if available, is also a first-rate manure to apply, as it not only supplies the elements required by the plants, but also improves the mechanical condition of the soil. Chemical manures are also valuable, and while not generally practised, it has been found beneficial, even on our richest soils, to apply about 1 cwt. of superphosphate per acre with the seed. Besides giving the plants a quick start—necessary when weeds are to be dealt with—it helps the crop to mature earlier, and in most instances increased yields are the result. At Mondrook much benefit has been derived from fertilisers, even when applied to the previous crop.

An excessive dressing of manure tends to produce a strong coarse brush.

Winter Green Fodders.

Coastal Districts.—On the whole 1 cwt. superphosphate per acre has given the best results with winter green fodders on the coast. In experiments carried out by the Department the addition of 28 lb. of sulphate of potash to 1 cwt. superphosphate has produced an average increase of 6 cwt. green fodder per acre, but the value of this increase is more than counterbalanced by the cost of potash fertiliser at present, so that it cannot be recommended. The application of 2 cwt. Thomas' phosphate has given a greater increase than 1 cwt. superphosphate per acre, and also a higher net profit per acre (taking pre-war cost of fertiliser), but unfortunately this fertiliser is not quoted on the market just now.

Southern Tablelands.—Not many tests have yet been made with fertilisers for green winter fodders on the Southern Tablelands, but the few that have been conducted indicate that 2 cwt. superphosphate per acre is the best fertiliser.

North-western District.—Insufficient results from fertilisers have so far been obtained in this district, and their general use cannot therefore be recommended.

Northern Tablelands.—In the cooler New England district, an application of, say, 2 cwt. superphosphate is advisable.

Other Fodders.

Lucerne and Clover.—Sow $\frac{1}{2}$ cwt. superphosphate with the seed to get quick growth of seedling plants, and top-dress established stands with 2 cwt. of superphosphate per acre in winter or early spring. Top-dressing with superphosphate has given remarkable results in the rehabilitation of old lucerne stands, up to 400 per cent. increases in the subsequent crop being obtained in some cases.

Sorghum.—Where farmyard manure is available, it can be applied broadcast at the rate of 10 tons per acre, and lightly harrowed in. Green manuring is not sufficient in itself to maintain the fertility of the land; neither is farmyard manure. Artificial manures are also required to make up the deficiencies. As the result of many experiments with fertilisers for sorghum on the North Coast, an application of 2 cwt. superphosphate per acre is recommended where farmyard manure has been applied or where green manuring has been practised. Where the soil is deficient in decaying organic matter and consequently in nitrogen, $\frac{1}{2}$ cwt. sulphate of ammonia or nitrate of soda should be added to this superphosphate. On the South Coast and Southern Tablelands where the yields of fodder are lower than on the North Coast, from 1 to $1\frac{1}{2}$ cwt. superphosphate per acre is recommended. The manuring depends very largely upon the nature of the soil. On light sandy soils more potash, and possibly more of the nitrogenous manure, are required, while on good clay soils less potash may be used. Superphosphate, or some other form of phosphatic manure, nearly always gives good results on all classes of soils, and should not be omitted. Superphosphate is particularly valuable in promoting vigorous development of the young growth, especially in the early spring and in cold climates where young sorghum plants are apt to grow slowly and become choked by weed growth if they have not the stimulation that is given by this fertiliser.

The artificial manures should always be sown with the seed by using a fertiliser attachment on the drill. If the seed is sown by hand in drills, the manure should be scattered along them first. As good results cannot be expected from manure sown broadcast, as are obtained when it and the seed are put in together with a drill. The manure is then placed in such a position that it can be utilised immediately by the young plants, and fulfils one of its functions by inducing a vigorous healthy start.

Sudan Grass.—Increased yields are obtained from the application of chemical fertilisers, and experiments have shown that 1 to 2 cwt. of superphosphate per acre or a mixture containing equal parts of superphosphate and bonedust can be used with profit. The effect of manure is most apparent in the first growth, as a rule, increasing the percentage of flag, succulence, stooling propensities, and height of stalk.

Root Crops.

Potatoes.—The following manures and mixtures have been found suitable for potatoes in the different parts of the State, the amounts indicated being those required per acre:—

NORTH COAST AND CENTRAL COAST ...	2 cwt. superphosphate or $1\frac{1}{2}$ cwt. superphosphate and $1\frac{1}{2}$ cwt. bonedust.
NORTH COAST PLATEAU	$1\frac{1}{2}$ cwt. superphosphate and $1\frac{1}{2}$ cwt. bonedust.
SOUTH COAST	2 cwt. superphosphate and $\frac{1}{2}$ cwt. sulphate or muriate of potash.
NORTHERN TABLELANDS	$1\frac{1}{2}$ cwt. superphosphate and $1\frac{1}{2}$ cwt. bonedust; on sandy soil use 2 cwt. superphosphate and $\frac{1}{2}$ cwt. sulphate or muriate of potash.
CENTRAL TABLELANDS	$1\frac{1}{2}$ cwt. superphosphate, and $1\frac{1}{2}$ cwt. bonedust.
SOUTHERN TABLELANDS	1 cwt. superphosphate, 1 cwt. bonedust, and $\frac{1}{2}$ cwt. sulphate or muriate of potash.

Turnips and Swedes.—The rapidity of growth of turnips and swedes necessitates a ready supply of all the soil constituents they require and the substance above all others thus in demand is phosphoric acid. Superphosphate

applied at the rate of $\frac{1}{2}$ to 1 cwt. per acre supplies a readily available form of phosphoric acid. It has a marked effect upon the growth of the young plants, and results in a greatly increased yield.

Mangolds.—Although experiments are at present being carried out by the Department to determine the most profitable fertiliser mixture for this crop, results will not be available for some time, and positive recommendations based on local field experience are therefore impossible. It may be said, however, that mangolds are an exhausting crop, capable of making use of a greater amount of plant food during their growth than most crops, and for this reason it will in all probability be found that a heavy application of a complete fertiliser will be profitable. In the repairing of the soil's fertility, farmyard manure (though usually difficult to procure in any quantity) plays an important part. Heavy dressings of this may be applied, preferably in the form of rotted manure, but as farmyard manure is somewhat deficient in phosphoric acid, about 1 cwt. of superphosphate per acre should be applied with the seed.

Vegetables.

Farmyard manure, green manure and artificial fertilisers can all be used with advantage by the vegetable grower. Without enlarging here upon the advantages of the use of the two first-mentioned manures in relation to their beneficial effect upon the mechanical condition of the soil, it may be said that artificial manures are better used to supplement applications of farm manure (or, failing this, of green manure) than in place of them.

Of animal manures, each has its particular utility, but availability is a big consideration, and use must be made of whatever kind is handy, for all are more or less of value in the growing of vegetables.

Horse manure is drier than most manures, and for this reason it acts most quickly and is most efficient in the raising of early crops. As it decomposes rapidly, and consequently generates heat in a shorter time than a slow decomposing manure (such as cow manure), it is most valuable for winter use.

Cow and pig manures are of a heavier nature, decomposing more slowly and being therefore slower in action. They are good moisture-holders, and are therefore very valuable during the summer. Sheep-manure is fine-textured and very concentrated, and is therefore of great value in the vegetable garden; unless care is exercised, however, weed seeds may inadvertently be introduced with it as with all other dung. Poultry manure is the most concentrated of all animal manures, and on this account it must be applied with discretion. If dry sand is scattered regularly on the floor of the fowl-house, the droppings will be drier and therefore more suitable for spreading on the surface of the soil. If fresh poultry manure is used, it should be raked or lightly dug into the surface of the soil or applied in the form of liquid manure. If it is intended to dig the manure into the soil, it is advisable first to allow it to rot in the compost heap.

Many of the earlier planted crops, such as lettuce, cabbage and silver beet, will be more tender for being forced by applications of liquid manure. Liquid manure is best made from fowl droppings; in fact, it is in liquid form that this valuable animal fertiliser is best applied. The method of preparation is as follows:—

Soak a sugar bag of fresh poultry, cow, or pig manure for a week in a cask with the head knocked in: one holding from 40 to 50 gallons is the most handy. Use the resulting solution at the rate of one part to three parts of

fresh water. Fill the cask again, and when the manure has soaked for a week use the solution at the rate of one part to one part of fresh water. The cask may then be filled up a third time and after the liquid has been allowed to stand for a week it may be used neat. This form of liquid manure is safe, and if used weekly at the rate of 4 gallons to every 18 feet of running row, no further stimulant is necessary for most growing crops.

Do not apply liquid manure to plants if the soil is at all dry. Dry soil should first be watered.

Chemical fertilisers have a special utility in the vegetable garden, even where the product is grown on a fair area and for market purposes. Used in the small quantities required for such limited areas they are not a very expensive item, and they can be conveniently applied according to requirements. Indeed, it is not advisable to apply the whole of such fertilisers at the time of sowing or planting. A certain proportion (even half the quantity) should be reserved and worked into the surface soil between the plants during cultivation at a later period in the crop's growth.

Crops that must quickly make a large amount of leaf growth, like lettuce, cabbage, &c., respond readily to applications of nitrogenous manures in this way. Sulphate of ammonia and nitrate of soda both supply nitrogen in a form in which it readily dissolves in water, and which is thus quickly available as a stimulant to plant growth. They may be used at the rate of $\frac{1}{2}$ cwt. to 1 cwt. per acre, either as a top-dressing (though they should not come into contact with the plant) or dissolved in water and applied as liquid manure.

Peas, beans and other leguminous plants do not need to be supplied with nitrogen in the form of fertilisers, but phosphoric acid supplied in the form of superphosphate or of bonedust has a marked effect on plants of this class. It is of particular use where a rapid return is looked for—as in the case of spring-sown crops—and it is the manure most needed by practically all our crops. Superphosphate at 2 to 3 cwt. per acre or bonedust at 4 cwt. per acre (most suitable for summer use) may be mentioned as suitable quantities.

Sulphate (or muriate) of potash can also be used to advantage as part of a "complete" fertiliser, though in this State they cannot be recommended for use alone.

Miscellaneous Crops.

Sugar Cane.—Fertilisers are not extensively used by cane growers in this State. Trials have been conducted by different farmers on their own account, and it may be said that where the land is fertile and is being well farmed the only utility of fertilisers is in connection with ratoon crops. Some farmers favour bonedust with a little blood added, and others have had fairly satisfactory results with complete fertilisers; a few have been well pleased with their experience with nitrate of soda.

Cotton.—On medium soils a mixture of equal parts superphosphate and bonedust should be applied at the rate of 2 cwt. per acre. On better class land 1 cwt. per acre will be sufficient.

LIST OF FERTILISERS IN NEW SOUTH WALES.

The accompanying list of manures obtainable in New South Wales, together with their composition, as guaranteed by the vendors, is published in the interests of the farmers, and it is hoped that it may serve as a guide to those requiring any particular class of manure. It is complete to April, 1922.

It must be clearly understood that the figures given are not those obtained by analysis of the sample by the Department. They represent the *guarantees* given by the vendors in accordance with the provisions of the Fertilisers Act. Where possible, samples have been taken from bulk by one of the officers of the Department, and purchasers may be confident that the manures included in the list are up to the guarantee.

On account of the unsettled conditions obtaining at present, the market value of these manures may alter. An attempt has, however, been made to assign a "unit value" to the fertilising ingredients, viz., nitrogen, phosphoric acid, and potash.

A word is necessary in explanation of the column giving the "manurial value" of the manures. These figures are calculated from the composition of the manures and the market prices then current, a definite unit-value being assigned to each of the fertilising ingredients. The units on which the values given are computed, are as follow :—

UNIT-VALUES of fertilising ingredients in different manures for 1922.

	Per unit.
	s. d.
Nitrogen in nitrate	29 1
„ in ammonium salts	19 10
„ in blood, bones, offal, &c.—fine	22 11
Phosphoric acid in bones, offal, &c.—fine	6 7
Phosphoric acid (water soluble) in superphosphates	7 7
Potash in muriate of potash	12 9
„ „ sulphate of potash	8 8*

PRICE per lb. of fertilising ingredients in different manures for 1922.

	Pence per lb.
Nitrogen in nitrate	15·6
„ in ammonium salts	10·2
„ in blood, bones, offal, &c.—fine	12·3
Phosphoric acid in bones, offal, &c.—fine	3·5
Phosphoric acid (water soluble) in superphosphates	4·1
Potash in muriate of potash	6·8
„ „ sulphate of potash	4·6*

* The above figures (especially for potash salts) are liable to fluctuation. Those quoted were correct at the end of August, 1922.

To determine the value of any manure the percentage of each ingredient is multiplied by the unit-value assigned above to that ingredient, the result being the value per ton of that substance in the manure. For example, a bonedust contains 4 per cent. nitrogen and 20 per cent. phosphoric acid:—

$$\begin{array}{rcl} 4 \times 22s. 11d. & = & \text{£}4 11s. 8d. = \text{value of the nitrogen per ton.} \\ 20 \times 6s. 7d. & = & \text{£}6 11s. 5d. = \text{,, phosphoric acid per ton.} \\ \hline & & \text{£}11 3s. 4d. = \text{value of manure per ton.} \end{array}$$

It must be clearly understood that the value thus assigned, depending solely upon the chemical composition of the manure, does not represent in all cases the actual money value of the manure, which depends upon a variety of causes other than the composition, and is affected by local conditions; neither does it represent the costs incurred by the manufacturer in the preparation, such as cost of mixing, bagging, labelling, &c. It is simply



Manurial Trial with Potatoes.

This plot of Queen of the Valley was manured with superphosphate at 3 cwt. per acre and yielded 10 tons 12 cwt., as against 10 tons where only 2 cwt. superphosphate was used, and 7 tons 17 cwt. where no manure was used.

intended as a standard by which different products may be compared. At the same time, it has been attempted to make the standard indicate as nearly as possible the fair retail value of the manurial ingredients, and it will be found in the majority of cases the price asked and the value assigned are fairly close.

These figures have been checked by analyses of samples collected by an officer of the Department. It by no means follows, however, that the particular product guaranteed and here published will be in stock for any length of time or that the prices may not vary.

Now that the Fertiliser Adulteration Act is in force, the purchaser has only himself to blame if he pays for an inferior article. Every vendor is obliged to furnish a guarantee with every delivery of fertiliser, setting forth its actual composition as determined by analysis.

If the purchaser has any reason to suspect the genuineness of the guarantee, all he has to do is to notify the vendor of his intention to take samples for analysis, in sufficient time to enable the vendor or some person appointed by him to be present. The samples must be taken before the consignment is finally in the purchaser's possession; for example, if the fertiliser is sent by rail, the sample should be taken at the railway station or siding. Three samples must be taken, one being given to the vendor or his representative, the second kept by the purchaser and submitted to an analyst, and the third forwarded to the Department of Agriculture for future reference, in case of divergence in the analyses of the other two. All three samples must be sealed up.

In the case of bonedust, blood and bone manures, &c., the valuation has been made on the assumption that the product is in a fine state of division, and is based on the amounts of fertilising ingredients only; but it must be borne in mind that finely-ground bonedust acts more rapidly than coarse, and that unground fragments of bone only become available as fertiliser very slowly.

A number of waste products which may in many cases be economically utilised have been analysed in the laboratory at various times. The results of those analyses appear in Table IV on pages 122 to 124.

When purchasing a manure, always insist on a guarantee of its composition as determined by the analysis.

Never add lime to a manure containing sulphate of ammonia or blood and bone manures, as in these cases loss of nitrogen results; and when lime has been applied to the land, do not use such manures until about three weeks afterwards.

TABLE I.—SIMPLE FERTILISERS.

Manure.	Where obtainable.	Guaranteed Composition.					Manurial Value.			
		Nitrogen.	Equal to Ammonia.	Lime.	Potash.	Phosphoric Acid.				
		per cent.	per cent.	per cent.	per cent.	per cent.	£	s.	d.	
Sulphate of ammonia	Australian Fertilisers Proprietary, Ltd. (successors to Geo. Shirley, Ltd., 7 O'Connell-street).	20·4	24·8	..	..	..	*20	4	7
Nitrate of soda ..	" "	15·6	18·9	..	..	..	22	13	3
Muriate of potash ..	" "	..	..	..	58	..	36	19	6
Sulphate ..	" "	..	..	..	52	..	†31	12	5
" ammonia	Australian Gaslight Co., Haymarket	20·4	24·8	..	..	..	20	4	7
" "	Farmers' Fertilisers Corporation, Hunter-st	31	20·4	24·8	..	..	20	4	7
Gypsum ..	" "	..	..	..	96 Cryst. CaSO ₄	..	..	..	..
Sulphate of potash ..	" "	52·7	..	32	1	2
Agricultural lime. (Burnt lime, air slaked).	" "	..	..	..	..	..	..	..	..
Ground rock phos- phate.	" "	..	..	..	..	..	31·95	..	..
Sulphate of ammonia	Paton, Burns, & Co., 75 York-st.	..	20·4	24·8	20	4	7
Muriate of potash ..	" "	52	..	36	19	6
Nitrate of soda ..	" "	..	15·6	19·1	22	16	7

* May be purchased at 17s. 6d. per unit or £18 per ton at producers' works.

† These figures (especially for potash salts) are liable to fluctuation. Those quoted were correct at the end of August, 1922.

II.—BONE AND BLOOD MANURES, 1922.

Manure.	Where obtainable.	Nitrogen.	Guaranteed Composition.			Equal to Tricalcic Phosphate.	Manorial Value.
			Ammonia.	Phosphoric Acid.	per cent.			£ s. d.
Bonedust	Australian Fertilisers Proprietary Ltd. (successors to Geo. Shirley Ltd.), 7 O'Connell-street.	per cent. 3.8	per cent. 4.61	per cent. 22.0	per cent. 48.03	11 11 11	
Bone and blood	" " " "	5.0	6.07	17.0	37.11	11 6 6	
B. and B. manure	Kitchen and Sons, Ltd., 365 Kent-st.	5.0	6.07	17.0	37.11	11 6 6	
Extra B. and B. manure	" " " "	5.0	6.07	13.0	28.38	10 0 2	
Blood and bone	R. S. Lamb & Co., 32 Jamieson-st.	4.12	5.0	13.74	30.0	9 4 10	
Pure fertiliser	N.S.W. State Abattoirs, Homebush Bay	6.68	8.11	10.87	23.73	11 4 8	
No. 1—General purposes bonedust	Wooster Fertilisers, Ltd., 16-20 Bridge-street	3.7	4.5	21.98	48.00	11 9 6	
No. 2—Pure steamed bonedust	" " " "	3.91	4.75	24.50	53.50	12 10 11	
No. 3—Blood and bone manure	" " " "	5.76	7.00	13.74	30.00	11 2 5	
No. 5—Raw bonedust	Riverstone Meat Co., Ltd., Riverstone	4.01	4.86	24.41	53.30	12 12 7	
Blood	" " " "	13.5	16.0	.....	.....	15 9 4
Blood and bone	" " " "	4.75	5.77	20.00	43.66	12 0 6	
Sandown blood and bone fertiliser...	J. Cooke & Co., Propy., Ltd., Sandown Works, Parramatta.	6.85	8.32	11.40	25.50	11 12 0	
Excelsior bonedust	M. Gearin and Sons, Old Botany road, Mascot	3.5	4.25	22.0	48.03	11 5 0	
Bonedust,	M. O'Riordan and Sons, O'Riordan-rd., Alexandria	3.7	4.5	21.98	48.0	11 9 5	
Bone and offal manure	Newcastle District Abattoir Board, 27 Hunter-st.	6.25	7.50	11.00	24.01	10 15 8	
Dried blood	" " " "	12.00	14.57	.....	.....	13 15 0
Bonedust, B.D. 1	Paton, Burns, & Co., 75 York-st.	3.7	4.49	22.12	49.20	11 10 5	
" " " " B.D. 2	" " " "	3.7	4.49	22.12	49.20	11 10 5	
" " " " B.D. 3	" " " "	3.3	4.01	20.07	45.19	10 11 11	
Bone and blood manure, B.B. 1	" " " "	5.0	6.07	17.00	37.11	11 6 6	
" " " " B.B. 2	" " " "	5.0	6.07	13.00	28.38	10 0 2	
Bone phosphate ... ..	" " " "	.....	.....	.....	.....	.....
Dried blood	" " " "	13.00	15.79	.....	.....	14 17 11

III.—SUPERPHOSPHATES, MIXED FERTILISERS, AND IMPORTED FERTILISERS.

Manure.	Where obtainable.	Nitrogen.	Guaranteed Composition.			Manurial Value.
			Water-soluble Phosphoric Acid.	Total Phosphoric Acid.	Potash.	
		per cent.	per cent.	per cent.	per cent.	£ s. d.
Superphosphate	Australian Fertilisers Proprietary Ltd. (successors to Geo. Shirley, Ltd., 7 O'Connell-st.)	.....	17.0	.....	.....	6 8 11
Basic Superphosphate	"	.....	.....	17.0	.....	.....
No. 2	"	2.0	10.0	.....	1.0	*6 8 3
No. 4	"	4.0	8.0	.....	2.0	*8 5 6
No. 5	"	3.0	10.0	.....	7.0	*11 4 7
No. 6	"	3.0	10.0	.....	4.0	*9 6 4
No. 8	"	4.0	11.0	.....	.....	8 2 9
No. 10	"	2.0	13.0	.....	.....	6 18 3
No. 11	"	.....	12.0	.....	4.0	*7 2 0
No. 1 Superphosphate	Farmers' Fertilisers Co-op., Ltd., 3 Hunter-st.	.....	17.0	.....	.....	6 8 11
No. 0 Phosphatic fertiliser	Woolster Fertilisers, Ltd., 16-20 Bridge-street.	3.30	4.5	20.61	.....	11 15 10
No. 6 Potato	"	4.52	3.0	*14.19	5.0	13 1 5
No. 7 Complete	"	5.01	4.0	14.56	2.0	11 12 5
Sulphide Superphosphate	Gibbs, Bright & Co., 37 Pitt-street	.....	17.0	.....	.....	6 8 11
Nitro	"	1.6	15.0	.....	.....	7 7 4
No. 1 Bone and	"	1.5	8.5	19.0	.....	8 7 11
No. 2	"	0.8	13.0	19.0	.....	7 16 5
Potato manure	"	1.25	14.5	16.0	3.5	8 19 4
Orchard	"	2.3	13.00	14.5	4.5	10 1 7
Maize and fodder crop manure	Gibbs, Bright & Co., 37 Pitt-street	3.0	11.0	14.0	1.0	8 15 0
Root crop	"	3.25	7.5	3.0	.....	8 19 11
Leguminous	"	.....	15.5	18.0	2.4	7 18 0
Special orchard manure	"	2.3	12.0	12.8	7.25	11 9 0
Superphosphate	Paton, Burns, & Co., 75 York-st.	.....	17.0	.....	.....	6 8 11

* Prices to be reduced after April.

IV.—WASTE PRODUCTS, ASHES, &c., NOT ON THE MARKET.

Manure.	Original Source.	Water.	Volatile and Combustible.		Nitrogen.	Insoluble.	Lime.	Phosphoric Acid.	Potash.
			per cent.	per cent.					
Deposit from wool-scouring tanks { 2 3	Liverpool Wool-scouring Works	..	..	..	64	per cent.	..	per cent.	..
	"	..	..	..	102	..	..	16	72
	"	..	..	..	137	..	..	14	39
Deposit from breakers	"	..	..	..	181	50.68	85	88	1.60
	"	..	..	..	19.57	8.24	97	None	20
Sediment from wool-scouring works	Vass	..	..	..	59	..	..	..	None
	"	..	..	..	2.95	..	4.56	..	..
Scutch..	Australian Glue-Gelatin Works, Alexandria	56.98	..	..	..	..	..	..	..
" from lined belts	Hugh Wright, Anburn	5.22	72.42	1.80	3.61	9.36	89	29	..
	Fellmongery	9.70	57.08	6.86	1.22	26.27	67	..	..
Tan-yard refuse	Tanneries, St. Mary's	6.43	33.83	2.24	21.43	26.96	56	..	..
Tan refuse	"	7.10	50.90	2.62	16.03	18.58	18	..	..
Fleshings from tannery	"	.91	75.37	4.43	5.98	..	1.14	94	..
Salt (sweepings from tannery)	"	3.01	..	7.0	38	..	..	..	..
Wool-waste	"	..	..	8.15	..	..	..	..	..
Peat..	"	34.33	28.20	1.97	29.03	2.75	37	32	..
	"	72.93	16.68	35	10.89	..	..	..	..
Barnt peat	S. Cook, Pymont	49.51	31.63	7.5	84.45	..	..	96	91
	"	..	..	..	..	..	..	25	33
Filter-press muck	Cane-mills, Broadwater	16.39	26.07	.22	34.86	13.20	13	5.98	44
Megass..	Clarence River cane	22.86	67.32	63	8.61	30	..	01	95
Megass ash	"	..	..	..	87.69	3.07	16	51	..
Bloodwood ash	Richmond River cane	..	..	..	1.11	21	4.79	21	..
Ironbark ash	"	..	..	..	8.47	..	2.25	5.53	..
Blackbutt ash	"	..	..	..	..	7.27	..	94	2.02
Red-gum ash	"	..	..	..	..	..	10	70	..
Spotted-gum ash	"	..	..	..	..	..	..	67	1.65
Boxwood ash	"	..	..	..	..	..	..	3.07	5.30
Grass-tree ash	"	86	1.78	..	33.48	24.94	..	3.76	3.76
Vine-cuttings ash	"	49	..	..	60.64	11.34	1.85	..	6.00
Red-apple ash	"	..	..	..	54.52	13.96	4.7	..	2.19
She-oak ash	"	..	..	..	8.57	42.35	8.85	..	3.09
Hardwood ash	"	50	1.35	..	62.38	13.50	1.76	..	27
Ash of wild melon	Stock Branch	..	..	..	21.43	5.12	4.85	..	..
Wood ashes	"	30	..	..	41.37	35	2.89	..	..
Ash of kerosene shale	Wentworth Irrigation Area	11.12	..	..	11.12	50.75	58	3.21	..
Eucalyptus leaves ash	Hartley Vale	1.49	27.63	70	67.59	..	..	28	10.51
"	"	..	..	..	..	..	..	..	20.30
Camphor laurel ash..	"	..	..	..	..	..	..	..	2.55
Coachwood and sassafras wood ash	"	..	..	..	..	16.16	3.60	..	13.53
Gidgea wood ash	"	..	..	..	..	40.3	36	..	25
Bracken fern ash	"	..	..	..	56.17	9.64	5.09	..	4.98
Broom millet ash	"	2.59	..	..	57.23	11	4.67	..	15.33

IV.—WASTE-PRODUCTS, ASHES, &c., NOT ON THE MARKET—continued.

Manure.	Original Source.	Water.	Volatile and Com- bustible.	Nitrogen.	Insoluble.	Lime.	Phosphoric Acid.	Potash.
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Coals (ash)								
Clinker from locomotive boiler								
Residue from furnace	R. E. Bragg, Marriekville	1.55	35.63	.54	52.40	.64	.43	.69
Sea-weed ash								
"						9.27	.49	.59
"							1.27	
"								17.55
"								2.26
"	Mainly	.43			56.28			4.7
"					43.06			13.98
"					.07			34.30
"	Mr. Harvey, Department	3.25	19.46			.53		
"								3.22
"					61.63	4.22		
Sea-weed, fresh state		80.00		.16		.41	1.00	31.41
Sea-weed		41.03	42.49	.14				.60
Sea-weed, dried		18.58	65.97	1.64	15.44	3.44	.14	.14
"					(ash)			
Sea-weed, air-dried		3.60					.42	1.02
Air-slacked lime		16.58			1.88	75.44		
Residue from calcium carbide		41.36			1.08	36.19		
Limestone rock	Queanbeyan	1.10			4.70	48.20	1.22	
Agricultural lime	Portland Cement Co.	18.43			23.80	Hydrate } { 13.80 } { Carbonate } { 43.97 }		
Gypsum	Marulan				4.47			
Cave deposit, shells, &c.		2.11		.82			1.59	.88
"	Cowan, Hawkesbury River	23.06	16.01	2.43	26.77	13.88	7.40	
Deposit (coral, shell, &c.)		2.13	13.53	.72			3.53	.39
Shells	Pacific Islands							
Flue deposit	Pambula River				83.75	2.56	.32	.31
"	Maitland				91.17	.42	1.29	.17
"	Liverpool				63.53	6.64	1.82	1.61
"		6.30	2.45					.38
"				.74	18.60	7.02	.78	
Night-soil mixed with lime	Wagga Wagga	6.70		.63	82.19	.44	.28	.69
Night-soil	"	9.14		.28	78.92	1.18	.18	.54
"	"			.50				.62
"	"							.64
Night-soil preparation, No. 1		8.22		3.73	50.22	13.32	9.65	.91
"	No. 2	7.20		1.83	29.02	8.05	4.10	.45
"	No. 3	25.95		1.64	69.17	1.89	1.61	.70
"	"Pibhoc" manure		9.54	.21	57.58	14.71	1.26	.56
"	F. Artlett, Parramatta	.92	30.06	2.10	46.38	2.09	1.92	.61
"		7.23	42.59	4.97				
"		10.11	12.36	.54	77.95	30.12		
"	Mr. Halslead, O'Brien's patent	1.54					.63	
"		29.52	56.15	2.55	14.33			
"					(ash)			

IV.—WASTE PRODUCTS, ASHES, &c., NOT ON THE MARKET—continued.

Manure.	Original Source.	Water.	Volatile and Combustible.	Nitrogen.	Insoluble.	Lime.	Phosphoric Acid.	Potash.
Street sweepings	Sydney Municipal Council	61.63	19.57	.35	15.45	..	..	..
Farmyard manure	Bathurst	67.96	22.09	.40	8.16	.16	.42	.28
Stable manure	Bathurst	39.26	3.95	.41	70.16	..	.20	.30
Fowl manure	Bathurst	1.54	15.23	.86	79.96	2.10	1.94	.67
Fowl yard manure	Bathurst	4.8	14.26	.91	59.59	.64	.84	.33
Sheep manure	Liverpool Wool-scouring Works	7.73	50.91	1.96	32.26	3.12	.84	1.17
Sheep tag	Abattoirs	9.71	3.94	1.79	2.30	2.30	.91	.92
Refuse manure	Abattoirs	12.00	74.51	4.14	6.56	..	1.80	..
Plying-fox manure	Abattoirs	3.34	3.34	3.34	30.29	1.02	.36	1.15
Fish fertiliser	Abattoirs	14.47	64.36	10.37	4.52	..	7.27	..
Shark fertiliser	Abattoirs	9.02	68.04	10.59	3.86	..	7.27	..
Fish manure	Abattoirs	10.88	59.25	6.10	5.89	9.82	8.28	..
Rabbit bar, long	Anderson, Oxford-street	8.73	88.64	14.03	3.63	..	..	..
" short	" "	9.72	87.76	14.00	(ash).	..	..	..
Bat guano	" "	14.11	17.69	1.55	28.77	13.72	11.42	..
" "	" "	10.86	19.65	2.24	51.95	1.75	3.55	15
" "	" "	13.70	34.35	4.76	3.30	22.28	13.04	trace.
Bat deposit	Cave Flat, Cooradigbee	5.43	12.98	.50	57.64	5.60	12.12	..
Guano deposit	Tamworth	8.75	38.40	6.17	12.85	..	9.24	..
" "	" "	5.42	20.97	3.10	31.89	..	7.87	..
" "	" "	14.55	29.91	3.66	15.81	..	12.98	..
" "	" "	9.35	44.32	6.73	7.33	..	13.17	..
" "	" "	4.57	11.41	.21	..	34.90	28.30	.22
Ground guano	L. R. Mercy, Ashford	23.75	35.57	3.63	1.05	16.32	3.11	.60
Deposit from cave	Queanbeyan	5.71	5.71	.59	9.48	42.80	..	..
Bone breccia	Maitland	4.84	17.55	.74	63.42	4.56	.51	.06
Muck from waterworks reservoir	Maitland	63.06	29.86	.81	3.80	.96	..	..
Muck raked from waterhole	" "	33.52	62.35	.82	..	..	1.70	.05
Sawdust	" "	57.80	62.35	.74	40.68	1.30	..	..
Decayed wood, bark and leaves, bloodwood	" "	79.92	79.92	.8	17.77	1.50	..	..
Decayed wood, bark and leaves, pepper-tree	" "	8.24	74.08	3.29	..	..	1.29	1.49
Coconut oil cake	" "	18.81	74.08	4.30	..	..	1.83	.86
Castor cake	" "	16.02	7.24	4.30	..	..	1.46	1.17
Pea cake	Java	14.52	80.32	6.77	..	..	1.33	1.39
Bean cake	North China	42.74	42.15	1.07	13.77	.02	.03	.04
Rice husks	" "	88.58	9.97	.55	..	..	1.2	.49
Field pea, whole plant	" "	83.97	14.96	.73	..	..	.11	.21
Tares, whole plant	" "	79.00	17.86	.85	..	..	.14	.69
Marsh mallow, whole plant	" "	82.57	15.90	.90	..	..	.11	.54
Horse bean, leaves and stalks	" "	97.8	81.52	3.29	8.70	.05	1.18	.06
Refuse from wheat cleaner	State Wheat Office, Fyrmont	8.53	28.04	3.64	..	..	28.13	..
Whale bones	" "	8.53	28.04	3.64	..	..	28.13	..

SECTION III.

The Farm Holding.

CLEARING.

THE methods by which land is cleared in New South Wales vary widely according to the nature of the timber and the purpose to which the land is to be applied.

Where cultivation is the object in view, the work must be done with some degree of thoroughness, the trees being either grubbed out to a depth of 9 to 12 inches, or burnt off to 1 or 2 inches below the surface. The former method permits of the use of the set-plough, but the latter limits the farmer to the stump-jump implement.

Where dairying is intended, the practice in heavily timbered coastal districts is to cut the brushwood and undergrowth, to ringbark all big trees, and, after waiting for some months, to apply a fire-stick to the dry material where it lies.

In western districts, where wool and mutton-growing are alone thought of, it is usual to sweeten the soil and improve the pastures by cutting down of small timber, ringbarking more or less of the larger trees, "suckering" as required for a few years, and permitting nature to do the rest.

Clearing for Cultivation.

To deal fully with these various methods is unnecessary for the purposes of this Handbook. The primary clearing on many properties is done by contract, and the farmer, even if previously ignorant of this class of work, usually acquires sufficient knowledge while the contractor is on his land to enable him to proceed at his own convenience with the extension of his cleared area. A general indication of the principles underlying the different methods may, however, be of use.

A warning should be interpolated here that, if it is decided to clear by contract, land which is to be put under cultivation, it is necessary to see that the contractor is bound down pretty strictly as to the depth to which the roots are to be run to, whether or not the timber is to be burnt on the ground, and to an agreement that when the land is being broken up, the contractor shall follow the plough to run any roots exposed.

Before proceeding to the consideration of the various methods of clearing, it should be stated that there are many farmers in different parts of New South Wales who do not like the practice of clearing land of green timber and applying it to cultivated crops at once. They state that the results are better if the timber is "rung" and allowed to die before it is removed. They

have found it takes the soil two years to sweeten after green timber is cleared, whereas the sweetening period is much shorter if the other method is adopted.

Hand Grubbing.

Fortunately clearing need not now be the very heavy, tiresome work that it was a generation ago, science having come to the assistance of the farmer with winches, jacks, hauling gear of different kinds, and explosives, and by the use of two or more of these agents in conjunction it is possible now to clear in a few days areas that at one time would have taken almost as many weeks. For convenience, the principles of hand-grubbing may be stated first, and the application of the various mechanical devices and of explosives afterwards.

The grubbing of timber, especially green timber, in preparing land for the plough, is one of the most laborious tasks with which the new settler has to contend. If the weather has been dry for some time previous to the beginning of operations, the ground is exceedingly hard and the task doubly difficult, as more labour is necessary to remove the earth from around the tree (that the roots may be cut to allow the tree to fall), and also, the earth requires to be dug to a greater depth, as the lower roots, owing to the dryness of the soil, will not draw out so easily when the tree begins to overbalance, as they would if the ground were soft. The same applies also to the running of those roots which are near enough to the surface to interfere with the ploughing, and which if not taken out at first may cause breakages to the plough and harness, and injuries to the man and horses.

The advice that clearing should be done when the soil is moist has to be offered with some reservation, however. It almost invariably happens that that is the time when the farmer is least able to give attention to the extension of his cleared area, for the reason that he is then usually fully occupied ploughing or cultivating elsewhere on the farm. What clearing is done has often, therefore, to be carried out during dry spells, when the ground is too hard to cultivate, and so hard as to make clearing very hard work indeed.

One of the commonest errors of beginners is to think that if they are getting the trees down quickly they are getting along famously, but the experienced hand knows that if the tree falls, breaking off and leaving the tap root unmoved, the hardest part of the work is yet to be done; for when the tree has fallen, there is no leverage to assist in drawing the tap or main roots.

Another error is to try to save labour by removing as little earth as possible from around the tree or stump; it is invariably found that before the job is finished the barrow-loads of earth have run into cartloads ere the mattock and axe can be swung freely and the taproot reached. Until that is achieved, and the root is severed, the end is not in sight. The soil should be opened well back from the trunk, a mattock and long-handled shovel being the most suitable implements. As will be found a few pages further on, one of the great utilities of explosives in clearing is to loosen the earth at the base of the tree, to enable a cavity to be cleared out and the taproot uncovered.

The root system having been opened up, the first thing to do is to cut through, or partially through (with as wide a cut as possible), the roots on the side towards which the tree leans (see Fig. 1). If there is a taproot, a cut should be made into it as far as possible on this side. Explosives are very useful at this stage, inasmuch as an auger hole can be bored in the taproot and gelignite employed to sever it.

Meanwhile the roots on the other side being intact will hold the tree, thus enabling the workman to operate in security. All the cutting possible having been completed on the side to which the tree leans, the roots on the other side are followed a bit further out, and severed one by one. Nothing



Fig. 1.—Showing how large-headed trees can be canted with lever.

is gained by cutting these latter roots close in to the tree. On the contrary, the further they can be followed the better, especially if tackle is used, or if the tree has a decided lean or there happens to be a favourable wind. As shown in the illustration, a long sapling, used as a lever, can sometimes be employed with advantage to cant the tree.

The manual labour involved in clearing land thoroughly by hand is very heavy, and for the man who is dependent on immediate returns most costly in the long run. Indeed, it would pay a man better to defer building a cottage, and to camp in a tent for six months or a year, so as to have the money for pushing forward with the clearing. Some of the clearing can be done by degrees as opportunity occurs, but it will always be most profitable to get at least half of it done so as to catch the autumn or spring season for sowing a crop which can be growing while the rest of the work is in progress.

Winch Grubbers and Jacks.

Such machines as the jack, "forest devil," and winch grubber, can now be had for a comparatively small outlay, and they are capable of doing all that is claimed of them, providing they are properly handled.

With the aid of a tree-pulling winch, and by severing with an axe or by means of explosives the larger main roots 4 or 5 feet from the trunk, both green and dead trees of 5 and 6 feet diameter can be pulled down in a very short time. Away from the coast, in districts where the timber is of normal size, several acres can be brought down in the course of a day. The

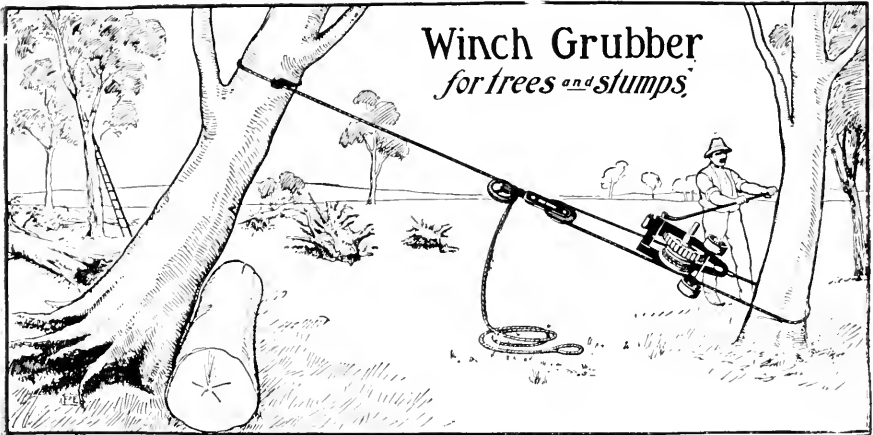


Fig. 2.—A winch grubber of modern type.

method of attaching the gear is shown in Fig. 2. One end of a steel rope is passed through a pulley-block as high up the trunk as convenient, while the other is hitched to the machine and an anchor-tree. If the main roots have been severed well back from the trunk, the tree can be made to "run" its own roots as it falls.

An implement that is almost indispensable where clearing is going on is the jack. For running roots, prising out trees or stumps, moving logs, boulders or floating rocks, or drawing old fence posts, &c., it is well suited, doing the work with little exertion on the part of the man, and in a surprisingly short time. The use of this implement is illustrated in the accompanying figures.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.

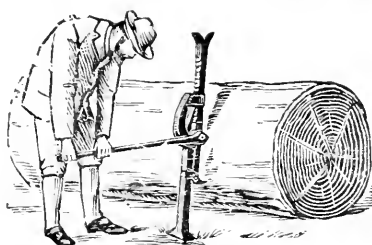


Fig. 7.

Yet another machine, in which the lever is again the chief agency, is that known as the "forest devil." It consists of the ironshod end of a wooden lever pivoted between a pair of parallel iron plates, and an arrangement of bolts or steel clutches provided to grip two chains, one attached to the tree pulled and the other to the anchor-tree. If the distance is at all considerable, steel bars are often used for portion of the way instead of chains. A man grips the free end of the lever and walks backwards and forwards in a semicircle, whilst a lad rearranges the clutches or bolts at the end of each trip so as to reverse the direction of pull. The slack portions of the chains fall to the ground as they are drawn in. As the lever may be of any desired length, the power which may be obtained is practically limited only by the strength of the tackle. In South Gippsland, Victoria, appliances of this nature have been largely used in clearing the heavy forests of that region, particularly for drawing stumps after a burn.

In connection with machines of all these kinds, it must be borne in mind that no machinery will continue to work well without oiling, and the cost of a tinful of oil is but a fraction of that of a broken part, quite apart from the vexatious delays that breakages entail.

Block and Tackle.

In certain districts it is economical to hire a team of bullocks or steady horses, and to use hauling gear on a more powerful scale. The method, though extensively used in the past, is being superseded in many parts of the State by the machines for manual power just described, but it still has its utility, and there are those who prefer it, though winch grubbers or explosives are generally employed in conjunction with it.

The team having been obtained, the selector himself, with what assistance he can arrange for, can perform the necessary shovel, mattock, and axe work in opening up the ground about the trees and stumps. Under fair weather conditions great headway can be made in getting the trees down, and the heavy logs hauled off the clearing, while the tops can be at once disposed of by burning on the spot. The advantage of this system is that the owner of the area can see for himself exactly how the stumps and roots are removed, and this will repay him tenfold when the area comes to be worked.

There are several methods of hauling down timber, but the description of two here will suffice to indicate the principles.

For one used in clearing the site of Cowra Experiment Farm, the plant consisted of:—

200 feet of 2-in. circumference wire rope.

150 feet of 2½-in. circumference wire rope.

Two pieces, 20 feet long, of 3-in. circumference wire rope.

Three pulley-blocks, size of sheaves 8 inches x 2 inches, viz., one treble, one double, and one single sheave.

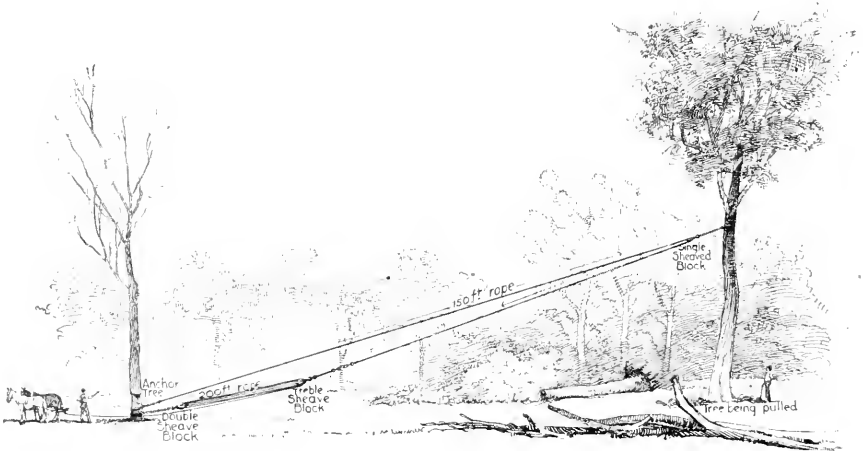


Fig. 8.—Tree-hauling gear, as used in clearing at Cowra Experiment Farm.

Mr. Geo. Marks, Manager, Grafton Experiment Farm, thus describes the use of this tackle:—

One of the short pieces of 3-inch rope, with the single-sheave block hooked on, is placed round the barrel of the tree that is to be pulled down, a ladder being brought into requisition to fasten the rope as high as possible. The 200-foot rope is reefed in pulleys of double and treble sheave blocks. The double block is hooked on to the other short piece of rope, which is then fastened round the butt of a neighbouring stump or tree, on the side on which it is intended to pull the tree. The end of the 150-foot rope is hooked on to the treble block, passed through the single block attached to the tree, and after the slack is taken up, is anchored by winding it round the butt of the stump or tree, where the other block is anchored, or if the stump or tree is small and not likely to stand the strain, to another tree in the line of pull. A pair of strong steady horses is hooked on to the end of the 200-foot rope, and everything is then ready for the pull. The slack is taken out of the ropes, and, by means of a strong steady pull, the tree will come down.

The side from which the tree will be pulled will depend upon the shape and lean of the tree, the slope of the land, the direction of winds, if any, and the nearness or otherwise of anchor-trees.

When the ground is soft and in good order, as is the case after or during rains, green trees up to 2 feet in diameter may be pulled down, taking almost every root with them, without easing; and dry trees of any size with sound barrels may be pulled down. If the ground is dry and hard, or the trees are extra large, it will be found necessary to ease them by removing the soil around the butt of the tree to a depth of a couple of feet, and perhaps cut some of the larger roots. It will thus be seen how important it is to take advantage of any wet weather, thus effecting a great saving of labour. Five men and a pair of steady horses could pull down about 5 acres of ordinary box timber in a day.



Fig. 9.—Manual tree-hauling gear.

In the case of stumps, or trees with hollow or defective barrels, they should be grubbed round well before commencing to pull, as there is often not the same leverage obtainable, and should the tree break off level with the ground, the butts and roots would have to be taken out in the ordinary way, thus necessitating a great deal of extra labour.

All blind stumps and roots that may have been cut in easing the trees are then taken out to a depth of 18 inches from the surface—a depth that will not interfere with future ploughing, and, if necessary, subsoiling of the area. These should be taken out thoroughly.

The tackle illustrated in Fig. 9 has been found very useful where the trees are of a moderate size. It does not help so far as opening out about the main roots and cutting them through are concerned, but it saves worrying

around the taproot. A log is usually placed at the foot of a tree that is being felled, as shown in Fig. 2. The effect is to "draw" the roots on the near side of the tree. The logs shown in Fig. 9 are placed for the tree to fall on, so that in sawing the trunk time may not be lost by the saw cuts biting the saw as the ends of the unsupported parts of the trunk press in against each other. This can also be prevented by using wedges gently tapped into the cut as soon as it is deep enough to carry a wedge. The wire rope is about 25 yards long, and an ordinary double purchase tackle is used. In hauling, the operatives stand well away from the line of fall, and as the ropes slack off when the tree begins to fall the blocks are jerked aside. The rough ladder shown is made of a couple of bloodwood saplings, which are tough and soon become very light when stripped of the bark. The gear is fixed ready before the tree is opened up.

The mistake is often made when pulling down trees by machinery when the ground is hard, of not easing the trees sufficiently to allow of the drawing of the roots, and consequently when the strain of the machinery is brought to bear on the tree, it, being too firmly held in the ground (especially if the barrel or trunk be hollow), breaks off level with or close to the surface, and then more labour is necessary to get the stump out than was at first required if it had been gone about in the proper manner.

At times the burning of big trunks that have been brought down is almost as difficult a problem as was the standing tree itself. Explosives are proving valuable in shattering such trees and enabling the farmer to burn them.

Before filling in the holes that have been made by the removal of large stumps, a careful examination should be made, and all roots that will interfere with the ploughing removed.

LAND CLEARING BY EXPLOSIVES.

One has only to watch a man hand-grubbing a forest giant in the heat of a summer day, and to follow him home in the evening, to appreciate really the magnitude of his task, and it is an open question if any system or machine used singly or in combination, would have lightened his heavy task to the same extent as a few packets—perhaps a few plugs—of gelignite would have done. After removing dray-loads of material in trenching round a tree or stump, in order to be able to swing the axe or mattock, roots may be met that the axe cannot reach, whereas an auger hole and a few plugs of gelignite (varying in number according to the size of the roots) will sever and shatter the hindrances and loosen up the surrounding soil at the same time. The same question arises when the forest devil or 10-ton jack, or any other mechanical device for pulling down green timber is being used—that of getting rid of the trunk. Frequently the crosscut or lightning saw is used to cut the log into suitable lengths for handling, stacking and burning; but it is a much cheaper proposition to frill and poison the tree, and then, when dead, to shatter it with gelignite, and burn in an upright position. Besides, the hot ashes falling from the burning upright tree operate considerably in "stoving" out the tree-roots. When the tree falls that section of the trunk, and any larger limbs that are not consumed by the fire, can be better handled with a little gelignite than by all the axes in the country, and with infinitely less labour and hard work, though the axe must be used on the lighter and more easily handled portions.

There is nothing more troublesome after the trees have been felled, all their limbs, branches and leaves burnt, and grass is beginning to appear, than the wilderness of blackened and half-burnt logs that is to be seen in almost any section of this State. Frequently there is no light wood available, without endless carting, to burn off these blackened tree trunks, and such a proposition would be ruinous. But gelignite does just the very thing that is needful for dealing with such logs; it makes kindlings, and in making cords and cords of kindlings it converts large sections of those troublesome logs into the very condition that is essential, if rapid and effective burning off is to be accomplished.

Ordinary ringbarking is the method usually adopted for the killing of timber preparatory to clearing, and if thoroughly done at the right season it is effective; but it is very slow, often taking well over twelve months to bring about the desired result. A better method is frilling and poisoning, (see page 148) as this kills in a few weeks, and often in a few days. Even with this method some trees will be more resistant and will sucker, no matter how carefully they may be treated; but, generally speaking, the treatment is highly effective, enabling the dead timber to be handled well within twelve months, and affording the owner the additional advantages of an extra season and a sweetened soil, due to the timber having been allowed to die in the ground instead of having been cleared off green.

Necessary Tools.

The tools necessary are:—Earth auger, bulb bar, wood augers (two), chisel bar, tamping stick, crimping pliers, electric firing battery, galvanometer, firing cable, No. 6 detonator (ordinary), No. 6 detonators (electric or E.D. fuses), and the explosives.

Earth auger.—This is made from an ordinary $1\frac{1}{2}$ -inch Mathieson wood auger, the centre screw lead being cut out and the auger end fishtailed to the depth of about $\frac{1}{2}$ inch, and new cutting edges then filed on the proper sides of both wings; the handle or shank is lengthened to suit, but $4\frac{1}{2}$ feet is a convenient length, as holes 4 feet deep are ample for practically all tap roots.

Bulb bar.—This tool was designed to expedite the placing of holes round and under trees and stumps, and as will be seen from the accompanying illustration it is unnecessary to remove the core of earth, as has to be done when using the earth auger. The bar is 5 feet long, of $\frac{7}{8}$ -inch octagonal steel, one end being thickened up to $1\frac{1}{2}$ inches diameter, and drawn out to a fine point 3 inches long on the lead end; behind the thickened section the bar is gradually tapered back to the diameter of the bar ($\frac{7}{8}$ inch) for, perhaps, a couple of inches. The top end is headed for driving-in purposes. When this bar is in use, it is driven home preferably with a wooden maul, as a steel sledge knocks the steel bar head about too much. When it is about 8 inches in, water is poured into the hole made, and the driving is continued until the hole is of the desired depth. This makes a circular hole of $1\frac{1}{2}$ inches, and when the bar has to be withdrawn there is only the friction of the bulb section to contend with, as the bar shank is so much smaller in diameter; besides, the water poured in during the driving operation follows the bulb down, lubricating the sides of the hole, and making the job of withdrawing the bar comparatively easy. It may happen that in driving this bar down, a root may be gone over or under,

and this may make the task of withdrawing the bar more difficult, but it was to avoid this that the taper was designed at the back or top side of the bulb. In any case a 6-foot length of $\frac{1}{4}$ -inch chain, double half-hitched round the bar at the ground level, and then round a long rail or stout sapling, which can be used as a lever, will soon release it. Any blacksmith can make this implement; in fact, it might easily be made on the farm at a moderate cost. It will get through more than ten times as much work as the auger, and it will ease much hard work.

Wood augers (two)—The ordinary $1\frac{1}{2}$ -inch Mathieson wood auger similar to the one the earth auger is made from, is a highly efficient tool, though a good deal of trouble is often met with in getting it to start boring after it has been withdrawn for clearing purposes—which is necessary from time to time—on account of chips being left in when releasing the screw lead preparatory to withdrawing.

The L'Hommedieu or bull-nosed auger of $1\frac{1}{2}$ -inch diameter is a rapid and efficient wood-boring tool, but it needs a Mathieson auger to start the hole; usually an inch or two will suffice. It cuts quicker and with less exertion to the operator, and when withdrawn for clearing out the hole—as is necessary from time to time—it goes right down to the bottom at once, making re-starting easy and simple. A handle or shank 4 feet 6 inches long is a convenient length in each case.

Chisel bar.—This is a most useful tool, and a practically indispensable implement when using explosives, as so many trees and stumps have large, solid, or even hollow hip roots, partially under or very near the surface, where a grubbed hole, somewhat similar to a rabbit hole, but smaller, allows the charge to be bunched right up against the timber, causing a maximum amount of shattering, a result that is very desirable for rapid burning off afterwards.

The best way to make this implement is to have the centre portion, between the two working ends, made of a piece of ordinary 1-inch black iron piping 3 feet 6 inches long, the external diameter of which would be $1\frac{1}{4}$ inches (galvanized piping will interfere with the welding of the steel terminals). A piece of $\frac{3}{8}$ -inch steel, 6 inches long, is then welded into each end of this pipe length, one piece being drawn out to a cutter bar, 3 inches wide, ground on the inside only and set back an inch or so as shown in the accompanying illustration. The piece of steel at the other end is made as an ordinary chisel bar, 1 inch wide and sharpened cold-chisel fashion; besides being useful for grubbing charge holes, small and medium roots may easily be cut, if met with during grubbing operations.

Tamping stick.—This must always be of timber, about an inch in diameter, and an old broom-handle about 5 feet long makes a most efficient one.

Crimping pliers.—These are used for fixing the detonators on to the safety fuse and cutting it into convenient lengths. Some people use their teeth, but it is most unwise and should not be encouraged under any circumstances. (See Figs. 2, 4, and 5.)

Electric firing battery.—This is used only where several charges have to be exploded simultaneously, as there is no other reliable method. It is mostly, if not entirely, used when it is desired to blow trees and stumps right out of the ground. This firing battery is in no sense a chemical battery, but is similar in operation to a magneto or dynamo. There are different types on the market, varying from a capacity of a single shot, for coal-mine work, up to fifty shots at one time; in style they also differ, ranging



1



2



3



a

b

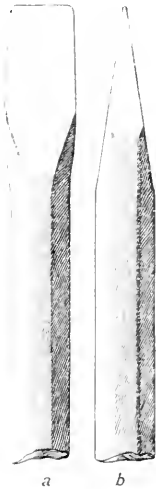
4



a

b

5



a

b

6

Fig. 1.—Implements used in Clearing by Explosives.

1 and 2, Matheson Wood Auger before and after cutting out the screw head. 3, L'Hommedieu or Bull-nosed Auger. 4, (a) Top and (b) bottom ends of Bulb Bar. 5, (a) Front and (b) side view of wide chiselled end of Cutter Bar. 6, (a) Front and (b) side view of narrow chiselled end of Cutter Bar.

from the ordinary Q type, where a handle is revolved at a high speed and at the same time a button pressed to break the current and flood the circuit with a full, fat spark, to the Rackbar type, where a long handle-bar with a fine-toothed rack attached, is pushed down briskly and a cut-out plate struck at the bottom to flood the circuit. This scheme of liberating the current generated at the very last moment is to ensure that the whole amount will speed round the circuit in one energetic mass and so provide sufficient to fire all the charges concerned; otherwise the firing would be irregular and some charges would be unexploded. The Rackbar type is by far the better machine, and a 10-shot capacity is the most convenient size.

The Galvanometer is a very weak, chemical dry-cell battery, and is only useful for testing the electric detonators before inserting them in the various charges, and then after connecting up these charges in series and coupling up to the firing cable, to make sure that all connections are secure and no "shorts" exist. With care these dry cells will last for months, and when they run down they can be renewed for a few shillings. It would be extremely risky for anyone who is not thoroughly conversant with galvanometer testing to attempt to renew these dry cells. Too strong a cell would explode and not test the electric detonator.

The Firing Cable is, or should be, 100 yards long and composed of two wires or strands of wires, separately insulated and waterproofed to prevent "shorting," and then further insulated and waterproofed to prevent damp or wet penetrating them. They are highly flexible, and should be quite moisture-proof under all circumstances; with care they will last for years.

No. 6 Detonators (ordinary).—These consist of small copper cylinders, about $\frac{1}{4}$ inch diameter, open at one end only, and charged with about 16 grains of fulminate of mercury, a very sensitive compound with a high detonating force. Their function is to explode the charges of gelignite by detonation, and they should be handled with all care and respect, since their explosive force is in the neighbourhood of 60 lb. per square inch, which is more than sufficient to blow one's hand off.

No. 6 Detonators (Electric or E.D. fuses).—These are similar to the ordinary No. 6 detonators as to the copper cylinder and charge of fulminate of mercury, but they have an addition to enable them to be fired electrically instead of by ordinary safety fuse. Attached to each electric detonator are two wires, and on one end of each wire is a small metal pole, one slightly shorter than the other. Uniting the ends of these poles of varying length is an extremely fine platinum wire, over which fits a gun-cotton priming, very similar in appearance to a fusee match head. This priming rests right up against the fulminate of mercury in the copper cylinder, the whole attachment being kept firmly in place by a waterproofed insulation compound on its open end, performing the dual purpose of keeping the contrivance in its place and preventing any moisture reaching the fulminate. In operation, the spark generated in the firing battery flies down one wire and across the fine platinum wire bridge, which instantly becomes incandescent, just as an ordinary electric lamp does, thus setting fire to the gun-cotton priming which explodes the fulminate of mercury and detonates the charge of gelignite. The current having completed its function in the first E.D. fuse, rushes up the other wire and along to the next fuse, repeating the same operation, up to number of charges in the circuit or the capacity of the firing battery.

Explosives.

There are many kinds of explosives on the market, most of which are applicable to the varying work of land clearing. Gelignite, dynamite, rack-a-rock, and black powder are the most generally known and distributed, and are therefore comparatively easy to obtain; in normal times most of the agents for explosives handle the above. They all have their advocates and will all do good work; but the conditions under which some will and some will not, make it essential to explain in detail.

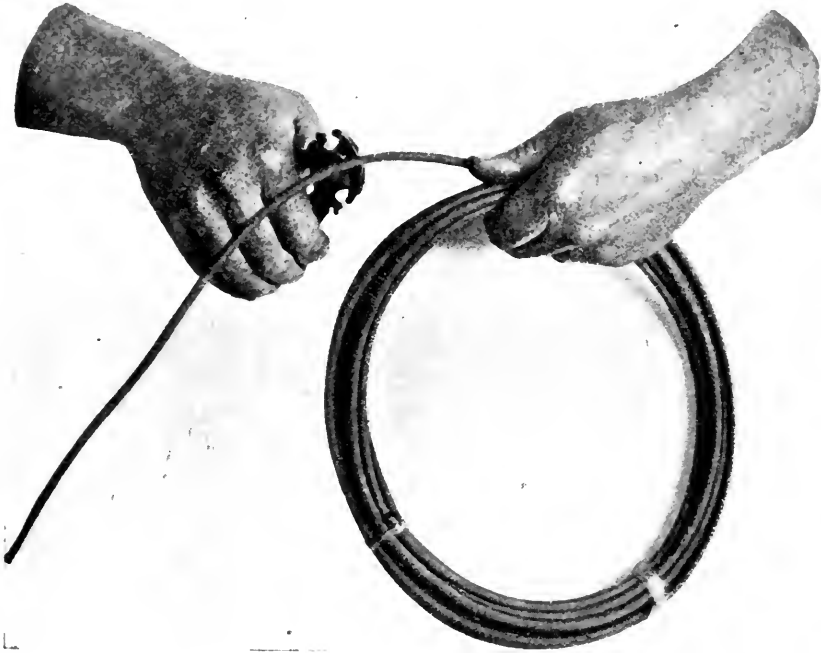


Fig. 2.—Cutting the required length of fuse.

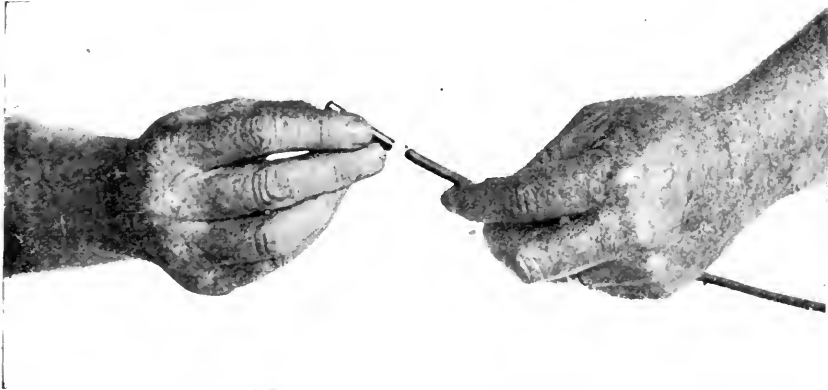


Fig. 3.—Inserting the fuse in the detonator

Gelignite and dynamite are both nitro-glycerine compounds, and for land clearing purposes they practically do the same work, but there is a vast difference in their character and method of manufacture, which stands out in favour of one to the exclusion of the other, for the farmer who is not necessarily an expert with explosives.

Dynamite is a mechanical mixture and soluble in water, that is to say, the nitro-glycerine being only absorbed or taken up in a containing earth, separates out from that containing earth on coming in contact with water, and this crude form of nitro-glycerine is highly sensitive to friction, even when a wooden tamping stick is in use. It is highly dangerous for the reason that the farmer may frequently be working in wet ground when clearing, and the above conditions would operate. Many serious fatalities have been attributed to this solubility of dynamite.

Gelignite is a definite chemical compound, being nitro-glycerine gelatinised chemically and mixed with certain other ingredients. It is quite insoluble in water, and if left in it for long periods would certainly deteriorate, but its chemically combined parts would never separate.

Both of these explosives—dynamite and gelignite—will burn freely if a match is applied, and in the open air in such a condition would be comparatively harmless; but if thrown into a hot confined fire, where air had very little access, such as a stove fire, or a fierce burning log, serious results are likely, for the reason that as the explosive burns, the gases produced by the chemical change are generated very rapidly, and not being able to get away they form a pressure about themselves, which explodes them—really spontaneous combustion.

Rack-a-rock is a combination of two chemicals, one a solid and the other a liquid, neither being classed as an explosive separately but becoming so when they are brought together as rack-a-rock. The solid section consists of a 98 per cent. chlorate of potash cartridge, packed in small calico bags of sausage shape and varying diameter. The liquid is an oil known generally as murbane or almond oil, and chemically as nitrate of benzole, and by soaking the chlorate of potash cartridge in the murbane oil for about three minutes, it becomes a powerful explosive. It is somewhat slower in its explosive action than nitro-glycerine compounds, as used in this State, and for that reason it is well adapted to the work of land clearing; but it is of very little use in wet holes or wet ground, not for the same reason as dynamite but because water apparently breaks up the chemical combination of the chlorate of potash and the murbane oil, rendering it inoperative. All the foregoing—gelignite, dynamite, and rack-a-rock—are exploded by detonation through a No. 6 detonator, and not through the ordinary fuse by itself, though it is good practice to use half a plug of gelignite in addition, as a primer, when firing rack-a-rock, as a No. 6 detonator often proves not to be strong enough for absolute certainty.

Black powder is a proportional mechanical mixture of three substances—nitre, sulphur and charcoal—not so strong in explosive force as any of the foregoing, and very much slower in its action. Its slow pushing action is ideal for work in the soils, but the lack of explosive force throws black powder out when handling trees and stumps; it is used extensively for log splitting in the sleeper-cutting and timber business, as its slow action does not shatter

and destroy the logs like the more rapid gelignite and dynamite do. Black powder is exploded by fire and not by detonation, and the ordinary safety fuse is used for this purpose.

Safety fuse is the ordinary powder fuse, used for firing blasting powder, and attached to a detonator for firing gelignite, dynamite and rack-a-rock. It consists of a continuous core of powder through the centre of an inflammable and practically waterproof wrapper, is made with great skill and very little variation, and is tested carefully by the Explosives Department, having to answer certain rigid requirements before it is permitted to be placed on sale. The rate of burning is about 2 feet per minute, and for land-clearing purposes, where charges are usually fired shortly after they are tamped, it is quite waterproof. There are several makes on the market, the double tape being pre-eminently the best, but of unnecessarily high quality and price for land-clearing purposes, where a cheaper article, such as "blue sump," is quite as effective.



Fig. 4.—Crimping the cap on the fuse.

All the foregoing explosives have their adherents, and justly so, but gelignite is recommended as the safest in the hands of the farmer, who is not necessarily an explosive specialist. Gelignite is all ready prepared in convenient cartridge or plug form, will stand a considerable amount of rough handling, is not affected by water, and can probably be purchased more generally than any of the other explosives. It is somewhat too suddenly strong and rapid in its effect, however, and appears to give better service when slowed down mechanically. In very cold weather gelignite, in common with all nitro-glycerine compounds, becomes frozen, getting as hard as a board. In this condition it should not be used, on account of its liability to miss-fire and, curious though it may appear, of its greater sensitiveness to friction. Its susceptibility to explosion in this frozen condition is due, experts tell us, to the rubbing together of the frozen ice crystals of nitro-glycerine. Proper warming pans are on the market for the purpose of thawing out frozen gelignite, but a simple and effective

way is to place the plugs or cartridges in an ordinary tin billy, and to stand this billy in a bucket containing hot water—so hot that you can just about bear your hand in it—for about twenty minutes, when it becomes soft and pliable. On no account should the bucket containing the hot water and frozen explosive be put on or near a fire: such a proceeding would be highly dangerous.

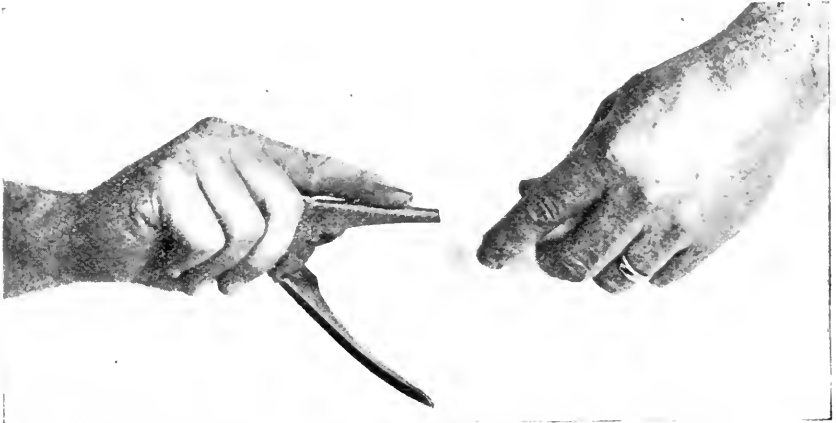


Fig. 5.—Punching a hole in the plug of gelignite, showing the correct position of the hands and gelignite when making the hole with crimpers.

When gelignite was originally recommended for land-clearing purposes in pre-war days, it contained about 62 per cent. nitro-glycerine, but as the war period extended and the demand for nitro-glycerine for military purposes became more acute, the percentage was reduced to 50 per cent. This 50 per cent. nitro-glycerine product is more satisfactory than the old 62 per cent. form for clearing purposes, owing to the reduced percentage of nitro-glycerine having a much slower effect. Both qualities are now available locally.



Fig. 6.—Inserting the capped fuse in the gelignite.

Methods of Using Explosives.

The application of explosives to the various methods of clearing, from shattering by burning to the blowing right out of stumps and trees, varies so widely—what with the different root systems, variety of timber, soil conditions, &c.—as to make it next to impossible to give a concise description in writing of just where to place the charges, and just how much explosive to use. A certain variety of tree may “tap” very badly in one district, and may make no tap-roots at all in another; or the soil may be strongly resistant, with a good stiff solid subsoil for shooting off, and everything in favour of good results in one place, or it may be sandy and friable, and offering but little resistance in another. Such cases need to be tackled rather differently, so that the beginner, after he has mastered the handling and preparing of the charges, &c., and has thereby gained confidence, has to study many points if he is to succeed in keeping down the cost of his clearing, never using the axe if gelignite will do the job quicker and better, or *vice versa*, and never using two plugs if one will be enough.

On most areas the stump question looms large, and in describing the method of handling the stump, the handling of the tree is also described in general principles, since one is the same as the other, except that the trunk and branches have been removed.

It may be taken almost as an axiom that charges should never be placed by means of auger or bulb bar holes in sandy ground or under hollow stumps, that is, stumps with, say, a hollow of a foot or more in diameter. In such cases the charges should be placed by means of the chisel bar close under the hip roots and where the stump is held the strongest, so that the gelignite is resting right up against the timber in a bunch. This ensures the maximum of shattering. The amount of the charge depends wholly on the mass of timber to be shattered; it is next to impossible to lay down hard-and-fast rules as to the amount of charge to be used where such wide variations are the rule rather than the exception.

If a battery is being used, all the charges will be fired at the one time and together, but very good results can be obtained by placing one charge and firing it with ordinary fuse; then preparing another charge hole, the position of which will be dictated to a large extent by the results of the shattering of the first charge, in conjunction, of course, with the next heavy hip root. The work can be continued thus right round the stump, until it is shattered satisfactorily for burning. This is where the grub-hole application of charges is ahead of the auger or bulb-bar application, since a charge put in with the latter would so loosen up the whole soil area of the stump as to make it quite impossible to place another auger or bulb-bar charge under it.

In handling strongly-rooted solid stumps of, say, up to 3 or 4 feet diameter, the auger or bulb-bar can be employed with advantage for a one-charge and ordinary fuse job, but it is advisable to put this hole down quite 4 feet and well under the centre of the stump. The reason for putting this hole down so deep is that the explosive force of the charge travels at a definite and regular angle towards the point of least resistance, which naturally is the surface soil; consequently the deeper the charge is placed, the wider will be the range of the explosive force, and the greater will be the total area of root-system affected. A point in manipulation which might with advantage be

used to a much greater extent, and the effect of which is plainly noticeable when grub-hole charges are used, is that of bunching the charge. By this is meant putting the several plugs that comprise the charge in one lump, instead of, as in a bulb-bar hole, distributing them to a certain extent up the length of the hole. To accomplish this, the hole has to be what is termed "bulled"; this consists of opening out a chamber at the bottom or deepest point, by exploding a small charge of gelignite at that point before the main charge is put in position. The size of this "bullying" charge depends on the number of plugs it is intended to use in the attack upon the stump itself and the physical condition of the ground. Generally speaking, however, one-third of a plug of gelignite will open up a cavity about 6 inches in diameter

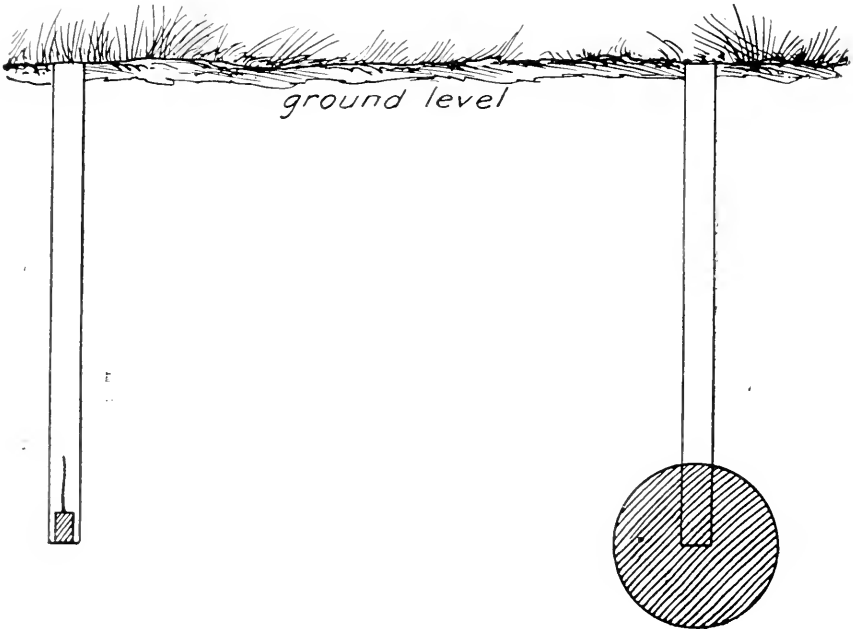


Fig. 7.—"Bullying" a Hole.

A small charge of, say, one-third of a plug is first exploded at the bottom of a hole driven with a bar, and in the chamber so created ten to fifteen plugs can be placed as the "business charge."

every way, which will hold anything from ten to fifteen plugs. To prepare this "bullying" charge of a third of a plug and to explode it in the bottom of the hole, take a No. 6 detonator, free from sawdust packing, and insert a piece of ordinary fuse about 8 inches long in the open end and crimp it on in the usual way with pliers; then, after making a hole with the handle of the pliers or a piece of stick in the piece of a plug, push the detonator with fuse attached into the hole and split the top end of the fuse so as to expose the powder to facilitate lighting. So soon as the fuse is lit and the powder flame spits out, drop the charge quickly into the bulb-bar hole and push it down to the bottom with the tamping stick, then remove the tamping stick and stand to one side, as the explosion throws out a certain amount of

dirt and compressed air straight in front. No tamping of any kind is to be used in this operation, as it is not necessary. After the explosion, push the tamping stick down into the "bull" to make sure everything is clear, before putting the final charge in; if necessary, clean out the hole with the earth auger and proceed to drop the charge in, one plug at a time, pushing each plug down into the "bull" chamber with the tamping stick; lastly the primer—the plug with the detonator and sufficient length of fuse attached—is put in gently and pressed home. Now get a wad of paper—any sort will do—and make a ball about the size of a fist; hold the fuse firmly in place with one hand, and press this paper wad down into the hole to a depth of about 3 feet, or two-thirds of the depth of the hole, taking care that the primer is not drawn out from contact with the rest of the charge, while holding the fuse. Having fixed the paper wad firmly, drop in a few handfuls of loose moist earth; tamp this very gently until it is firm and solid, and is not moving the paper in the hole; then add more earth and tamp it until the remainder of the hole is full of well-tamped earth. To facilitate the lighting of the fuse, cut a diagonal snick in the top end, right into the powder core, and into this insert a small wedge-shaped piece of gelnigite; this ignites quickly when the match is applied and is not easily blown out by the wind. The reason for using the paper wad when tamping is that ample air space may be left in the region of the explosion; the effect of such an air chamber is to slow down markedly the rapidity of the action of the gelnigite when it explodes—an effect that is of importance, both in regard to the wider area covered by the explosion and also the more economic use of gelnigite. It is not advocated as a general thing that green or growing trees should be blown out, because of the sweetening of the soil that goes on in a more definite way while timber is dying than if green timber is removed at once. The increased cost due to live trees having a much stronger hold and consequently requiring more explosives must also be considered. It sometimes happens, however, that it is necessary, or at least advisable, to remove green timber. In such cases better results can probably be obtained by firing the charge electrically, putting down three or four holes, so placed round the tree as to do the lifting where the rooting indicates it to be necessary. In this case all the holes should be about 4 feet deep and "bulled," and the same precautions as to tamping and using the paper wad should be adopted, as previously described; then after connecting up the wires of the various charges "in series," round the tree, leaving one wire from the first and last charge to be connected to the twin wire firing cable, lay this firing cable in the direction of the sun, so that when the operator comes to exploding the charges with the battery, he will be facing the tree with the sun at his back. Should the explosion throw pieces of timber or stones in that direction, he then will have a clear vision and no glaring sun in his eyes to interfere with him in any movement that may be necessary to avoid injury. The cable is 100 yards long, and it is advisable to use the full length and to get right out in the open if possible. The practice of getting behind a near-by tree should not be encouraged, as it may happen that a flying piece of timber may be hurled into the branches of the tree and may be diverted sufficiently to fall upon someone there, or it may strike a dead limb overhead and bring it rattling down. Being well out in the open offers many advantages as to safety.

After firing the charges, disconnect the cable ends from the battery terminals at once, and twist them together; take the galvanometer to the tree just blown out and pick up the other two ends of the cable and by placing one

on each of the galvanometer terminals, test the cable as to whether any flying timber or stones have broken the continuity of either of the internal wires. This is the time to discover breakages, and not when just about to fire the next batch of charges. In locating a breakage, should there be one, the injury to the outer insulation will frequently be a guide, but by taking the cable in the fingers of each hand and slightly bending it while running along it from one end to the other the breakage can be detected. The outer covering must be cut lengthways, the two insulated inside wires separately exposed, and the broken ends fixed by twisting a piece of naked detonator wire on to each broken end, thereby bridging the fracture, and the repair covered with some insulation tape, so as to prevent contact with the other wire, and also to prevent moisture from affecting it. As this operation often necessitates the splitting or cutting of the outer insulation for 2 or 3 inches, further insulation tape must be twisted round the cable proper to cover and protect the repair.

It is frequently found that an otherwise solid tough stump of 3 or 4 feet diameter has a pipehole of perhaps a couple of inches, or may be 6 inches across, and filled with decayed vegetable matter offering fair resistance. With the earth auger or bulb bar put a hole down the pipe, so that the charge will be at least on a level with the ground—a bit below is better—and into this put up to five plugs including the primer (the one with detonator and fuse attached); tamp well, and use the piece of wedge-shaped gelignite to light the fuse end with, remembering that fuse burns at the rate of about 2 feet per minute. Logs frequently have similar pipes, but the difficulty there is to get the hole beyond the charge sufficiently solid to prevent the explosion from blowing right through and out the other end; at times, however, it is possible to get a good basis against which the charge can blow off, and a satisfactory shattering result.

In handling solid logs, a hole should be bored from the side as centrally as possible, so as to equalise the burden both ways (diametrically, not longitudinally), and about two-thirds of the way through, standing on the ground to bore, as that is easier than on top of the log. Bore the first hole about 6 to 8 feet from the stump end, unless the timber is exceptionally curly and a bad splitter, when the hole should be closer to the stump end. Charge the hole with from two to five plugs (including primer) according to the diameter of the log, the greater number being for logs of, say, 4 feet. It will be noticed, after firing, that the splitting has extended for a distance of, say, 8 feet beyond the hole on the end of the log away from the stump, and in the direction of the spot where the next hole is to be. As this first shot split 8 feet beyond the hole, it is fair to conclude that the next one will do so also; the second hole should, therefore, be bored 16 feet away from the first, or 8 feet beyond the extremity of the first split, and it should be treated in just the same way as to the charge, unless very excessive shattering took place in the first explosion. Operations should be continued on this line until the whole log is handled. Of course, if a battery is available, all the charges can be fired at once, with some saving in gelignite perhaps, but one needs some previous experience in splitting the logs of the district to derive the full benefits of electric log splitting. A big saving in explosives can frequently be effected by working from the split of the previous shot, and again, what one log has done is no guarantee as to what another may do.

Dead trees are handled in the same manner as stumps (and without a battery) by working round the main roots, one at a time, shattering some right up against the butt, and others several feet away. The latter are handled by grubbing a hole on top of the root with the chisel bar and putting the charge right on the timber, tamping the soil down on it with the thick end of the mattock handle after the blade has been temporarily removed. Having shattered all the roots satisfactorily, the trunk can be handled in much the same way as the log was handled, by boring a hole about two-thirds through, but at an angle of about 45 degrees; a hole is easier, both to bore, charge, and tamp at an angle than horizontal. After splitting, a few days may be given to allow of the tree drying out before firing. Should the trunk be hollow, it is unnecessary to split it, as the fire will soon reach the inside when once the roots are shattered close up. With a greater realisation of the advantages of the chisel bar and a correspondingly greater use of it, together with the advantage the grub charge hole has over the auger or bulb bar hole, much of the difficulty which at present attaches to the handling of big timber without a battery might be overcome, or at least looked at without prejudice. The "bulled" hole, handled as described above, is a further big advantage, both as to the explosives saved and the results obtained.

Approximate and Comparative Costs.*

Taking gelignite at 1d. per plug, ordinary No. 6 detonators at 1d. each, and fuse at 1s. per coil of 24 feet, which would mean $\frac{1}{2}$ d. per foot, some idea can be given of what the cost should approximate in clearing land. It will be conceded that the conditions enumerated earlier are ever varying, and with them the skill of the operator, so that hard-and-fast accuracies as to costs are not so simple as one might believe. If as a basis of explanation a solid hardwood stump of 4 feet diameter, with 4 feet above ground, and five fairly solid hip roots, is taken, it would take to hand-grub it, say about a day and a half, and costs 15s., with labour at 10s. per day.

On the above basis, if handling it with gelignite, &c., 15s. would purchase just 180 plugs at 1d. each, but as detonators and fuse would also be required, we may deduct 1s. for detonators and 1s. for a coil of fuse, which should be ample, leaving the amount at 13s., which represents 156 plugs of gelignite. If each packet of gelignite contains fifty plugs, we have three full packets, and with them such a stump could be blown right out of sight, and instead of taking one and a half days, it would take, say, about one hour to prepare and fire.

This was the method employed when explosives were first used for clearing in New South Wales, but it was unnecessarily expensive, and the method now recommended consists of using only sufficient explosive to split the stump up so that it will burn easily.

To split and burn such a stump, all the charges are best put in with the chisel bar, so as to get the gelignite right up against the timber to be split, as it is there that it gives its maximum effect. Taking each hip root singly, and having grubbed the first hole well under the heavy part of the root up against the stump, we decide to put in, say, three plugs of gelignite, which, with one

* The prices quoted on this and the following page were current a few years ago, but both explosives and labour have since risen considerably. The changes do not, however, affect the general contention as to the economy of explosives for clearing purposes.

detonator and a foot of fuse, would total fourpence halfpenny ($4\frac{1}{2}$ d.). After firing this charge it may be found that excessive shattering has taken place, and it is decided to cut the charge under the next hip root down to two plugs; this, with one detonator and 1 foot of fuse, represents threepence halfpenny ($3\frac{1}{2}$ d.). The shattering from the first charge may even have been so extensive as to allow of the second hip root being missed altogether. Presuming, however, that the two-plug charge effects sufficient shattering, and that it is decided to maintain the two plugs for the remainder of the stump, and that finally a hole is bored with the wood auger into the barrel of the stump (if it has not already been split about), and place therein two plugs, using also a detonator and 2 feet of fuse, totalling fourpence (4d.), the total explosives used for this stump (with its five hip roots) will thus be thirteen plugs of gelignite, six No. 6 detonators, and 7 feet of fuse, and the total cost 1s. 10 $\frac{1}{2}$ d. In actual practice this cost may be even further reduced.

Another way of handling this stump, which would save a little time and explosives, perhaps, though leaving the complete shattering more to chance, would be to put a bulb-bar hole down 4 feet directly under the centre of the stump, and "bull." Into this "bulling," say, ten plugs may be placed, all in one charge, and tamped with paper wad, as described on page 142. This would make the explosion utilise ten plugs, one detonator, and 4 feet of fuse, a total cost of 1s. 1d. Each method needs considering as the subject crops up, however, for both are likely to give satisfactory results under favourable conditions.

Blowing out green timber is not advocated, but it may at times be advisable, and a typical case will be given as to costs, &c.

Two green box trees, with ample branch area, had to be removed. One was 3 feet 6 inches diameter at the ground level, and under it three holes were put with a bulb bar, 4 feet deep and all "bulled." The bar was driven at an angle of about 45 degrees, starting about 18 inches from the trunk, so as to locate the charge in each of the three cases directly under the part of the tree most strongly held on that side; the three holes, when "bulled," were probably all within a radius of 18 inches at the "bulled" level. Into one hole thirteen plugs were placed, whilst the other two had nine plugs each, the thirteen-plug hole being on the heavier side of tree. All these holes were tamped with paper wads, and were fired electrically, the tree being blown out and down at a cost of thirty-one plugs and three electric detonators at 3d. each, or a total cost of 3s. 4d. for explosives only; the time occupied would be about an hour.

The other tree was a "twinned" green box, some 4 feet 6 inches long by 3 feet wide at ground level, under which were placed three holes, two of which were "bulled"; the other hole was a tap-root one, and consequently could not be "bulled" in the timber. Into the tap-root hole ten plugs and into the "bulled" holes fifteen plugs each, were placed, making a total of forty plugs, with three electric detonators. In this case the tree was blown out and down at a cost of 4s. 1d. for explosives only. In both instances there was ample evidence of overcharging, the barrels being split up about 15 feet and the trees being blown several feet away from where they had been growing—a happening that is almost inseparable from blowing trees right out. It may be mentioned that for dead trees the operation would be similar in every detail, except that probably 25 per cent. less gelignite would be used.

Boulders and Floating Rocks.

These are frequently found on good farm land, and are a source of constant trouble, necessitating ploughing round them and often causing breakages to machines. With the aid of explosives they can be removed without the tedious work of drilling holes in them, by means of what is termed "plaster" charges. The number of plugs of gelignite in these plaster charges varies from, say, five to twenty, according to the size of the rock that is being handled. Very large rocks are better handled by drilling a hole in them, as only a fraction of the explosive is then necessary to break them up. In fixing these charges, one plug, with detonator and sufficient fuse attached, is placed on the rock surface, and the other plugs of the charge are placed all round and over it. The whole is kept in position by an inch thick covering of stiff plastic clay, well pressed down on to the stone round the edges. The plaster, in addition to keeping the charge in position, serves to exclude the air. Very little material is thrown about by this explosion, but the report is particularly sharp and severe as it is in the open air.

It is necessary to use a little thought in placing these charges, as the angle of fracture, which varies in different types of rock, plays an important part in the success or failure of the work.

When handling "floaters" partially embedded in the earth, it is better to clear the soil away from under them and particularly from directly below the spot where the charge is placed, so as to leave a hollow below, thereby increasing the shattering effect of the explosion.

It must be remembered that only a fraction of the gelignite used in these plaster charges would be needed if a hole was drilled in the rock, but it is not everybody that can successfully use a hammer and drill in rock, especially when that rock happens to be granite. The plaster charge is, therefore, suggested as avoiding the tedious work of drilling at the expense of a little extra gelignite.

Post-hole Sinking.

Although gelignite will render the ground soft and workable for the digging out of post-holes, it is questionable whether it is to be recommended as a general practice, as the subsequent firming and ramming is rendered very troublesome, and after a good fall of rain, posts so fixed are apt to be drawn crooked by the strain put on the wires, due to the loosening up of the ground for several feet around. Hard ground may be troublesome to work, but it is just this hardness that makes for permanent efficiency in fencing.

Storage of Explosives on the Farm.

Regulations as to the handling of explosives have been issued under the Explosives Act, 1905, and persons acting contrary to these render themselves liable to heavy penalties.

Any person is entitled to keep explosives, such as gelignite, cheddite, &c., together with detonators, up to a total weight of 25 lb. For any quantity in excess of this amount, a magazine is necessary.

Information concerning magazines and licenses for them may be obtained from the local police and from the Explosives Department, Sydney.

POISONING GREEN TIMBER WITH SODIUM ARSENITE.

A method that has been found useful for rapidly killing off the trees, and at the same time reducing suckering to a minimum, is poisoning with arsenite of soda, though it must not be supposed that this treatment will cause such a change that within a week or so the trees will burn readily. The usual drying-out must take place after the death of the tree before it can be burnt.

Arsenic—the ordinary white arsenious oxide of commerce—is not soluble in water to any great extent, so that soda, either the ordinary washing soda or caustic soda, has to be used to dissolve it. When large amounts of the solution are required, washing soda will be the cheaper, but for small quantities of solution, caustic soda will possibly be found the handiest.

When preparing the solution, whether caustic soda or washing soda is used, first dissolve the soda in a convenient amount of water, using heat, if desirable, to assist and hasten it; then slowly add the arsenic, which has been previously made into a thin paste (as the housewife treats her cornflour), stirring all the time; place on a strong fire, and after it has come to the boil, allow it to remain boiling for at least half an hour; stir from time to time, and be careful to stand on the side away from the fumes, as they are poisonous and are apt to cause sickness. When the arsenic is thoroughly dissolved the solution may be made up to the required bulk by adding the remainder of the water, either hot or cold.

A useful formula for quick and effective work in all kinds of timber is:—Arsenic, 1 lb.; washing soda, 1 lb., or caustic soda, $\frac{1}{2}$ lb.; water, 4 gallons; whiting, $\frac{1}{2}$ lb. The addition of whiting is merely that it may serve as an indicator on trees treated; it turns white on slightly drying, clearly marking the trees that have been operated on. An empty kerosene tin makes a useful measure for dissolving in, as it holds 4 gallons.

The best time to carry out the work of poisoning is when the tree is passing into the dormant stage, that is, when the sap flow in the tree is ceasing. This period varies in different districts, but as a rule it commences about February. On parts of the North Coast ringbarking has been carried out to best advantage as late as June, and early July in certain years. The main object in catching the sap to season is to prevent suckering. Trees can be killed by arsenic or ringbarking at practically any time of the year, but to prevent this suckering it is necessary to operate when the sap is just completing its downward course.

Having decided on the season and dissolved the poison, it is necessary to “frill” the trees. By “frilling” is meant a succession of downward axe cuts completely round the tree, each cut well overlapping the adjoining ones, so as to leave no unsevered section of bark up which the sap can flow. There is no doubt that “frilling” alone would kill timber if allowed time, but the poison does it in a fraction of the time; in fact, trees have been killed in a few days. The cuts must be through the bark and well into the wood proper, and as close down to the ground-level as is convenient to cut them consistent with the shape of the tree, say, from 6 to 10 inches up.

For trees of 4 feet in diameter, pour about a quart of solution into this frilling, right round the tree, using an old teapot or kettle, as the spout makes pouring easy, and less is wasted by spilling. Smaller trees naturally need less solution. Saplings may be cut off low down, and the solution dabbed on with a swab-stick to kill and prevent suckering.

It is very important that the frilling and the application of the poison be consistently and thoroughly carried out, and not in any way scamped or slurred, if good results are to be looked for.

There need be no fear of stock being poisoned by eating the fallen or dead leaves from poisoned trees, for with the comparatively small quantity of solution used, the likelihood of leaves absorbing any free arsenic is very remote. Nor is there much danger from stock grazing on areas frilled and poisoned, though it is desirable to keep all stock off for three or four weeks, when all possible chance of danger will have disappeared.

No estimate of cost can be given, as this will necessarily depend upon so many factors which vary with each particular area. Although arsenite of soda is obtainable as such from drug merchants, its use when procured in that form cannot be recommended for the poisoning of green timber, as it is most irregular in its arsenic content. Owing to the war, prices for arsenic, caustic soda, and washing soda are at present high and are constantly altering, so that it would be of little use to farmers to quote them here. It is therefore advised that when a considerable area is to be treated one or other of the wholesale chemists be written to and quotations obtained.

Destroying Stumps with Acids.

An impression has persisted among farmers for many years that tough stumps can be got rid of, or at least rotted so that they will burn freely, by treating them with some strong acid, such as sulphuric or nitric acid, and waiting a few weeks. In order to test the matter properly, a series of experiments was designed by Mr. F. B. Guthrie, Chemist, in 1913, and deep auger holes were bored in selected stumps of tough timbers, some green and some dry. Quantities of the chemicals named, separately and together in varying proportions, were poured into different stumps. The results were noted regularly for six months, at the end of which time an examination showed that in the case of both green and dry stumps the acid had had no appreciable effect. The average cost per stump worked out at 1s. 9d., which included labour at the rate of 7s. per day; it is an open question whether men could be found who would use two such dangerous acids at that figure.

Saltpetre has also been said to be useful in preparing dead timber for burning off, but numerous private experiments go to disprove the theory.

Clearing Coastal Lands for Pasture.

In outlining on page 125 the purposes and methods of clearing, reference was made to those adopted in coastal districts, where the object is to enable grasses such as *paspalum* to be sown as early as possible, and cattle to be depastured thereon. To secure a good "burn" is then the concern of the settler, and usually it is obtained by felling the brushwood, ringbarking the larger timber, and firing some months later. The accompanying short articles indicate the methods more fully, but several of those described in the foregoing pages, especially explosives, are of use in either bringing the larger trees down or disposing of old stumps.

Clearing Brush Lands.

The late Mr. John McKenzie, of Gloucester, some years ago detailed his experience with considerable tracts of country:—

Commence operations during the month of March, when the risk of running fires has passed. First with brush-hooks carefully cut all the vines and undergrowth; then, if all softwood, fell everything. If there is hardwood through it,

those up to 10 inches should be felled also, and the larger hardwoods ringbarked deeply, cutting right through the sapwood. In felling care should be taken to get the trees to fall as nearly as possible in the one direction. This gives a more even distribution of the fallen stuff and ensures a more rapid and effective burning. When the brush has been felled it should be left untouched for at least eighteen months. After that period it may be fired, but very great care should be taken in selecting the day to light it. Our greatest success in burning has not been on the hottest days or days when the wind has been strong, but on a day on which the atmosphere was dry and a light breeze blowing. It should be lighted as quickly as possible all along the side from which the wind is blowing, and on the low land first if the wind is favourable. If the brush so dealt with is softwood, after the fire nothing will be left but a few charred stumps, and the land is ready for sowing as soon as the ashes have cooled.

When brush has been felled during the cold weather no growth is likely to show through it till the spring, but with rains and warm weather up come many shrubs, weeds, and vines of endless variety, the seeds of which appear to be stored in the brushes waiting for sunlight to germinate. The result is a rank growth, increasing as time goes on, and in parts hiding the felled timber. Several varieties of softwood brush throw out suckers, which by the second year will have grown to a height of 10 or 12 feet. To the inexperienced this gives an idea that there may be a difficulty in firing; as a matter of fact it rather aids the fire. The green growth is not amongst the decaying rubbish, but above it, and seems to hasten its decay. It acts as a protection against rain; I have frequently noticed after heavy showers that rubbish so covered is perfectly dry. With the hot winds of summer soft weeds and vines, which would resist much hot weather if close to the ground, quickly shrivel when dependent on spindly stems which have found their way through the rubbish by a long winding course, and burn readily with the dry material. If the fire is a success very few stumps sucker; weeds of various kinds come up, but most of these are edible. Parramatta grass we find the most troublesome weed, but it only lasts two or three years. If grass seed is sown immediately after the fire it will continue to grow even amongst the Parramatta grass. Black thistles may be expected to come up in abundance, but they are an advantage. If the burn has not been a clean one, or Parramatta grass is very thick, the thistles make a second and a clean burn a very simple matter. When the thistles begin to wither and the down is abundant one match thrown down on a hot day will start a running fire which will cover the whole area in a very short time.

The cost of felling brush country here is 17s. 6d. to 20s. per acre, and this is really the whole cost of clearing if a suitable day is picked for burning. One intelligent man can fire thousands of acres in the day. The actual cost of clearing the average forest country on the coast districts is difficult to get at because it is done gradually; first ringbarked, then suckered and grubbed. This may require to be done annually for some years. Finally, say five years after being ringbarked, it may be burned off at a cost of 14s. to 20s. per acre. For grazing purposes only, many people do not burn the dead timber off forest country, and quite overlook the fact that brush country may be dealt with for grazing purposes in the same way. Brush timber requires to be more deeply ringbarked than forest trees, and some varieties take longer to die than forest trees; but after a brush is ringed and the undergrowth cut, stock find their way into it, and that they get abundance of food is proved by their condition.

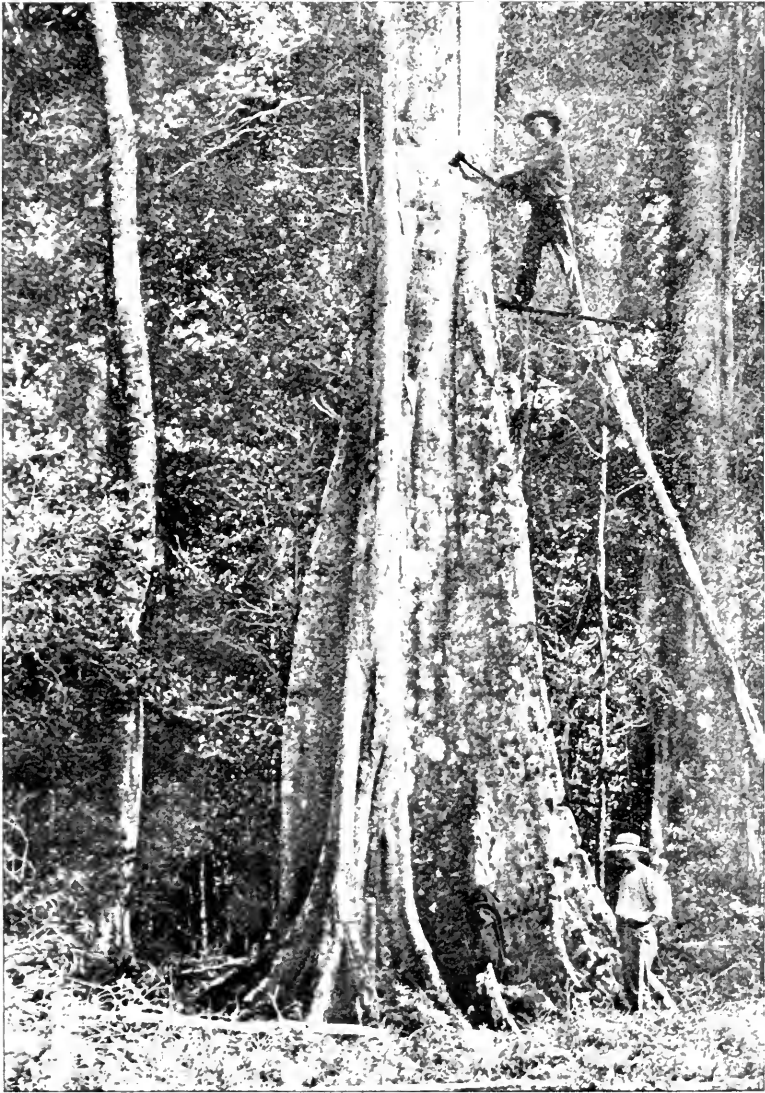
Felling and Burning Scrub Lands.*

The burning of felled scrub is a very important operation. A good fire cleans up all but the large stumps and logs; a bad fire means endless and constant hard work afterwards. Usually the scrub is felled early the previous autumn. The undergrowth and young trees of 2 to 3 inches diameter are first cut down with a brush-hook. This is very important, for the "running" of the fire is materially influenced by the thoroughness with which this work is performed. Then comes the felling of the trees. Those of small diameters

* G. Marks, Manager, Grafton Experiment Farm.

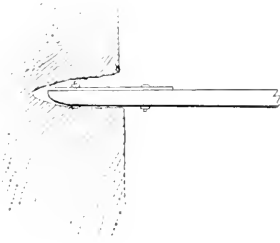
are felled in the usual way, but the larger hardwoods have to be "rung." In districts where the larger timber is not so hard, but have abnormally developed butts, it is necessary to use the "spring-board."

By means of this contrivance the tree is cut some distance from the ground, usually 8 to 12 feet, occasionally as high as 20 feet. A great deal of labour is thereby saved, as in addition to the smaller diameter, the wood is straighter and freer in the grain, which renders the cutting much easier. The spring-board is made of some light, tough wood, is about 4 feet 6 inches



Using the spring-board to fell a Carrabean tree on the Dorrigo.
A belt of typical scrub forms the background.

long, and 6 to 8 inches wide. At one end an iron shoe with turned-up edge is securely bolted. This is necessary to "bite" into the recess cut in the side of the tree, and prevent slipping. At this end the board is about 2 inches thick, but it tapers to about $1\frac{1}{4}$ inches at the other end. Red cedar is prized amongst expert axemen for the purpose. It is tough and light, and with the imprints of nails from the boots, affords sure foothold for the men whilst at work.



Showing how the spring-board is secured to the tree. The leverage on the outer end causes the edge of the shoe to "bite," so that it cannot slip.

Where hardwood timber has to be employed, the "board" may be reduced to 1 inch in thickness as it is essential that the springboard be light as well as tough. It has to be lifted and placed in position, or lowered, with one hand, the other being engaged in holding on to the tree; and should the tree crack unexpectedly and commence to fall, the descent has to be made very quickly.

Another form of platform is sometimes used in the form of a trestle, but the one described is more serviceable and universally used by expert axemen, and it may be adapted to any tree and at any height.

Drive-trees.

When possible, a "drive" tree should be used. A number of trees are cut half-way through, or a little more, and left standing. Then the drive-tree, which is usually a large one, is felled so as to strike its partially-cut neighbour and snap it off. This one in turn strikes others, and if favoured with a suitable wind, trees covering from one to several acres in extent may be brought down at once. Occasionally trees "miss," and have to be gone over again.

Scrub-felling is dangerous work, and should never be undertaken by a man alone. A quick eye and keen ear are indispensable, and even with the best judgment, a tree may snap unexpectedly, or rebound off another. The tools must have keen edges, and be kept in good order by occasional use of the grindstones, and more frequent application of the small carborundum stone.

Burning.

The length of time required for drying before burning is governed by several factors, viz., elevation, season, size and thickness of timber, whether isolated or surrounded by other brush, the area felled in one block, and the date of felling. Some settlers prefer to allow the scrub to lie for eighteen months before firing, which means that the burn takes place the second summer after felling. The more general practice is, however, to fire during favourable weather the first summer after felling, the drying period thus ranging from seven to about ten months, which is ample for all the leaves, light branches and smaller trees to become sufficiently dry for burning. An additional twelve months means that the larger timber is dry and will burn more readily, but the leaves and light twigs and branches have been destroyed by the weather, and there is an additional undergrowth of suckers from the stumps and other green vegetation, which rather retards the free advance of a good fire. The leaves and small branches favour a good sweeping fire,

that cleans up all the small timber, and the heat so obtained kills the suckering growth of the green stumps, thereby ending this trouble for all time. With favourable, hot, dry weather, a large proportion of the larger trees will also be burnt.

The selection of a suitable day is very important. A hot, dry day with a breeze should be chosen. Westerly winds are drier than the sea breezes. If the scrub is felled early and is dry, such a favourable day may be obtained in October, November, December or January. After December, monsoonal rains usually set in, and the humidity of the atmosphere is not conducive to the best results. Usually December is the best month. If neighbours are



"A good burn." Portion of block of 120 acres burned only a few weeks before

also clearing, it will be found of great mutual benefit if they can all agree to fell and fire their respective areas as one block. In any case, it is advisable to give the necessary notice to neighbours, and not to light the scrub if a particular wind is likely to carry the flames beyond control and burn out a neighbour's homestead and grass.

Before the date of firing is decided upon, preparations should be made to ensure the fire starting quickly, by arranging a continuous line of readily combustible material, such as dead leaves, bushes, light twigs or other rubbish, all round the edges. If there is danger of the fire getting beyond control, its spread can be largely prevented by clearing a strip several yards wide all round. This is best performed with a garden rake or forked stick, the refuse being heaped along the line of scrub.

A breeze is essential to a good fire. It acts as a forced draught, and much timber is consumed which on a perfectly calm day might be barely charred. When it is decided to fire, plenty of help should be available to ensure that

the fire shall start, as it were, all at once. Dry bushes, torches saturated with kerosene, or even a plentiful supply of matches, are used to start the fire in numerous places on the running front, so that the wind may drive it forward as one unbroken sheet of flame. This is performed by lighting the edge of the scrub every few yards, and running on ahead to escape the heat. If it is desired to confine the fire strictly to the area felled, it should also be set alight beforehand on the leeward side, so that it will burn slowly against the wind and meet the windward flame some considerable distance from the edge. With a fair breeze, the fire travels very rapidly, and it is only a matter of a couple of hours before a whole block of 100 acres is burnt out.

Should the area to be fired be in close proximity to farm buildings, it is advisable to provide beforehand suitable fire-beaters and a few vessels of water. It frequently happens that the wind changes after the fire has been



A paddock of cocksfoot, rye grass, and white clover; twelve months after the scrub was fired and nine months from the time of planting seed

burning some time, and any precautions made along these lines need never be considered too much trouble. After the fire has burnt itself out, any timber which may not have been burnt, and which can be easily handled, should, in the course of a few days, be heaped up against large logs and set fire to. The land surface will thus be cleaned up and the sowing of grass seeds later facilitated. As most of the scrub timbers consist of softwood, logs that are not burnt can be left alone. In the course of a year or so they will readily rot, and a fire-stick applied on a hot, dry day will speedily get rid of them with a smouldering fire. In this connection it is advisable to exercise extreme care, for the weather that suits this operation also favours fire running through the somewhat dry grass of adjacent pastures.

Ringbarking in the West.*

Any person interested in land settlement cannot but observe the large areas in blocks of 10,000 to 50,000 acres now being made available for lease in the Western Division of the State.

Stock returns show that the carrying capacity of western country is very much lower than it was a few years ago, and if success is to be obtained improved methods of management must be adopted. Some settlers are making provision for water by tank sinking, and many are improving by ringbarking.

The varying results observed in the western districts led the writer to inquire into the causes of the differences. In some cases it is due to letting large contracts at the one time, the work extending over the greater portion of the year. Where large areas of ringbarking have been under observation, by far the most satisfactory results have been obtained where the work has been done in the summer. Indeed, in two cases the most unusual circumstance of barren suckering was observed through ringing being done in a wet winter, and the country is not as good now as it was before the expenditure was incurred.

With a view to ascertaining the views of others, the Pastures Protection Board rolls were obtained from the secretaries of the Cobarr, Wilcannia, Bourke, and Hillston districts, and circulars were sent to station managers. Forty-six replies were received. Several stated that they had had no experience, whilst others were very indefinite. However, the writer is indebted to several gentlemen for lengthy replies, containing the results of their experiences, extending over many years.

The first question asked was: What time of the year do you consider the best for ringbarking?

A very general reply was when the sap is up. A practical guide to know when the sap is flowing freely is when the bark strips easily, or when the leaves are of a brighter green than ordinarily. It is a well-known fact that trees are dormant in winter, and that the sap is then down. Theoretically, then, it would not be advisable to ringbark in winter, when the sap is down. Why? Because the tree's food supply is cut off above the ring, and the stored starch goes to the dormant buds, and they develop into suckers.

The time of year when the sap is flowing freely will depend on the locality, weather, and species of tree.

Nearly all trees are killed after the first ringing, excepting box and gum (also known as Coolabah), which always sucker more or less, depending on the season when the operation is carried out and the method of ringing adopted.

In handling replies to the above question a vote was given to each month where the pastoralist had specifically mentioned it. Appended is the result:—

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
8	9	9	5	4	2	2	2	2	2	2	3

From this table it will be seen that the warm summer months are mostly favoured. The above are the results of observation by practical men.

* C. J. Woollett, Stock Inspector, Tamworth.

The next question was: When do you find the most vigorous suckering, after winter or summer ringing? This question was partly covered by the first. Ten persons were of opinion that suckering was freer after winter than summer ringing, and three votes were recorded *vice versâ*. Two had the proviso, "if followed by heavy rains," when referring to summer ringing.

To the third question, what kind of ringing do you prefer, several replies were received, and these may be summarised thus:—

Timber.	Chip out or Scarf.	Frill.
Box and Gum	14	1
All others... ..	2	8

The disparity between the totals is because some correspondents only referred to box and gum.

It is an almost unanimous opinion that chip ringing is the only satisfactory method for old box and gum, and scarf for trees from 10 to 18 inches in diameter. Frill ringing for these varieties has been abandoned.

Mr. McKellar, of Merri Merigal, who has 300,000 acres of ringbarked country under his charge, and an experience extending over twenty-five years, described chip ringing thus:—"The chip ringing I refer to is made by two down chops, the first being the same as in frill ringing, and the second about 2 inches above and allowing the axe-head to fall outwards, which breaks the chip out. My experience here is that you must damage the outer surface of sapwood the whole way round, or you will have trouble with the bark joining across the space."

Mr. Officer, Kergunyah, Cobar, stated:—"For full-grown timber I prefer the chip out, but for trees under 9 inches in diameter, a strip of bark 8 inches wide. Timber under 4 inches in diameter I do not ring, as the suckering is too vigorous, and if cut any depth a great many blow down and grow stronger. These I trim to 7 feet of all limbs, and so improve the country by allowing the sun to penetrate and sweeten the grass." Mr. Officer has 40,000 acres of ringbarked country, done over a period of years, and is one of the most successful men in the district.

Another very general and successful method is to take a strip of bark 9 to 12 inches right round the trunk, removing every vestige of bark about 3 feet from the ground. By this method, the tree naturally dies more slowly than when the cut is made into the sapwood, but there is the very great advantage that suckering is slighter.

In connection with dealing with suckers, Mr. Madden, The Rookery, Cobar, wrote:—"In ringbarking suckers, which are too big to split off with the axe, it is always an advantage to ring the suckers in preference to the stump underneath them. When the stump is 'rung,' the sprouts will come out of the ground from the roots, and are very hard to get rid of."

Frill ringing for trees other than box and gum is recommended, and is the practice all over this district, where contracts for over 200,000 acres on different stations have recently been let.

"I feel sure the best method to adopt for belah and pine is frill ringing, i.e., not to take off a strip of bark but to wrench the axe slightly when it enters the tree. This is a cheaper method than chip ringing and is quite as effective. *Re* above timbers, we find feed grows through it four months after treating, though the trees may not die within a year to eighteen months. Odd ones will die almost immediately."—Mr. Parker, Mena Murtie, Wilcannia.

"In ringbarking pine, yarren, &c., such trees as do not sucker, the better plan is the quicker one, such as what is known as frill ringing. Just one chop with the axe round the tree, meeting the cuts in the wood, and then giving the axe a wrench, so as to make sure you miss none between the cuts."—Mr. Madden, The Rookery.

Several correspondents referred to the necessity of leaving the timber in the vicinity of tanks for shade and breakwinds.

Results from Ringbarking.

In order to give some concrete example of the benefits derived from ringbarking, the writer obtained the stock returns supplied to the Cobar Pastures Protection Board for the last five years, and ascertained the actual carrying capacities of several properties in the district, all more or less contiguous.

The total areas embrace over 860,000 acres, and, as far as appearances go, are much the same as regards quality of soil. The country is red, and the principal timbers are box, gum (*Eucalyptus intertexta*, sometimes called Coolabah), ironwood, pine, yarren, mulga, &c.

As a basis of calculation one head of large stock has been assumed to be equal to six sheep, and each property has carried upwards of 60 head of cattle.

The places are managed by men of long experience in the West, therefore the reader may be assured that the properties have been wisely stocked.

Station.	Total Area.	Area Ringbarked.	Sheep actually carried for last five years.	Carrying Capacity.
	acres.	acres.		1 sheep to —
1	240,000	15,000	11,560	12 acres
2	164,500	.....	6,693	24 „
3	40,960	40,960	5,235	7·8 „
4	93,000	10,000	5,730	16 „
5	255,585	90,000	29,839	5 „
6	71,000	40,000	8,379	8·4 „

These figures may be stated in a somewhat different way. Assuming the properties to be of equal carrying capacity under similar conditions, and taking one sheep to 24 acres as the standard for virgin land (as based on the capacity of property No. 2, none of which is ringbarked), the value of the

ringbarked country ranges from one sheep to 4 acres to one to 7·8 acres, or an average of 1 to 5 over the whole area. In other words, ringbarking has more than quadrupled the carrying capacity of the land. This will be seen from the following summary:—

Station No.	Total Area in Acres.	Area Ring-barked.	Sheep Actually Carried Last Five Years.	Carrying Capacity one Sheep to	No. of Sheep on Unring Country, at one Sheep to 24 acres.	No. of Sheep on Ring Country.	Carrying Capacity of Ring Country, one Sheep to
				acres			acres.
3	40,960	40,960	5,235	7·8 or ·13	.....	5,235	7·8
1	240,000	18,000	11,560	12 ,, ·08	9,166	2,394	7·5
4	93,000	10,000	5,730	16 ,, ·06	3,460	2,270	4·4
5	255,585	90,000	29,839	8·5 ,, ·11	6,900	22,939	4·0
6	71,000	40,000	8,379	8·4 ,, ·12	1,290	7,080	5·6
Totals and Average..	700,545	198,960	60,743	11·5 or ·09	20,816	39,927	5 approx.
2	164,500	.....	6,693	24 ,, ·04	.....	.....	.....

As to the question of cost, it has been ascertained from managers who have had the work done, and from contractors constantly carrying out the operations, that to "chip out" costs 10d. to 1s. per acre, and to "frill and scarf" 9d. per acre.

From the experiences referred to, it is obviously desirable to limit, as far as possible, all ringbarking operations to the hotter part of the year, or from December to April. The improved carrying capacity of the country resulting from judicious ringbarking much more than compensates for the expense.

FENCES AND FENCING.*

The methods of fencing differ widely in different parts of the State, and a complete statement of the subject from the point of view of the New South Wales farmer would involve the treatment of the subject in relation to the district, the nature of the fencing required, and the material available locally or most easily obtainable. It is obvious that such a work would occupy much more space than can be afforded in this Handbook, and all that has been attempted in the following pages is to make suggestions which may be of assistance to the settler in determining what class of fence he should erect, to give the specifications for certain complete fences, and to describe one or two other less expensive fences that have proved suitable for special purposes and districts.

In the days when fencing timber was plentiful, posts were usually placed about 10 feet apart, and experience has shown that the most efficient fences are those with panels of about that width. However, the increasing scarcity of suitable timber, together with much higher labour costs, have in recent

* Revised by A. H. E. McDonald, Chief Inspector of Agriculture.

years compelled landholders to exercise greater economy in the use of posts, and the panels are now of much greater width; in extreme cases posts are as much as 1 chain apart.

In erecting a fence, however, efficiency must be taken into consideration as well as cost, and it is very bad economy to endeavour to save a little on the original cost by reducing the number of posts if the result means higher cost of maintenance or a fence that will not give the desired protection. Such serious loss may occur through weak fences that it is very desirable that the fences shall be strong. The loss consequent upon several valuable working horses breaking through a weak fence on to ripe wheat, for instance, may be much greater than the saving effected in the erection of the fence.

While, however, it has been found that the strongest wire fences are those with panels of from 10 to 12 feet, experience has also shown that fences strong enough to resist all reasonable strains can be erected with panels of much greater width, provided suitable droppers are used. The extra cost involved in erecting a fence with narrow panels where fencing timber is expensive or difficult to obtain is therefore not always justified. In general, if posts are comparatively cheap and plentiful panels can be made about 12 feet apart, but where posts are not easily obtainable the panels should be made wider, and droppers used instead. The limit to the width of panels is still a subject of controversy. Frequently they are made 22 or 33 feet in width, and in some cases even 1 chain. It is practically agreed, however, that 22 feet is a very suitable width, and unless posts are very expensive that is the panel which should be adopted.

When wide panels are used it is essential to use droppers, and it is the difficulty experienced in securing good droppers at reasonable prices which makes many landholders reluctant to erect fences with wide panels.

A number of different types of steel droppers have been placed on the market, but a perfect steel dropper has not yet been devised. Defects that are commonly found are lack of strength and ineffectiveness of the hold which the dropper has upon the wire, the result being that the dropper shifts and fails to serve its purpose.

The wooden dropper of about 2 inches by 1 inch hardwood is undoubtedly the most satisfactory. Its greater efficiency should lead to preference being given to it, provided the cost is not unduly greater than the steel dropper. Wooden droppers are used by the Railway Commissioners, and their fences are models of efficiency.

Timber for Posts.

While certain kinds of timbers are undoubtedly the best for fencing, choice is limited by the kinds available in the vicinity of the area to be fenced. As a rule, too, more than one kind is available. Moreover, in many districts timbers are available which are useless for fencing purposes, and care must therefore be exercised in making a selection. Careful local inquiry should be made in regard to this point. In Section I of this Handbook, "Farm Lands of New South Wales," details are given of the timbers suitable for fencing purposes that are available in the different districts.

The chief points to be considered are strength and resistance to decay and to the attacks of white ants, and also to fire. Size is also an important consideration, though this depends on the kind of timber used, and upon the age of the tree from which the posts are cut. As a rule small trees are sappy and decay quickly, and therefore the most desirable size is about 8 inches by 4 inches. Posts of this size are strong and usually durable.

Some classes of trees, however—notably, the buddah of the western country—are extremely durable and strong, and post of 4 inches to 5 inches diameter are quite satisfactory.

Struts.

A quite common defect in the construction of a wire fence is that of placing the strut too near the top of the post, and consequently at too great an angle with the line of fence; the result is that when the wires are strained the post is pulled out of the ground. In order to prevent this happening, various plans are tried, the least effectual of which is that of weighting the post, as shown in the illustration (Fig. 2). Placed as the strut is in the illustration it is practically doing no good, as can be seen.

Another and more effectual method adopted by some is to place two long struts, one on each side of the wires. This is unnecessarily cumbersome and costly, when the same result can be obtained by placing the end of the single strut lower down on the post, but not lower than half-way. The longer the strut the better it will do the work it is intended to do.

Wire.

In cattle districts strong wire is required, and No. 8 gauge should be used. In districts where sheep are kept a greater number of wires in the fence is required, and the usual practice is to use a heavy gauge (No. 8) for the two top wires, and a smaller gauge (principally No. 10) for those below. In recent years a strong galvanised steel wire, No. 12 gauge, has been placed on the market; it has given excellent results, and is economical. In inland districts, black No. 8 or No. 10 is generally used, but in coastal districts, where the air is humid, galvanised wire is most satisfactory, owing to its immunity from rust.

Wire-netting.

The rabbit pest has made wire-netting absolutely essential on most holdings in western districts, on the tableland, and on portions of the coast. Netting is classified according to the gauge of the wire, the width of the netting, and the size of the mesh. It is generally recognised by experienced landholders that to make a fence rabbit-proof, a galvanised netting, No. 17 gauge, 42 inches wide, and $1\frac{1}{2}$ inch mesh, should be used. When placed in position, the height will be sufficient to stop rabbits, while a gauge of No. 17 insures long life to the wire. Tying-wire of No 16 gauge is usually used to attach the netting to the supporting wire, which must be of No. 8 gauge.

Barbed Wire.

The use of barbed wire very largely increases the efficiency of any fence to which it is attached. Objections are sometimes raised to it on account of the injuries occasionally caused to stock, but these injuries are, in most cases, brought about by misuse. For boundary or ordinary subdivision fence it is very useful, and the likelihood of stock being injured is very remote, provided it is kept reasonably well strained. Barbed wire should never be used in yard fences, or in fences where horses congregate, such as near stables, as in the fighting or playing which goes on amongst them, there is great danger of the animals being badly torn.

Barbed wire is most dangerous when it is allowed to lie around loose, or is allowed to become very slack in the fences. It cannot be condemned, however, merely because a few people are grossly careless in its use.

Insurance of Fencing.

Owing to the risk of destruction by fire to which fencing is subject, and the great expense incurred in securing new posts nowadays, all fencing in districts where fires are likely to occur should be covered by insurance. A number of firms are prepared to accept the risk at very reasonable rates. The insurance may be taken at per mile or at per post. The latter is most satisfactory, as payment is made on the posts actually destroyed, and therefore little dispute can arise in regard to the extent of the damage.

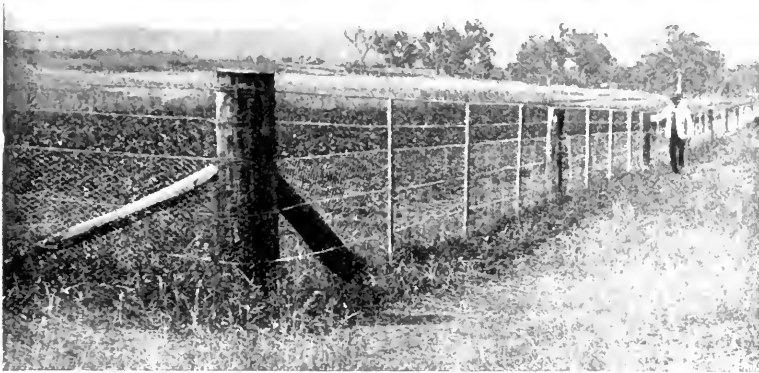


Fig. 1.—A wire-netted boundary or subdivision fence ; two posts and six droppers per chain.

Specification for Wire Fence, Netted.

The following specification of an actual fencing contract is presented as likely to be useful. The details would, of course, vary in accordance with local conditions:—

All fencing is to be on and in proper line. The posts when erected are to be straight, uniform and upright. The split posts are to be in line along the tops, and are not to follow the lesser irregularities of the ground.

Timber.—White and yellow box may be used in the construction of the fence.

All timber is to be taken from large trees. It is to be thoroughly sound, free from splinters and other defects, barked and straight. All measurements specified are to be taken to mean at the smallest dimensions.

Posts.—All posts are to be sawn square on top, and when erected are to have the earth placed properly around them and well rammed.

The distance between posts will be 10 feet.

All posts are to be bored properly with $\frac{3}{4}$ -inch auger holes, as required for the proper placing and spacing of the wires.

Split posts are to be 6 feet 6 inches long, and to have mean dimensions which range between 7 inches wide by 5 inches thick, and 8 inches wide by 4 inches thick. Centres are to be backed out to within 24 inches of the large end. No face is to be less than 4 inches, and one edge is to be rough-dressed.

Split posts are to be placed in the ground to a depth of 24 inches.

Round posts—*Corner* posts are to be 8 ft. 3 in. long, not less than 12 inches in diameter, and are to be placed 3 ft. 6 in. in the ground.

Straining posts are to be 7 ft. 9 in. long, not less than 10 inches in diameter, and are to be placed 3 feet in the ground. Straining posts are to be erected at distances of about $7\frac{1}{2}$ chains throughout the fence.

Gate posts are to be 9 feet long, to be placed 4 feet in the ground in a direct line with the fence. They are to be not less than 12 inches in diameter.

The tops of gate-posts in each gateway are to be level.

Permanent struts are to be placed at all angles and corners of fences and at every second straining-post. They are to be firmly mortised into the posts 22 inches from the top, and are to be firmly butted against the adjoining post or against a short post placed in the ground

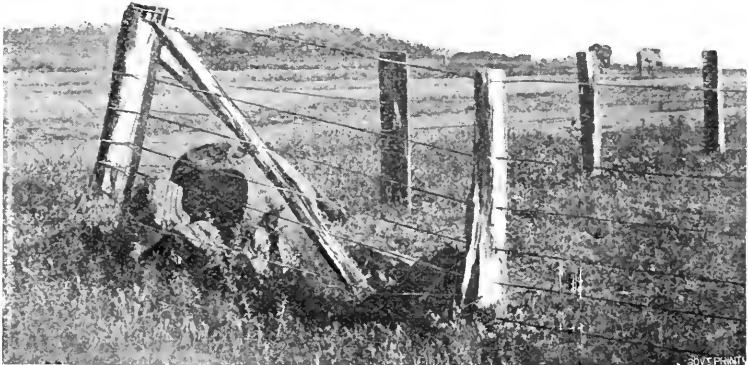


Fig. 2.—An improperly-stayed corner-post. Note the stones piled against the post in a vain endeavour to keep it in the ground.

to a depth of 2 feet, and situated at least 10 feet away from the bottom of the post which they are supporting. Struts are to be not less than 6 inches in diameter.

Gateways.—Four gateways are to be placed where directed. Gateways are to be 15 ft. 6 in.* from gate-post to gate-post; the fence posts nearest gateway are to be similar to corner posts.

Between the gate-posts a sill, 10 inches in diameter, and flattened to 6 inches at the small end, is to be firmly bedded. The flat face is to be level, and on a level with the ground on the high side of the gateway.

* As most farmers use headers and other machinery of great width, a very wide gateway is required where the paddocks are under cultivation.

Droppers.—Between the posts, one, two, or three droppers, as required, are to be placed equidistant from the posts and from each other.

The *wooden* droppers, 2 in. x 1 in. hardwood, are to be secured to the plain wires with staples, which pass over the wire through a hole in the dropper, and are then clinched on the opposite side of the dropper; they are to be tied to the barbed wire with No. 12 galvanised tying wire, which is to pass through a hole in the batten about $1\frac{1}{2}$ inches from the top of it.

The *metal* droppers, if used, are to be properly secured to the wires according to their kind.

Wires.—The fence is to contain four wires, including one galvanised barbed wire No. 12 B.W.G., which is to be placed 43 inches from the ground.

The other wires are to be three No. 8 wires, with the following spacings from the ground:—18 inches, 36 inches, and 51 inches.

All wires are to be thoroughly strained and secured in position.

Netting.—A selected brand of netting, 17 gauge, 42 inches wide x $1\frac{1}{4}$ inches mesh, is to be erected, so as to have the straight selvedge at the top. The netting is to be properly strained in an approved manner. A portion of the netting is to be placed, without bending, underground (in a suitable trench, previously dug the required depth, *i.e.*, 6 inches), so that the netting can be securely fastened to, and in line with, the second wire from the ground.

The netting is to be secured to the top and bottom wires with galvanised tie wire; to the top wire with 24 ties, and to the bottom wire with 16 ties to the chain (No. 16 gauge).

The barbed wire to be placed just above the wire to which the netting is attached; that is 43 inches from the ground.

All work to be finished in a workmanlike manner, and to the satisfaction of the officer in charge of the work.

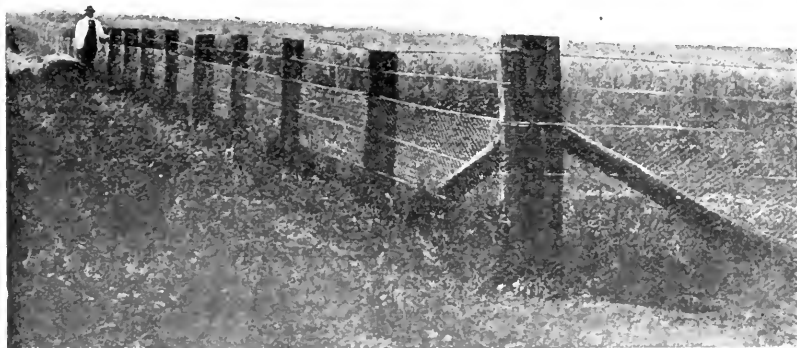


Fig. 3.—A corner-post properly strutted. A wire-netted boundary or subdivision fence; eight posts per chain.

Rail Fences.

Whilst for boundaries and general subdivision work the rail fence has been superseded by the wire fence, yet for some purposes, such as yards, approaches to gates, bridges, &c., it, or the stub or sapling fence, is still required. Such fences are more easily seen than wire fences, and their appearance indicates that they are a more effective barrier than even barbed wire. Some details regarding them, their cost and construction, are therefore likely to be of interest.



Fig. 4.—Three-rail fence; eight panels per chain.

Three-rail fence (Fig. 4).—The erection of this type of fence is gradually becoming more and more rare. It is quite unusual now for a new one to be erected. The two-rail fence, with one or two wires underneath the bottom rail and between the rails, is effectually taking its place.

The two-rail fence (Fig. 5) is largely used as indicated in the illustration—that is, for enclosing tanks, also for the yards about the homestead, stable or dairy, and for other similar purposes.



Fig. 5. A two-rail fence with two wires.

The single-rail fence (Fig. 6), with three, four, or five wires beneath the rail, is very suitable, and is popular in some districts for enclosing town and suburban allotments. With the increasing scarcity of timber, it is now being used in many situations and for purposes for which, formerly, only a two or three rail fence would have been considered suitable.

With or without wires, it is a suitable fence on hillside roads, to act as a barrier at dangerous places, to prevent travellers leaving the road.



Fig. 6.—Top-rail and wire fence; eight posts per chain.

The construction of the three kinds of rail fence is very similar. The following specification, which is suitable for many localities, will serve as a basis for those who contemplate erecting fences of this description:—

Specification for Rail Fences.

All fencing is to be on and in the proper line. The posts when erected are to be straight, uniform, upright, and in line along the tops; they are not to follow the lesser irregularities of the ground.

Timber.—White and yellow box or other approved timber may be used in the construction of the fence.

All timber is to be taken from large trees. It is to be thoroughly sound, free from splinters and other defects, barked and straight. All measurements specified to mean at the smallest dimensions.

Posts.—All posts are to be sawn square on the top, and when erected are to have the earth placed properly around them and well rammed. The distance between posts is to be 8 ft. 3 in. from centre to centre.

Split posts are to be 6 feet 6 inches long, and to be 9 inches wide and $3\frac{1}{2}$ inches thick. They are to be placed 24 inches in the ground, and are to be mortised as per gauge herewith with holes 6 in. x 3 in.

Round posts for corners and ends are to be 7 feet long, and not less than 12 inches in diameter; they are to be placed 2 ft. 6 in. in the ground, and are to be mortised as per gauge herewith. The mortises are to be 6 inches long, 3 inches wide, and 6 inches deep.

Rails.—The rails are to be 9 feet long, 8 inches wide, and 3 inches thick. The tenons on ends of rails are to be 6 inches long, adzed carefully to fit into the mortises; they are to be shouldered and finished so as to fill the mortise and to butt up to the posts.

Gauge for Mortising.—The posts will be mortised as follows, the measurements being taken from top of post to top of mortise:—

		Three-rail fence.	Two-rail fence.	Single-rail fence.
1st mortise	..	6 in.	6 in.	6 in.
2nd „	..	21 in.	28 in.	..
3rd „	..	36 in.	..	..

Cost of Rail Fences.

Rail fences are usually erected at so much per rod (16½ feet), which comprises two panels. The approximate cost of erecting rail fences at the present time (1922) is shown in the following table, though of course the amounts vary with districts and labour conditions.

Material.	Three-rail fence.	Two-rail fence.	Single-rail fence.	
	s. d.		s. d.	
Posts	2 @ 1s. = 2 0	2 @ 1s. = 2 0	2 @ 1s. = 2 0	
Rails	6 @ 1s. 6d. = 9 0	4 @ 1s. 6d. = 6 0	2 @ 1s. 6d. = 3 0	
	11 0	8 0	5 0	
Labour	3 3	3 0	2 9	
Total per roll ...	14 3	11 0	7 9	

The Homestead Fence.

The homestead fence (Fig. 7) is a neat ornamental type of fence which appears very suitable for enclosing the garden or front portion of the farmhouse. The fence illustrated is built of sawn timber, but where this is

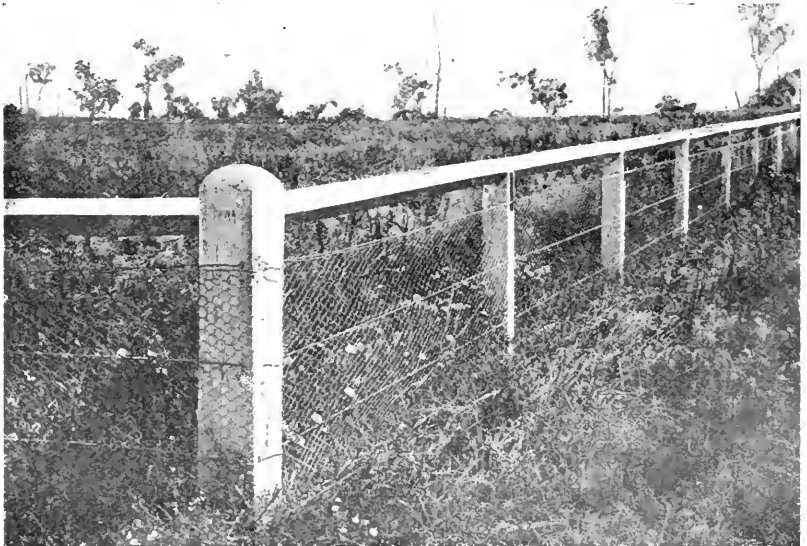


Fig. 7.—A homestead fence. The wires do not run through, but are tied on the outside edge of the post

difficult to procure, and where straight saplings are plentiful, a very similar fence can be built with round posts and straight saplings for rails. A fence of this description, when painted white, adds considerably to the attractiveness of the home.

The particulars of the construction of the fence illustrated are as follows:—The posts are hardwood (ironbark), 5 ft. 6 in. long, 6 inches wide and 4 inches thick, placed 2 feet in the ground and set 9 feet apart. The rails are hardwood, 4 in. x 4 in., laid edge upwards in notches cut in the tops of the ordinary posts and mortised into the end and corner posts.

The rails are secured to the ordinary posts with hoop-iron No. 10 gauge straps, 2 feet long by 2 inches wide, bolted to the posts with two 7 in. x $\frac{1}{4}$ in. bolts.

Six inches beneath the rail, rabbit-proof netting is attached by clips to three plain galvanized wires, which are secured to the outside edge of the posts by tying wire, which passes through a hole 2 inches from the edge of the post. With this plan of fixing the plain wires, the netting can be strained as tight and as flat as a board, and when secured presents, as may be seen from the illustration, a neat, even, flat surface.

Sheep and Pig-proof fences.

A useful subdivision fence where pigs or crossbred sheep are kept is constructed as follows:—Posts, three to the chain, 22 inches in the ground and 4 feet 2 inches out; bored on the edge for five wires, which are attached to the side of the posts by tie wires that pass through the holes in the post. To the three bottom wires is attached 2 feet 6 inches netting, 4-inch mesh, gauge 15 or stouter. One wire is attached to the posts along the ground, one about the middle of the netting, and one at the top. Two galvanized barbed wires are spaced between the top of the netting and the top of the post, and two to three droppers are used between the posts. A steel fencing wire, No. 8 gauge, is preferable for the top of the netting, and No. 10 wire for the middle of the netting. The netting is attached to the wire by No. 14 tie wire, and the wire to the posts by No. 12 tie wire.

Sheep and Cattle-proof Wire Fences.

A very effective sheep and cattle proof wire fence can be erected with posts 22 feet apart, using two droppers between the posts, or, if it is desired to still further reduce the number of posts, with panels of 33 feet, using three droppers in the panel. It is essential, however, that the droppers shall be strong, and, therefore, wooden droppers, if procurable at a reasonable price, should be used. The fence posts should be placed 2 feet in the ground and 3 feet 10 inches out. The straining posts should be 3 feet in the ground and well strutted. The wire should be spaced as follows, measured from the ground:—Six inches, 12 inches, 18 inches, 25 inches, 34 inches, and 46 inches.

Sometimes the barbed wire is placed on the top of the posts, but where cattle are to be controlled greater efficiency is obtained by making it the fifth wire, as cattle as a rule feed through and not over a fence. If only horses are to be controlled, the barbed wire can be placed at the top, as horses generally reach over a fence to feed.

The barbed wire is frequently attached to the outside of the posts, and held in position by a No. 12 tie wire, run through a hole bored in the fence. This method is very effective in protecting a crop which adjoins a grazing

paddock, but it is not so effective if stock are run at times on either side of the fence; in the latter case the barbed wire should be run through 1¼ inches auger-holes, bored in the centre of the post.

The three lower wires may be No. 10 gauge, the two upper No. 8, and the barbed wire No. 12 gauge.

Specification for Wire Fence for Cattle.

All fencing is to be on and in proper line. The posts when erected are to be straight, uniform, and upright. The split posts are to be in line along the tops, and are not to follow the lesser irregularities of the ground.

Timber.—.....* may be used in the construction of the fence.

All timber is to be taken from large trees. It is to be thoroughly sound, free from splinters and other defects, barked, and straight. All measurements specified are to be taken to mean at the smallest dimensions.

Posts.—All posts are to be sawn square on top, and when erected are to have the earth placed properly around them and well rammed.

The distance between posts will be 10 feet.

All posts are to be bored properly with ¾-inch auger holes, as required for the proper placing and spacing of the wires.

Split posts are to be used and to be 6 feet 6 inches long, and to have mean dimensions, which range between 7 inches wide and 5 inches thick, and 8 inches wide by 4 inches thick.

Centres to be backed out to within 24 inches of large end.

Split posts are to be placed in the ground to a depth of 24 inches.

Corner posts are to be round, 8 feet 3 inches long, not less than 10 inches in diameter, and are to be placed 3 feet in the ground. Straining posts are to be erected at distances of about 7½ chains throughout the fence. They are to be round, 7 feet 6 inches long, and placed 3 feet in the ground.

Gate posts are to be round, 9 feet long, to be placed 4 feet in the ground in a direct line with the fence. They are to be not less than 12 inches in diameter.

The tops of gate-posts in each gateway are to be level.

Permanent struts are to be placed at all angles and corners of fences and at every second straining post. They are to be firmly mortised in to the posts 22 inches from the top, and to be firmly butted against the adjoining post or against a short post placed in the ground to a depth of 2 feet, and situated at least 10 feet away from the bottom of the post which they are supporting. Struts are to be not less than 6 inches in diameter.

Gateways.—.....† gateways are to be placed where directed. Gateways are to be 12 feet from gate-post to gate-post; the fence posts nearest gateway are to be similar to corner posts.

Between the gate-posts a sill, 10 inches in diameter, and flattened to 6 inches at the small end, is to be firmly bedded. The flat face is to be level, and on a level with the ground on the high side of the gateway.

Wires.—The fence is to contain four No. 8 wires.

All wires are to be thoroughly strained and secured in position.

The following are to be the spacings, measured from the ground upwards, 18 inches, 28 inches, 39 inches, 51 inches.

Time.—The erection of the fence shall be duly completed within.....‡ months from date of signing contract.

* State kind of timber according to kinds desired.

† State number of gateways.

‡ State number of months.

Hints on Fencing for Settlers.*

In putting up a wire fence only—supposing the timber is already laid on the ground—the first thing to do is to dig the post holes, and there are, even in connection with such an apparently simple operation as that, a few things worth remembering.

The holes should be from 22 inches to 24 inches in depth. They should not be made too big, as this involves unnecessary labour both in digging, filling, and ramming; besides, the post will not have such a firm grip in the ground. They should be a little more than large enough to receive the posts comfortably, and leave room for the rammer to work to bottom of the hole. Dig the full depth straight away; if a little too deep it is easy to put in some loose earth to make post the required height. Sight the posts from the centre, and fill in and ram the bottom—say, the first 6 inches—thoroughly. The bottom, and near it, is the place where ramming is most required; as the top is approached less ramming will do. Place earth that remains neatly around the post to allow for subsidence.

The tools required for post-hole sinking are a medium size iron bar with rammer head and chisel point, and a long-handled shovel. This latter tool should have a round nose and be bent inwards at the sides, so as to form a kind of scoop. Small post-holes cannot be dug with wide shovels.

Sink post-holes, if possible, when the ground is in good condition—not too wet and not too dry. Ground saturated with moisture cannot be well rammed.

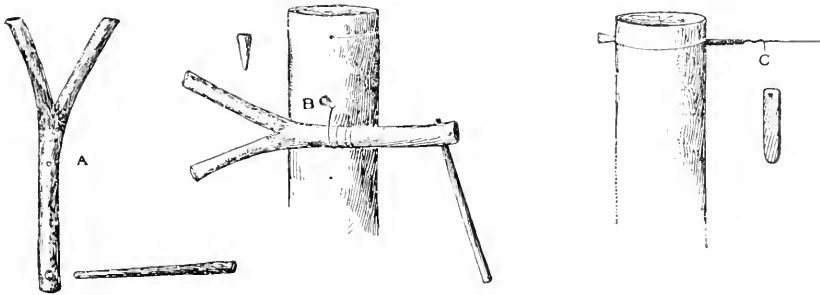


Fig. 9. —Forked Wire-strainer, Wire-key, and Plug.

The following gauge for spacing and boring a 7-wire sheep-proof boundary fence has been found to be thoroughly reliable.

Height from surface of ground to top of post, 4 ft. 6 in.

No. 7 wire	3 inches	from top of the post	
6 "	12 "	"	No. 7 wire.
5 "	9 "	"	6 "
4 "	7 "	"	5 "
3 "	6 "	"	4 "
2 "	5½ "	"	3 "
1 "	5½ "	"	2 "

Surface of ground 6 inches from No. 1 wire.

When boring, use a 5/8-inch auger, if No. 8 wire is to be used. Bore straight and right through, so as to push out anything that may impede easy threading of the wire.

* R. H. Gemys, Manager, Glen Innes Experiment Farm.

An easy and simple way of running or threading wire through split posts is to place the coil on a reel made on the capstan principle: this allows the wire to run off freely, and prevents it getting entangled, &c. The wire is then pulled through the holes from one strainer post to the next, and strained up tight. It can, however, be fastened anywhere between the posts with a patent strainer, which can also be made to work at a post. Another way is to bore right through the strainer posts and pull up either with rollers or forks.

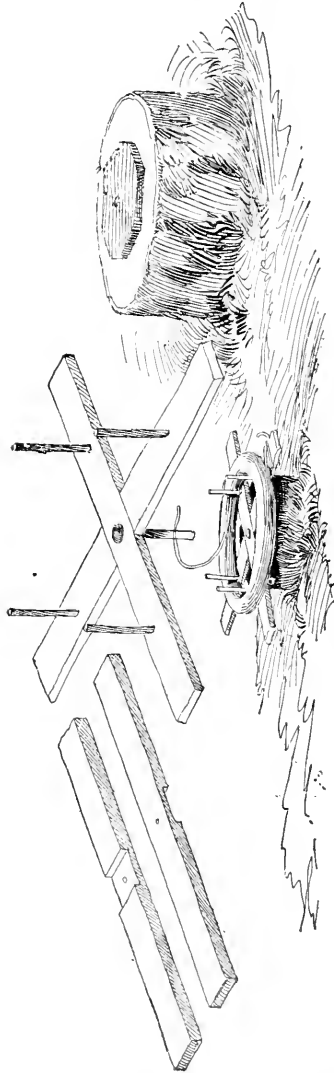


Fig. 10.—Reel for carrying and unwinding wire.

Strainer posts are the mainstay of a wire fence, and should be of the best timber procurable, with a diameter of not less than 12 inches. Those used at angles should be mortised to receive stays or struts. The strainers should be let into the ground at least 3 feet and be very thoroughly rammed. All posts should have the bark taken off before being put into the ground.

Drawn Iron Fencing Wire.

Posts to the mile.

Wire gauge.	Weight of 1 mile. cwt. qrs. lb.	Length of 1 cwt. yards.	Distance apart. ft. in.	(Fractions neglected).
4.	6 1 14	276	8 3	640
5.	5 1 7	332	9 0	587
6.	4 1 19	397	10 0	528
7.	3 2 20	479	11 0	480
8.	3 0 8	573	12 0	440
9.	2 2 10	680	13 0	409
10.	2 0 7	819	14 0	377
11.	1 2 18	1,050	15 0	352
12.	1 1 2	1,393	16 6 (1 rod)	320
			22 0	240

A Useful Barbed-wire Winder.

The accompanying sketch of a barbed-wire winder (Fig. 11) has been supplied by Mr. A. B. Paddison, Perthville. Most farmers have, at some time or other, to face the necessity of detaching barbed-wire from an old fence, and storing it for future use. Under ordinary conditions, the result is a cumbersome, loosely wound mass of wire, difficult to handle, and still more difficult to put to profitable use later.

Mr. Paddison uses a piece of $\frac{1}{2}$ -inch piping, about 6 feet long, and costing about 1s. This makes a first-class light windlass by heating and bending to the shape shown in the illustration. It is operated by two men, and the man operating the crank carries only about a third of the weight, and has the other hand free to turn the crank.

By means of such a device wire can be wound almost as tightly as the factory turns it out, and as fast as the men can walk.

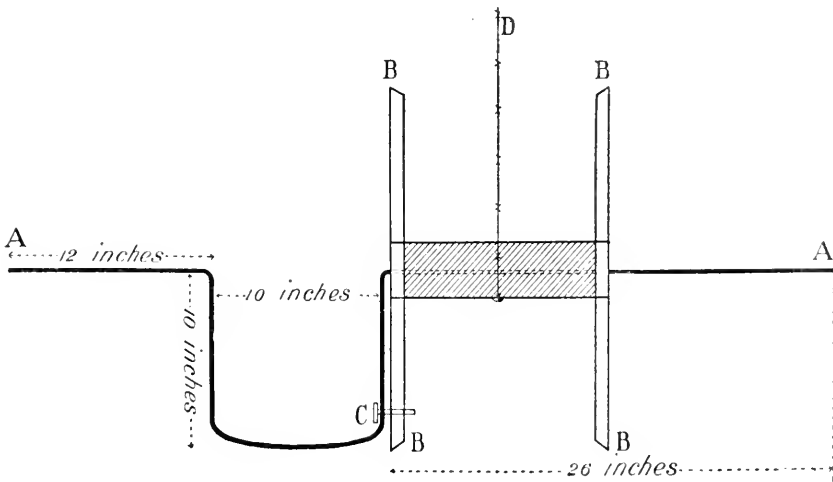


Fig. 11.

- A. Piece of $\frac{1}{2}$ -inch water-piping, 6 feet long before bending, and about 4 feet long after the crank is made.
 - B. Empty barbed-wire reel slipped on to pipe.
 - C. Strong cord fastening reel to the crank in pipe to prevent the reel turning.
 - D. Barbed-wire to be wound up, fastened to reel with small staple.
- When the reel is filled, cut the cord, take off and slip on another empty reel.

Gates and Gateways.

No fence is complete without an entrance, and therefore without a gate, for slip-rails at the best are only makeshifts, and are a source of loss both of time and temper. It is surprising that slip-rails are as common as they are, for excellent and serviceable light gates can now be purchased very cheaply, and even where the lack of eash is an obstacle to this being done, a handy man can, with the aid of an auger and a tomahawk, build and hang a strong useful bush gate, with no other outlay than the expenditure of a few hours' labour, and certainly in less time than is required for continual putting down and up of the slip-rails.

There are some who prefer something a little neater than the bush gate, but who wish the outlay to be as small as possible; for such, the batten-gate is admirably suited. The cost of the material required is not great, the gate

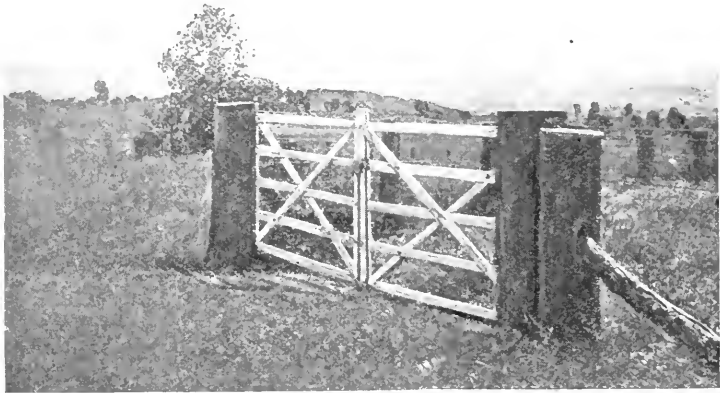


Fig. 12. — Gateway and round untrimmed posts.

is easily and quickly constructed, and if by accident it is injured, it is easily repaired.

It is the more common practice to make these gates of hardwood; but an objection to hardwood is its heaviness—for a heavy gate is generally the principal cause of its own inefficiency and final destruction. For this reason the gates at Cowra Farm (which are similar to those illustrated in Figs. 12 and 13) have been made of Oregon pine, which is light. It may be thought that Oregon pine is not strong enough for the purpose; but that supposition is not borne out by actual results, for on, at least, one dairy-farm in the State, Oregon batten gates have been in daily use for nine or ten years, and are still in excellent condition. They have never been broken or out of order during the whole time. It will be admitted that this material is strong enough for ordinary conditions of service, and that if it be broken it will be by some unusual act of violence, which, in most cases, would have been sufficient to have broken one constructed of hardwood.

The pair of gates illustrated in Fig. 12 are 16 feet wide. As reaper-threshers are now largely used, wider gates are required, and wheat paddocks should be provided with 20-foot gates. It will be noticed that the bottom batten is put down to within an inch of the sill. This is in readiness to carry the netting when the paddock is made rabbit-proof.



Fig. 13.—A gateway with squared and trimmed posts.

For openings up to 12 feet wide, a single gate, if made of light wood, may be made to do. The cost will be less, and a single gate is certainly more convenient than a double one.

The pair of gates, as illustrated, can be made ready for hanging in half a day. The materials required are—

	£	s.	d.
160 feet run. = 40 super. feet, 3 in. x 1 in. Oregon dressed all round, at			
40s. per 100 feet super.	0	16	0
3 lb. bolts, 3½ in. x ¾ in., 3 in. x ¾ in., 2½ in. x ¾ in.; washers, nails ...	0	2	3
Two pairs hook-and-eye hinges, 2 ft. x 2 in. x 1½ in.; 15 lb. at 9d. per lb.	0	14	0
	<u>£1</u>	<u>12</u>	<u>3</u>

The gates cannot be said to be finished until they have been painted, and the soundness of painting as an investment cannot be gainsaid. It will be better, and a saving of time, if the timber, after being cut up for the gates, is given a couple of coats before being put together. The gate, after it is completed and hung, can be given a final coat. The first, or priming coat, should be very thin, in fact may be nearly all raw linseed oil. The second and last coats will, of course, be a little thicker, and in order to dry hard, and with a little gloss, should contain a small quantity of turpentine and boiled oil.

With regard to colours, tastes differ, but judging by results, white, in this climate, seems to give the most satisfaction, and a first-class quality of white paint is a mixture of white lead and oil. Painting the ironwork (hinges) black will make a slight contrast, and will rather add to the appearance of the gateway.

The gate-posts should be quite separate and distinct from posts used in the construction of the fence. A better effect is obtained without additional trouble if they are slightly higher than the uprights in the gate, and also higher than the fence-posts adjoining the gateway. The main entrance to the farm, and also the gateways around the dwelling, may be still further improved if a little additional trouble be taken to square the gate-posts and round off the tops. The amount of improvement effected by this may be judged from a comparison of the illustrations (Figs. 12 and 13). The four posts in the gateways shown were practically identical as they left the bush. The cost of trimming is not very great.

Squaring a Gate-post.*

For a gate-post, a bushman likes to have a perfectly sound log. He is not always able to secure this, and often has to be content with one containing a small hollow or "pipe," which may be plugged up when the squaring is completed.



Fig. 14.—The log barked ready for squaring.

A log with a straight free-running grain is the more easily worked, but one with a curly grain is the more durable.

A suitable tree having been chosen and felled, and the necessary logs having been cut off, the first operation consists in removing the bark; the sooner this and the subsequent operations are done after falling, the easier they will be.

The tools necessary for squaring a log are—an American axe, a squaring or road axe, a level with a plumbing bulb, a rule or measure, a pencil, a line or string, and some chalk or other material for coating the string so that it will make a mark on the log.

For the sake of stability, as large a butt as is possible is left on the gate-post; only that portion, therefore, which is to stand above the ground is squared. The length of this portion is measured off, and the log fixed so

* J. Wm. Chapman, Cowra Experiment Farm.

that it will remain steady while the ends are being marked, at the same time in such a position that the most can be made of the timber it contains. The ease and readiness with which this is done depends entirely upon the skill and judgment—largely the result of practice and experience—of the axeman.

The squares or rectangles are now marked on the ends with the aid of the level and rule. The first line (a vertical one) is obtained by drawing a pencil along the face of the level when it is held "plumb" and as close to the edge as it is deemed advisable to go. The line at right angles to this is obtained by drawing a line along the top of the same instrument when it is held level. The other lines, necessary to complete the rectangle, are then obtained without difficulty by measurements. Another way of marking the first line on both ends is with the aid of a plumb-line. The other lines are then marked off it with the aid of a blacksmith's or other square and a measure.

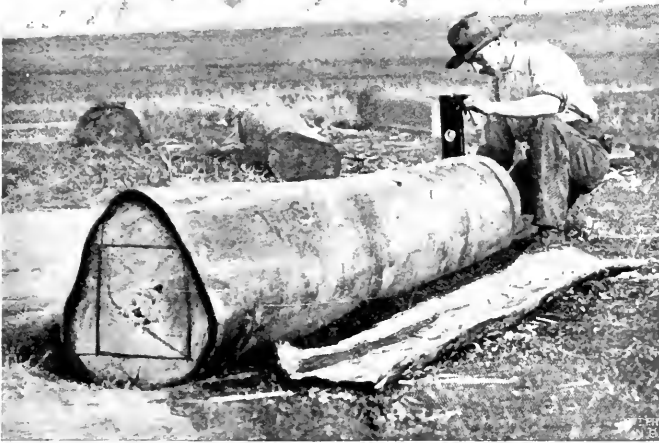


Fig. 15.—Marking the ends.

It is very necessary that some method be adopted to prevent a "wind" or twist in the squared log. Marking the first line on each end with the plumb-line or level is an easy and satisfactory way of preventing this; but, in the absence of either a plumb-line or a level, the "wind" may be prevented by marking the first line on each end with the aid of two laths, or light battens, used in the following manner. A lath, or batten, is tacked to one end of the log in either a vertical, or a horizontal position, the other lath is then held on the opposite end of the log, so that the edges of both laths "line," or correspond with each other, when sighted across. The longer the laths the more accurate is the work likely to be.

The ends having been marked, it is necessary to connect these marks with lines which will show the axeman how deep to chop. These lines are marked or "struck" in a similar manner to that adopted by a carpenter for marking a chalk line on a board. A carpenter's line, a piece of fishing-line, or failing these, a piece of string or sewing-twine, is used. Instead of coating the string with dry chalk as the carpenter does, it is found better, for the work in hand, to use a black or a white liquid. Black is to be preferred, as it makes a better mark than white on the log. A suitable liquid is made by mixing charcoal, soot, or burnt straw with water. To make a white mark, lime-wash or whiting and water is used.

A knot is tied in one end of the string, which is then wound crossways on the thumb and little finger of the left hand; it is then placed in the black or white mixture until saturated, when it is taken out, the knotted end is taken hold of, and the wound-up portion thrown out with a smart jerk; it should fall out quite clear and free from tangles. The knotted end is now placed in an axe-nick previously made on the end of the log and in a line with one of the vertical marks on one end of the log; the other end of the line is taken and held at the point where a continuation of the corresponding vertical line on the other end would meet the uppermost surface of the log. With one hand the line is pulled tight and held firmly

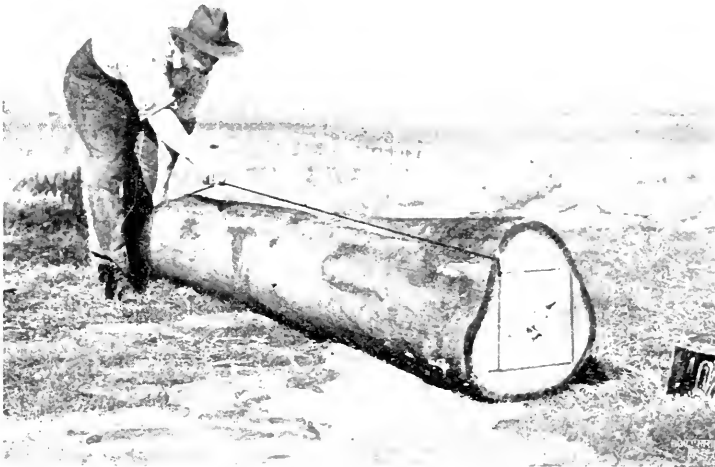


Fig. 16.—“Striking.”



Fig. 17.—Chopping to the line.



Fig. 18.—Splitting to the line.



Fig. 19.—Squaring the edges.

at this place, whilst it is seized towards the middle with the other hand and stretched upwards, held for an instant, and then released. It strikes the log with a smart smack and leaves a straight but somewhat bespattered mark connecting the uppermost end of the two vertical lines on opposite ends of the log. Another line is now "struck" on the other edge of the log. The log is then rolled over and corresponding lines "struck" on both edges of the other side of the log.



Fig. 20.—Striking after the first two edges have been squared.

Cuts, or kerfs, at intervals of 9 to 12 inches, are now chopped with a common axe, almost to the lines "struck." The intervening blocks are then split off with the same axe, after which the edges are finally trimmed with the squaring axe.



Fig. 21.—Finished.

The partially-squared log is now rolled over until the remaining marks on the ends are in a vertical position ; lines connecting these marks are "struck" and the edges squared as the others were squared. The top is then rounded off with axe and adze. This completes the squaring, the post is finished, and is ready for setting in the ground.

Concrete Fencing-posts.

With the prospect of timber for fencing-posts becoming scarcer each year, and because of some prominence being then given to cement concrete, it was decided early in 1908 to make an experiment at Cowra Experiment Farm with a short line of fencing with concrete posts, so as to determine if there were any special difficulties to be met with in this type of post, and to obtain some definite idea under local conditions as to its cost and efficiency.

The length of line erected is $2\frac{1}{2}$ chains, and included in the line are gate-posts, straining-posts, struts, stays, and ordinary posts.

The location of the fence is such as to ensure that the posts are subjected to a fair trial. It is the boundary line between a lane and the paddock in which the stables and other farm buildings are situated. The gateway is the entrance to this paddock, and is in constant daily use. On one occasion a dray collided with one of the gate-posts, but it suffered no appreciable damage. Fig. 22 is an illustration of this kind of fence ; its neat appearance commends it.

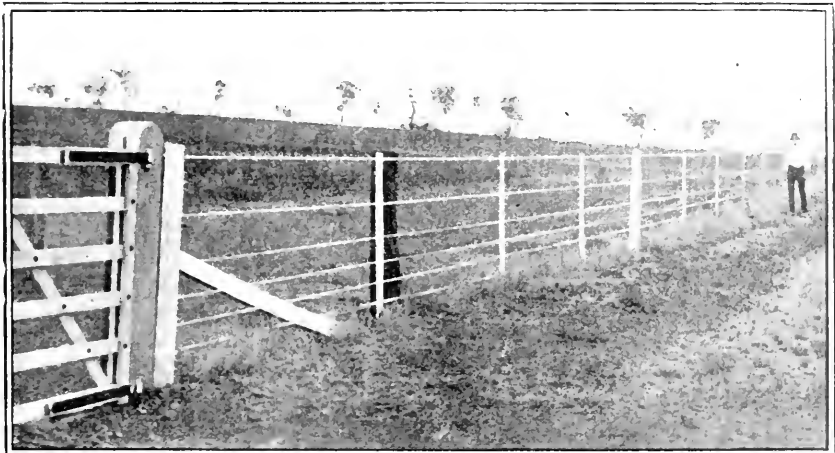


Fig. 22.—Concrete Fencing Posts at Cowra Experiment Farm.

The posts were made of the following mixture: cement, 1 ; sand, $2\frac{1}{2}$; gravel, 5. In the case of the ordinary fencing-posts and struts, the gravel was small, being about $\frac{1}{2}$ inch. In the larger and bulkier posts the gravel was of a much larger size, some pieces being the size of an egg. The dimensions of the ordinary posts are 6 ft. 3 in. long by $3\frac{3}{4}$ x 3 in. at the top, and $5\frac{1}{2}$ x 5 in. at the bottom. Each post is reinforced with four pieces of No. 6 crimped wire, placed 1 in. from each corner. The crimped wire was used

because it was on hand, and was considered to be stronger than the plain, but from what has since been learned it is believed that the ordinary No. 6 plain wire, bent at the ends, would be quite strong enough for reinforcement.

The wires are fixed to the posts, as shown in Fig. 23, by tying wire which passes through holes in the post, and 2 inches from its face. These holes are made when the post is moulded, by putting $\frac{1}{4}$ -inch iron rods through the sides and across the mould the required distance apart, *i.e.*, the distance necessary for the spacing of the wires. When the concrete sets, the rods are withdrawn, leaving holes in the post. Two of the rods are in the form of bolts, which on being screwed up hold the mould together, and stiffen it, so that the mould will remain firm when the material is tamped.

Where only plain wires are used on a fence, they can, if desired, be run through the holes in the post, but because of the ease with which a broken wooden or concrete post can be replaced, and because a much neater and better job can be made when affixing netting, it is believed that the proper method of affixing wires is by means of the tie-wires to the face of the post.

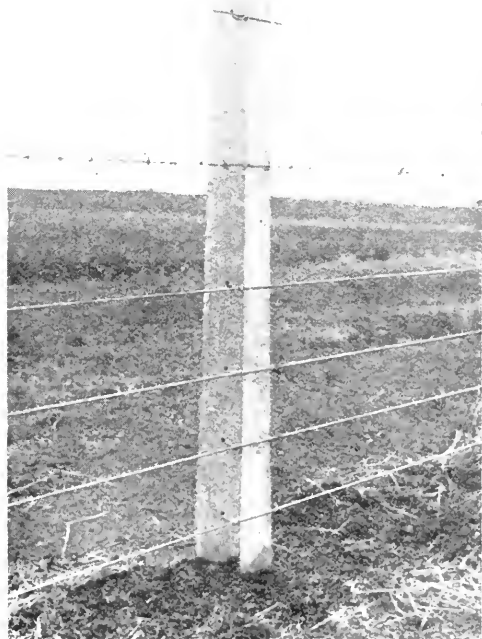


Fig. 23.—Concrete Fencing Posts at Cowra Experiment Farm.

The posts were moulded singly in collapsible moulds. The sides of the moulds were of $1\frac{1}{2}$ inch dressed cypress pine, and were kept apart by blocks 2 inches thick at each end. The top block had two small three-cornered filets tacked to it, in order to give a bevel finish to the top of the post. The moulds were held together by three bolts, the top and middle bolts being placed so that the holes, which were left when they were withdrawn, were at the required distance apart to correspond with the spacing required by two of the wires in the fence.

When making the post the mould, after being cleaned and greased, was placed on a board, so that the back of the post would be underneath, and sufficient material in a soft state to cover the bottom about 1 inch deep was placed therein. Two of the reinforcing wires were then placed on the concrete, at about 1 inch from each side, and extending from within 2 inches

of one end to the same distance from the other end. The mould was then half filled, and the rods to make the holes for the fencing wires passed through the sides. Material was then placed in the mould to within 1 inch

of the top, when the remaining two reinforcing wires were put in a similar position to the first two, and the mould filled. After being filled the material was worked to the sides by passing a trowel or spade between the material and side of frame or mould. When this had been done the material was thoroughly tamped with a small rammer. This operation brought the fine material to the top, which, on being smoothed off with a trowel or float, gave a smooth surface to the face of the post.

After the concrete had been allowed to set for two or three hours, the bolts were unscrewed and the mould taken apart, cleaned, and greased for another post. The newly-made post was kept in the shade to season for about a fortnight, being watered daily for the first week so as to retard the progress of setting.

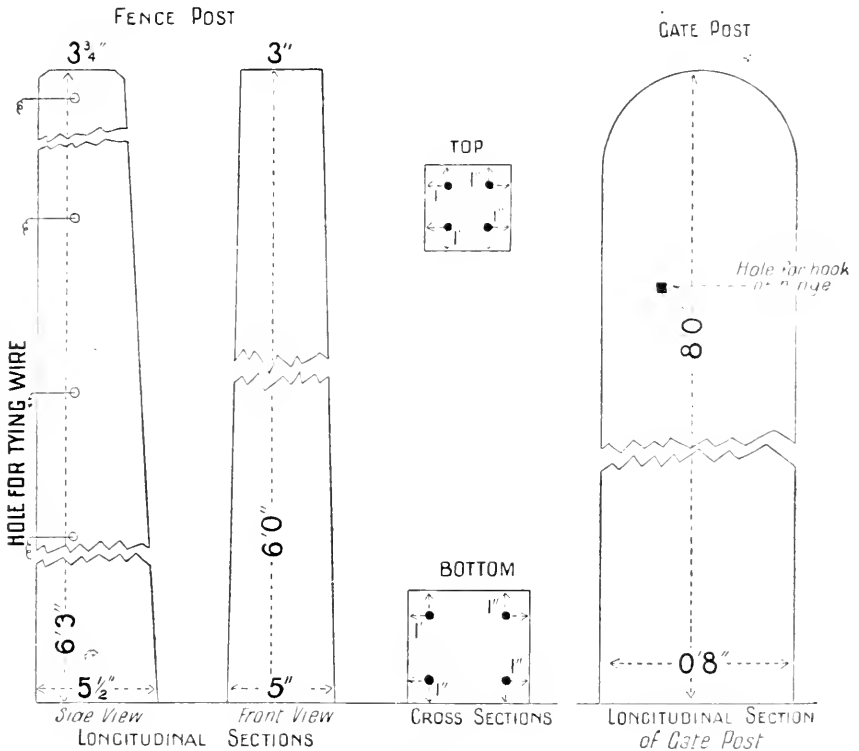


Fig. 24.

Information gained after the posts were made, produced the impression that the material could be used much drier, and though this would require more tamping, it would admit of the moulds being removed sooner from the posts without injury to them. It is also believed that the posts could be moulded on the ground, or on a bed of sand, instead of on boards.

The actual details of making the posts will vary according to the facilities available on different farms. If desired the moulds can be made in sets, and several posts made at a time. Under certain circumstances this plan will perhaps be found the most suitable, but for continuous work it is believed that making a single post in a collapsible mould will be found the better plan. If a single collapsible mould be used, it can be removed much sooner, and with less risk of injury to the post, than if a compound mould be used.

The gate, straining posts, and struts were made in a similar way to the ordinary posts, in moulds of the proper size. In each case stronger reinforcing rods of $\frac{3}{8}$ -inch round iron were used. It is believed that the $\frac{3}{8}$ -inch reinforcing rods in the struts or stays could be replaced with $\frac{1}{4}$ -inch rods without unduly weakening them.

The holes for the hooks of the hinges were made in the gate-posts by placing the hooks or gudgeons to be used in their relative position in the moulds. The tops of the gate-posts were rounded by placing a block of wood the required shape at the head of the mould.

The straining-posts are 7 feet 9 inches long, with a cross section of 8 inches x 6 inches. At 1 foot 10 inches from the top, a slight rectangular recess is moulded obliquely in the centre of one of the narrower sides for the reception of the end of the stay or strut. The straining-posts are placed 3 feet 6 inches in the ground.

The stays or struts are 9 feet long, with a cross section of 4 inches x 3 inches.

The appearance of the posts is improved if, after completion, they are given a coat of thin cement wash, made by mixing cement thinly with water.

The cost of fencing-posts made of concrete will depend upon the local cost of the material used. It is estimated that where suitable gravel and sand is easily obtainable concrete fencing-posts can be made for about 1s. each (labour and material). Fencing-posts of the dimensions given require about 18 lb. of cement, which at Cowra Farm cost about 8d. With sufficient moulds available, it is believed that a man could make about 100 posts per day.

The experience gained with the short line of fence referred to suggests very distinctly that concrete is a suitable material for fencing-posts in this climate. Concrete posts do not require specially skilled labour to make; they are neat, efficient, and durable, being unaffected by white ants or rot, and probably also by bush fires. Their first cost, however (about 1s.) makes their use uneconomical in districts where wooden posts are still easily obtainable. Concrete gate-posts are a decided advantage over wooden ones. Unsightly cracks do not appear in them, nor do they require painting regularly to keep them neat and in good order.

The experience thus obtained with concrete posts at Cowra Experiment Farm goes to show that they are sufficiently strong to withstand all ordinary shocks. They have the great advantages of being indestructible by fire, and of not decaying like wooden posts.

The Practical Use of Timbers.*

Although the following notes refer more particularly to western timbers, the principles enunciated apply nevertheless equally to timbers from other districts.

All trees that provide us with timber are outward growing trees—that is to say, they increase in girth by developing successive layers round the trunk next to the bark. Each year generally adds one of the layers or rings, and consequently they are called “annual rings.” In addition to the annual rings, trees have medullary rays, which are thin and generally broken lines, radiating from the centre, or pith, to the bark, and *vice versa*. These rays are not very apparent in some trees, but in dry cypress pine they are easily seen. Cabinetmakers call these rays the “silver grain.”

The trunks and branches of trees consist of two kinds of wood—the hard, dead heartwood, or duramen, and the soft sapwood, or alburnum. The latter is much lighter in colour than the former. The bark consists of an outer and inner layer.

Heartwood is much stronger and more durable than sapwood, and the outer portion of the heartwood is stronger than that near the centre, or pith, more particularly if the wood is “pipy,” because then it has been subjected to decay and is very brittle.

Old wood is stronger, though lighter, than young wood. The strength of timber is influenced by the quality of soil on which it grows. Evenness of grain in the annual rings denotes strong wood.

By strength of wood we mean the resistance it offers to force acting at right angles to its grain. This is called “transverse strength.”

It must be patent to all that where the strongest parts of timber are preserved the structure built would have a much longer life than where the weaker tissues are made to stand the strain.

Cypress pine is very fissile, but will stand very little transverse strain; and therefore, when using it, knowing of its weakness, workers should aim at conserving the strength in every possible way. Anyone familiar with pine used in stockyards knows that the rails most frequently break at or near the middle and at the tenon, which fits the mortise of the post. When pine sapings are used as rails the posts should be close together to lessen the strain when stock bump against the rails. Little or nothing but the bark should be removed from young pine in making a tenon, because the young wood is much weaker than that from mature trees, and by removing the harder heartwood of an already weak timber the strength and durability are very materially lessened.



Fig. 25.

* C. J. Woollett, Stock Inspector, Tamworth.

In Fig. 25 the stockyards are made of split pine. To the casual observer they appear to be very substantial and as strong as that timber will allow. Both the posts and rails are from mature and fairly sound trees. They are on a station

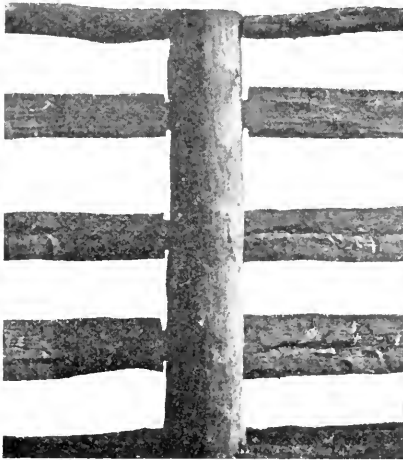


Fig. 26.

A chain is no stronger than its weakest link, and so here the strength of this fence depends on the strength of the tenon. Furthermore, even the tenon has been weakened by adzing wood from the convex outer hardwood, instead of from the inner wood towards the vicinity of the pith. Obviously, to make the yards as strong as possible with this class of timber, much larger mortises should have been made in the posts, and there should have been no adzing from the rails.

Fig. 27 is a picture of yards made of hardwood, which at first sight appear very substantial, but while they are strong enough to hold sheep, goats, or quiet milch cows, they frequently fail to stem the rush of frightened cattle. The rails are of sawn timber of a short, curly grained hardwood, and about $1\frac{1}{4}$ inches thick. They are much too narrow in comparison with their length. Being so narrow and long, they bend to only a moderate pressure upon their middles. To guard against the rails being forced out—which frequently happens—the mortises should be at least 2 inches deep; but, instead, they are only half that depth in the post.



Fig. 27.

belonging to a gentleman as keen, observant, and well informed on matters pertaining to agronomy as any person with whom the writer comes in contact. Yet, until the matter was discussed with him, although he was well aware of the characteristics of the timber, he had not given any thought to the reduction of the strength of these timbers when he allowed his men to cut them as they had done in making these yards.

In Fig. 26 the photo. is taken much closer to the posts and rails than Fig. 25, and from inside the yard.

The reader will observe that about half the rail has been cut away and a very small tenon left to fit the mortise of a very substantial post.

Fig. 28 shows how two rails gave way when a mob of cattle became frightened. These are comparatively new yards. Split timber is much stronger than sawn timber, and therefore for such purposes as stockyards the split hardwood is better than sawn, because the grain is not broken so often. Here strength has been sacrificed for neatness.



Fig. 28

Fig. 29 is an example of using rails out of all proportion to the strength of the posts; the former have also been weakened by cutting away such a large amount for the tenon.



Fig. 29

Attention to some of the points enumerated above relating to the construction of stockyards, may avoid the annoying occurrences of wild stock breaking away at, say, branding-time, through a weak rail being broken by the animals in their caperings round the yard, to say nothing of loss through broken limbs when they essay to jump out of a yard through an opening left by a broken rail.

How to Lay Timbers for Flooring.

Slabs of pine and old railway sleepers are frequently used as flooring for stables and cow-bails on farms and stations. At times they are not used to the best advantage, and consequently are heavy with the smell of urine, no matter how the attendant may try to keep the place clean.

Fig. 30 represents logs showing the rings plainly.

If the logs were placed as in Fig. 30*a*, urine would find its way through the space of the rings when the logs were seasoned, and there set up decomposition, decay, and an objectionable odour. Obviously they should be set as in Fig. 30*b*.

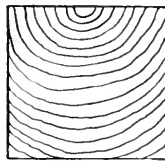
*a**b*

Fig. 30.

As milk absorbs odours very readily it is necessary that cow-bails should be as free from bad smells as possible. The same thing applies to the decking of bridges and culverts. If placed as in Fig. 30*a*, rain would find its way into the rings, and, when evaporated by the sun, would cause warping and, consequently, weakening of the timber for traffic.

CONSERVATION OF WATER.

Many areas of land taken up for grazing and cultivation have no natural permanent water supply; therefore the matter of providing a sufficiency of this most necessary element should be a first consideration with the settler.

TANKS AND DAMS.*

It is somewhat difficult to arrive at the quantity required for sheep and for cattle, say, over a period of twelve months. Every person must be his own judge as to whether the weather conditions of his climate warrant him in providing for a shorter period, or whether in the driest parts it will not be wiser even to provide for a longer period, but there are a few points that are worthy of consideration in determining the size of a dam.

Sheep, more especially when there is plenty of green feed with a moderate temperature, require very little water; indeed, they have been known to go



Excavated tank.

months without any and do well. When, however, feed is dry and dusty they drink a great deal. When there is a drought and the weather is very hot they almost live on water, and they also carry out a lot of water in their wool. Taking these things into consideration, and also the evaporation from the surface, I consider that $1\frac{1}{4}$ gallons per day for each sheep should be provided. This makes the requirements of each sheep for one year $456\frac{1}{4}$ gallons. Each cubic yard of water contains $168\frac{3}{4}$ gallons, which works out at about $2\frac{3}{4}$ cubic yards per sheep. As it is always safer to provide a little more, I would advise that 3 cubic yards of water be provided for each sheep intended to be watered at the tank, or tanks; for 100 sheep, therefore, provide 300 cubic yards of water; for cattle and horses, from 24 to 30 cubic yards should be provided for each beast for one year.

Having considered the quantity of water in cubic yards that will be required for the maximum number of stock intended to be kept, providing for the driest seasons (and of water there should always be more than enough), the next thing to do is to select the most convenient position or positions on the estate for watering stock.

* R. H. Gennys, Manager, Glen Innes Experiment Farm.

Tanks or dams may be placed so as to water more than one paddock if required. If the paddocks are large, however, it is better to place the excavations as near the centre as possible, in order that stock may not have to travel too far to water and will not tread down the grass so much going to and fro. There must be a catchment area that will catch enough water to fill the excavation in good heavy rains; a large area with a gentle grade is preferable to too steep a catchment, as the latter carries too much soil and rubbish down during heavy rains. See that the area is kept clean and does not contain pigsties, sheep yards, &c.; also, shade-trees should not be left in the catchment, but rather below it, so that the excreta from stock camping under them may not be washed into the tank and pollute the water.

Very steep slopes are soon trodden down, mud and clay falls in, and the shape of the excavation is spoiled. This applies to tanks that are not fenced in and that stock are allowed access to all round. Sheep only should be watered at these, and the slopes should not be less than 3 to 1. If made with bullocks, ploughs, and earthscoops, they can be taken out at this grade all round, but 3 to 1 is too steep for cattle and horses to water at.

All excavations intended to be used for large stock should be fenced in and access given at one side only, which is generally termed the roadway. This should have a grade of from 4 to 1 to 5 to 1, and should be corduroyed or stone-pitched—the latter is more lasting and safer in every way. This can be done by making an excavation 7 or 8 inches deep and filling in with large stones placed on edge, and all interstices tightly wedged with small stones to an even surface and then blinded with gravel a few inches deep.

Rule for Measuring Tanks.

Add together the top area and the bottom area, together with four times the middle area. Divide result by 6, and multiply by the depth. If the measurements are in feet divide by 27, and the result will then be the size of the excavation in cubic yards. Thus:—

	ft.	ft.	sq. ft.	
Top	...	60 × 80	= 4,800	top area
Bottom	...	20 × 20	= 400	bottom area
		40 × 50 × 4	= 8,000	middle area × 4
			13,200	
			13,200 ÷ 6 = 2,200	
			2,200 × 10 (depth) = 22,000	cubic feet
			22,000 ÷ 27 = 814.81	area of tank in cubic yards.

If it is desired to find the size before sinking, the length and breadth of what the bottom will be on completion can be obtained thus:—This tank has the top measurements 60 feet by 80 feet long; depth, 10 feet; slopes on three sides 2 to 1, and on one side (the roadway) 4 to 1; in the breadth, 2 to 1 for 10 feet=20 feet; this on either side=40 feet. This subtracted from 60 feet leaves 20 feet in breadth at bottom. In the length on one side, 2 to 1 slopes × 10=20 feet; and on the remaining side, which is 4 to 1 by 10 feet deep,=40 feet. For both sides 60 feet to be taken off from 80 feet in length of top, leaving 20 feet, thus 20 feet × 20 feet will be measurements of bottom.

TANK SINKING.

Owing to the settlement of returned soldiers on the land, and also the lessons of the 1918-19 drought, more work may be done in the future in boring, well-sinking and the excavation of tanks for water conservation. During recent years sub-artesian water has been found in many localities where it was not supposed it existed, and bores and wells are taking the place of tanks and dams. The Government has taken steps to assist liberally land-holders in the sinking of bores, and consequently very marked improvements have been made in the water supply, but in many districts tanks and wells must still be relied upon to provide water for stock requirements. Droughts have shown the necessity of providing ample storage, of maintaining the storage in good condition, and of keeping the supply drains in order.

Site.

Very careful consideration should be given to the selection of a site for a tank. The most important point is a good catchment, and this, on some holdings, is almost the sole determining factor. In undulating country catchments are generally good, and no difficulty is experienced, but in the level country of the western plains a new settler would do well to secure the advice of a more experienced man. Very often shallow watercourses exist, and the tank should be located on or near these. Roads provide good catchments, and a good flow of water can be obtained off the hard bare patches which exist on the plains. In selecting catchments attention should also be given to the nature of the country; for instance, a drain running over hard, compact soil will carry more water into the tank than one running over black soil, which develops large cracks during drought periods, and which absorbs a large amount of water before any reaches the tank. Although the experience of old settlers is of great value, even they make mistakes sometimes. Land often appears level when it has a fall of several inches, and in very level country it is often well worth while to have levels taken before fixing the site.

While preference must be given to the catchment, it is important that the tank should be located in a central position to save the stock from much travelling to and from water. If possible, the site should be near a belt of green timber, as stock come to water in the morning and like to linger round in the shade, taking frequent drinks before moving off in the afternoon. If shade is not available they probably take only one drink in the day, and consequently do not do as well as they otherwise would.

After locating what is apparently a good site, the nature of the soil should be ascertained. On some country a tank will hold well almost anywhere, but in other classes of soil some considerable difficulty is experienced, and recourse must be made in some cases to puddling. The nature of the timber is usually indicative of the character of the subsoil, but is not always reliable. Occasionally the country is patchy; while the subsoil in portion of the tank is good, a band of a porous character may be struck which will cause a leakage. Before sinking is commenced trial shafts should be sunk to the depth it is proposed to excavate the tank, and if it is considered the country is patchy two or three should be put down. An experienced man

can tell by the nature of the subsoil whether or not it will be "good holding," but if there is any doubt a test should be made by partly filling the shaft with water, so that its holding capacity can be ascertained.

Capacity.

If there is much of a fall in the land the tanks should be made long and narrow across the fall. If the length were made parallel with the fall the water would reach the surface at the lower end while it was still very low at the upper end, and consequently much of the storage capacity would be lost.

It is very important that the tank should be of ample capacity, so that the water will last through long periods of drought. In estimating the probable requirements, allowance must be made not only for the watering of stock, but for the loss by evaporation. From a water surface at ground level the evaporation in the western districts is equal to about 80 inches per annum. From the tank the loss would not be quite as great, for the water being below the surface, is protected in some measure by the banks, but if no water were to find its way into a tank for a year evaporation alone would be responsible for the reduction of its depth by 5 to 6 feet. This indicates that in excavation as great a depth as possible should be obtained; the best tanks in the western district are from 14 to 15 feet deep.

The Scoop.

In the actual work of making the excavation a good deal obviously depends on the implements used and the manner in which they are handled. It will be noticed that on the bottom of the scoop are two rods of iron called cradles. These after some use wear very thin, and should be removed and replaced (Fig. 2.). If this is not done the whole of the bottom of the scoop comes into contact with the ground, causing much more friction, and requiring considerably more exertion on the part of the horses. In the illustration the handle of the scoop is, as usual, straight, but some men

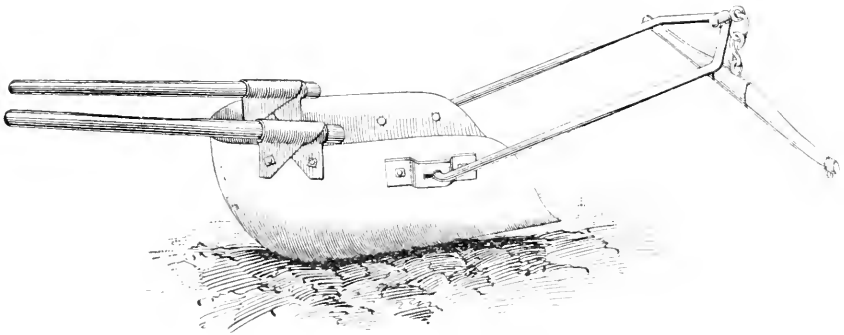


Fig. 1.—Type of small scoop generally used.

NOTE.—The scoop figured serves to illustrate the points referred to in the text, but more modern types of scoops, with much larger capacity and suitable for teams of two to four horses, are on the market.

prefer to have the handles bent upwards, arguing that less strength is then required to fill and turn the scoop. When scoops are new they are always bevelled at the mouth, as in Fig. 3 (a) which makes them hard to raise to the surface when full, and likely to "bite" as well as giving them a tendency to work downwards. When bevelled as in Fig. 3 (b) much less pressure on the handles sends them up, and they glide over the top of the loose earth without any trouble. When used for a considerable time the

mouth of the scoop wears very thin, and will easily buckle. To counteract this a piece of quarter-inch steel, 5 inches wide, is riveted across the mouth and bevelled at the same angle as in Fig. 3 (b).

Removal of the Earth.

The ground should be carefully ploughed before scooping commences, particular attention being paid to the uniformity of depth, so that the scoop will not bob up and down. The earth on which the embankment is to be built should also be ploughed, so that the removed earth will incorporate with it should the water overflow the excavation. If this is not done there is a risk of the water percolating between the hard undisturbed soil and the loose soil of the embankment, causing "weeping," and creating the possibility of a breakaway.

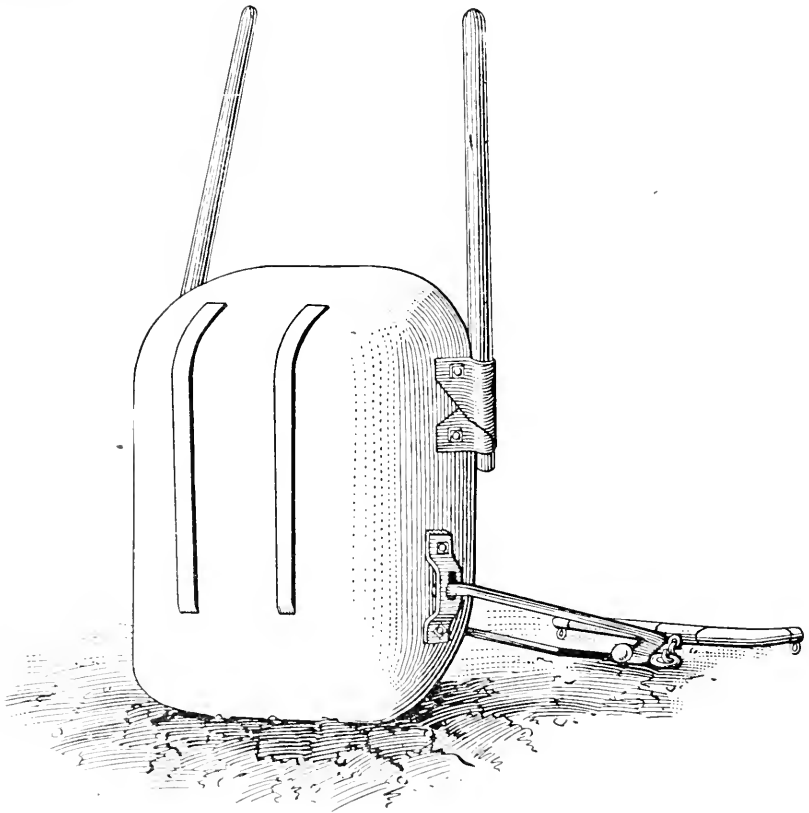


Fig 2.—Back of scoop showing cradles.

A frequent error of judgment on the part of tank-sinkers is the practice of placing the first scoop of earth near the margin of the excavation. This means that the horse has to drag the next filled scoop over the bank so formed. It is obvious that the operations should be reversed, and the earth placed at the back first and the embankment built up from behind. To increase the storage capacity the embankment should be built well forward. Usually the earth is banked on two or three sides, but it is an advantage to bank it right round to prevent evaporation as far as possible.

Filling.

To get the water into the tank, pipes are laid under one bank and the silt tank placed just outside it. On small holdings, where the tanks can be kept under observation, some means should be devised to divert the water as soon as the tank is full. If the water is allowed to continue to flow into the tank it gradually silts up, and the water which overflows is clearer than the water which is flowing in.

A chute should be provided where the pipe enters the tank, and a drain made right round the edge, leading to the chute, for the purpose of preventing water from running down the banks and causing scouring.

Silt Tanks.

Usually one silt tank is provided, but it is a decided advantage to have two or more, as then more silt is deposited and the water reaches the tank in a cleaner condition. Every possible opportunity should be seized upon to keep the tanks clean. They should be kept under constant observation, and whenever the water gets low as much silt as possible should be removed. Many landholders have discovered at the commencement of a drought that tanks which they had thought contained several feet of water actually contained several feet of silt and only a few inches of water.

Drains.

Wide shallow drains, in which the flow of water is slower and there is little scouring, are preferable to narrow deep ones. A drain 4 feet wide and 9 inches deep is much better than one 2 feet wide and 18 inches or 2 feet deep. When scouring is likely to take place the following method is very successful in preventing it:—A trench about 1 foot wide and 18 inches deep, and extending a couple of feet each side of the drain, is dug across it and filled with stones of 2 or 3 inch gauge. The efficacy of aprons such as this can be seen along roads and railways where they are used for the prevention of washaways. Where drains curve they should be widened; the sharper the curve the greater should the width be, and as a double safeguard an embankment can be placed on the outer side. Should drains meet before reaching the tank the main drain should be widened at the confluence, and the junction made at an acute angle. Otherwise considerable quantities of silt will settle.

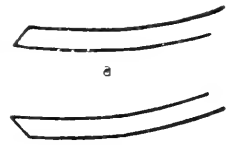


Fig 3.

Drains should always be kept in first-class order. When surface tanks are depended upon every shower is of importance, and unless the drains are clean, water from light showers does not reach the tank. Light road delvers are very useful for this purpose, but if the size of the holding does not warrant the purchase of such a delver, a crowder or delver should be made from a log or plank by the fitting of a steel point. A plough or shovel can also be used for this purpose.

Measuring Drains.

When the total length of drainage required runs to several miles it is a very tedious proceeding to measure for contractors' payment. The chain tape is in common use, but involves considerable risk of error. The following method used in measuring up road work is very simple, yet accurate, and could be applied to measuring drains, as well as fencing, &c :—A piece of white cloth is tied round the spoke of the wheel of a buggy, and the vehicle then advanced until the wheel has made a complete revolution. A mark having been made

on the ground before starting the circumference of the wheel is easily obtained. Then by driving along the proposed route of the drain, and counting the number of revolutions of the wheel, the total distance is easily arrived at. With two persons in the vehicle, one counting in tens, and calling "ten" each time, and the driver counting the number of "tens," there is no danger of mistake. When, for example, the driver has counted 43 "tens," and the other man has six towards the next ten, the number of revolutions must be 436. If the wheel were 14 ft. 8 in. in circumference, then the total distance would be 6,394 ft. 8 in., or nearly 97 chains.

FARM BUILDINGS.*

Of the buildings that must be regarded as a part of every well equipped farm, the residence is the first to be thought of, and eventually it is also the most important, affecting, as it does, the comfort and convenience of every one. The building erected in the first instance on many holdings in Australia is of a very temporary character, and often it is so inconveniently designed as to be of little use in the more commodious and permanent structure that follows it within a few years. Sometimes the original building has to be abandoned as a place of residence, and a new site chosen; more often one detached structure is erected after another until the home is simply a cluster of small buildings that have little appearance and that increase the labours of the housewife.

A FARMER'S COTTAGE RESIDENCE. (Figs. 1, 2 and 3).

In offering the accompanying plans for a farm home residence, one that can be erected as it were by instalments, the fact that it is necessary to make the job look finished at the completion of each section has been kept in view. The roof can be gabled and finished with a simple barge-board, which will give a finished appearance. Another and a very important point nowadays, the cost of construction, has also been carefully considered.

A large house, such as this would be when complete, must necessarily cost a fair sum to erect, the average cost per room usually being from £120 to £140, according to locality and finish, and including verandahs, laundry, bath and store rooms, which are considered as being provided in all plans.

The rooms here shown are of fair average dimensions, but without alteration of the design they can be enlarged—for instance, the dining and sitting rooms could be made wider from front to back, and so could the back hall if desired.

Material.

Provision is made for the use of light material, but the building would still be strong and durable. Of course, any heavier materials may be used, such as bricks, stone, or concrete, but it has to be remembered that the building may be erected in a district miles from rail or wharf, where the cost of cartage would be a considerable item. Then, again, with such material fewer tradesmen may be employed at the work; in fact, a good carpenter could do the bulk of it. For the foundations, wood blocks may be used, but, as the chimneys and fireplaces have to be of brickwork, the house would be more comfortable in winter, and the job would look better, if a close foundation wall were provided on the outside, with brick piers under the internal walls.

The walls are shown to be of wood frame, covered externally to a height of 3 feet 6 inches with weatherboards, and the remainder with fibro-cement sheets.

* A. Brooks, Works Overseer.

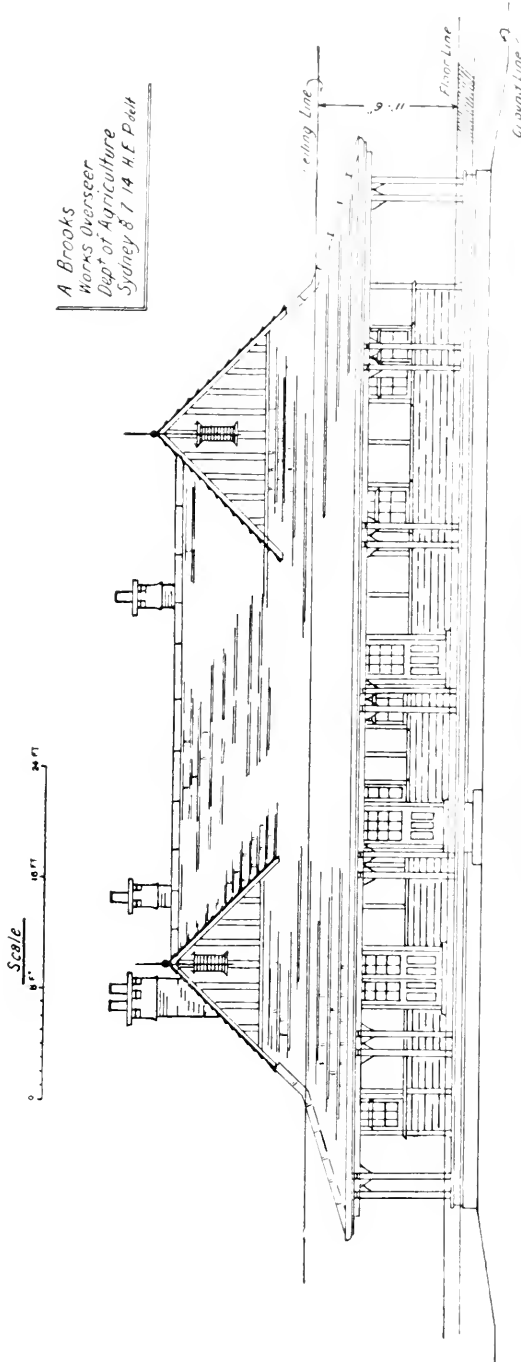


Fig. 1. Design for a Farmer's Cottage Residence.

To be built either as a whole or in sections.

Internally the covering would be of fibro-cement 4 feet high, and wood veneer sheeting above, with ceilings of the same material, and the whole finished as panelled work, with fillets covering the joints of the sheets. This material is strong when fixed, and can be finished in either paint or varnish, and makes a good class of work at a reasonably low cost.

For such rooms as the bathroom, larder, kitchen, laundry, and storeroom fibro-cement sheeting would be fixed internally the full height of walls.

The roof may also be covered with slates of this material, which are now extensively used, and are proving satisfactory, but the galvanized-iron roof is the most lasting, and, therefore, in back-country districts, where repair work requires to be avoided as much as possible, the iron roof is recommended.

By coating it with one of the roof-coating paints, and providing good ventilation and boarding under the battens, it is a cool roof. Of course, a good pitch must be given to the roof.

Ventilation of the rooms can be provided for by inserting gratings on the outer face of the walls at the floor level, and about 6 inches under the ceilings, also on the inner face in each room at about 4 inches under the ceilings. Larger openings must be made in the foundation walls, having strong wire-netting on frames, affording not only provision for ventilation, but (as a further precaution against the white ant) also for the admission of light. The foundations under the whole building should be lime-washed, and the ground surface left properly cleaned up. A door opening should be provided at the most convenient position for gaining admission under the building to inspect when desired.

Progress of the Building.

The first part to be erected might be that indicated on the plan by open lines, viz.:—The sitting-room (which may be used as a best bedroom), the dining-room, kitchen, larder, No. 1 bedroom, and back verandah, which provides space 13 feet x 10 feet 6 inches for sleeping out purposes, and the verandah continued round the back. The probable (pre-war) cost of this section would be about £650. This afterwards covers in the laundry, porch, and store-room, which would be the second portion to be erected, as indicated by blocked-in lines, and finally the extra bedrooms, permanent bath-room, and enclosed court-yard, as shown by hatched lines, which would complete the residence.

The probable cost of this work before the war would be £1,050 to £1,350, according to the materials used and the locality, the lower figure being the probable cost for the work being done with the lighter materials specified, and near the railway at about 250 miles from Sydney.

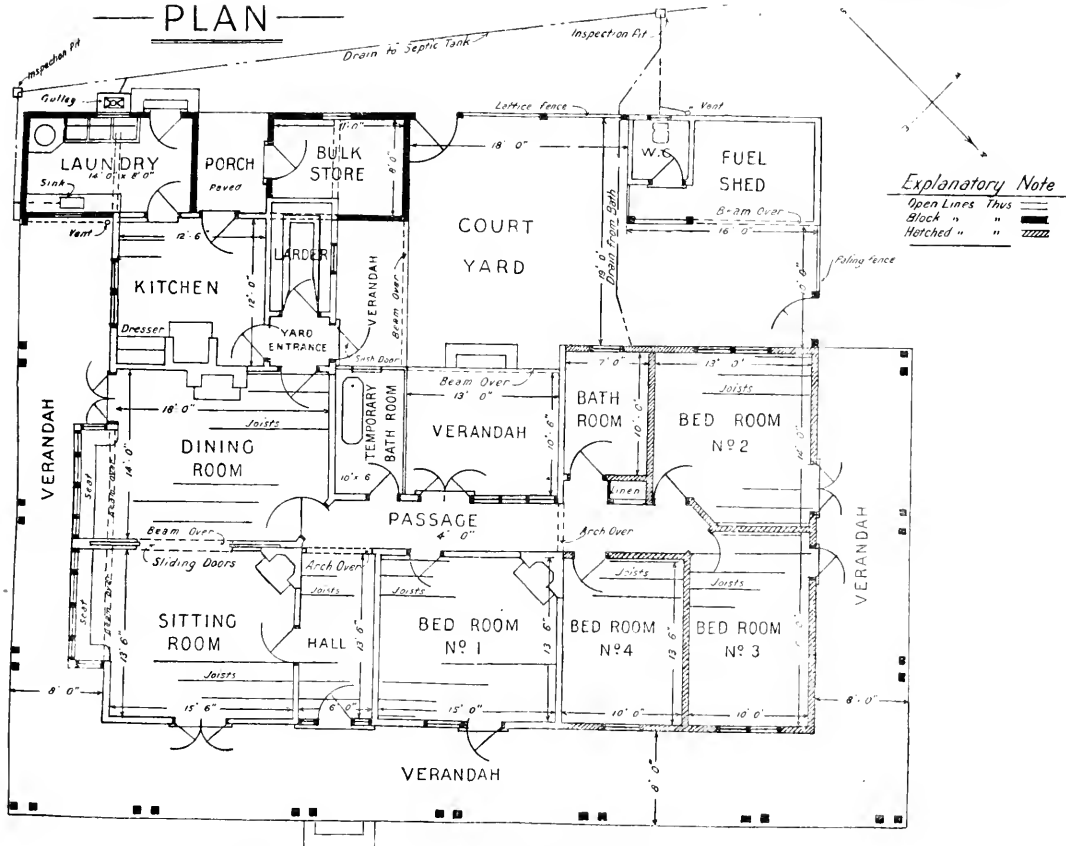
For the first section of the house, three 1,000 gallon tanks would probably be sufficient, but, as soon as possible, there should be provided an underground tank, with either a hand or a windmill pump to raise the water to an elevated tank to supply all requirements.

The whole drainage should be conducted into a small septic tank set about 2 chains from the house, and delivering the effluent into the vegetable garden or other cultivation. These tanks can now be had in various sizes from the State Monier Concrete Works ready to set in position and connect to the drain pipes.

The Roof Plan.

A plan of the roof, showing the lines of construction, as when the building would be completed, is also supplied. If a section only of the building is required, the roof should be hipped at the point to be continued, so that the materials can be used again in the extension.

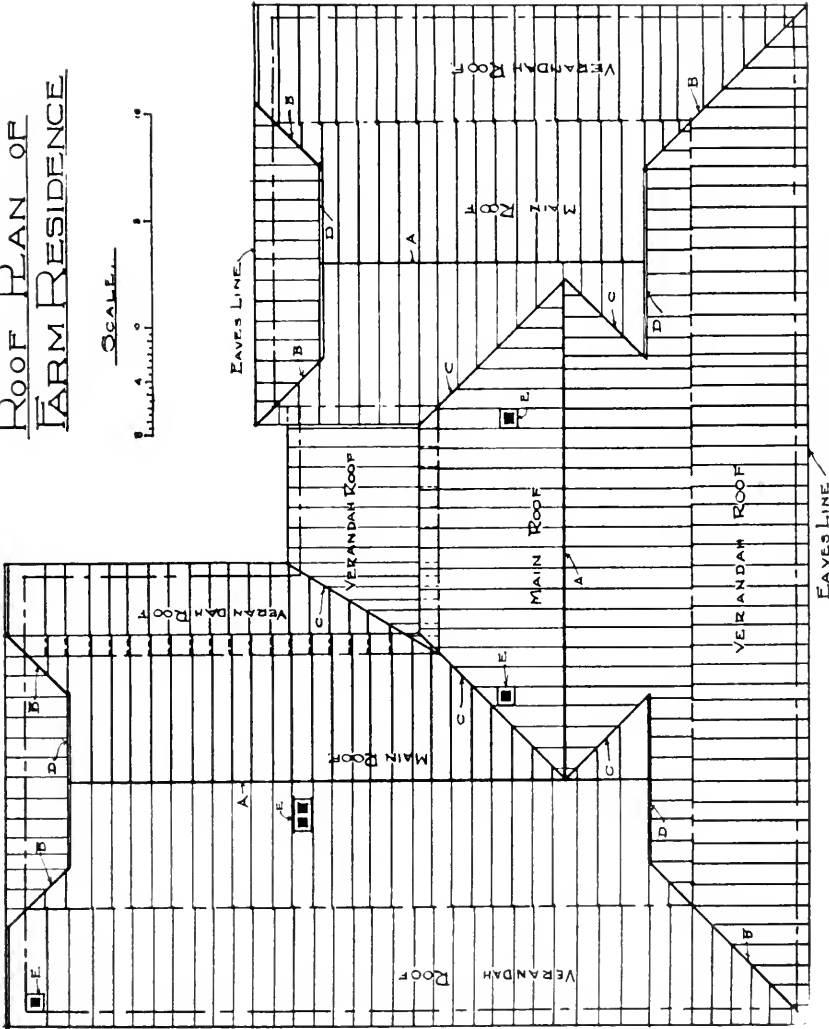
PLAN



To face page 194.

Fig. 2.—Plan of a Farmer's Cottage Residence.
 To be built either as a whole or in sections.

ROOF PLAN OF FARM RESIDENCE



EXPLANATORY NOTE.

- A - RIDGE
- B - HIP
- C - VALLEY
- D - GABLE
- E - CHIMNEY SHAFTS.

A. BROOKS
 WORKS OVERSEER
 DEPT. OF AGRICULTURE
 SYDNEY AND DISTRICT.

Fig. 3. —Roof Plan of a Farmer's Cottage Residence.

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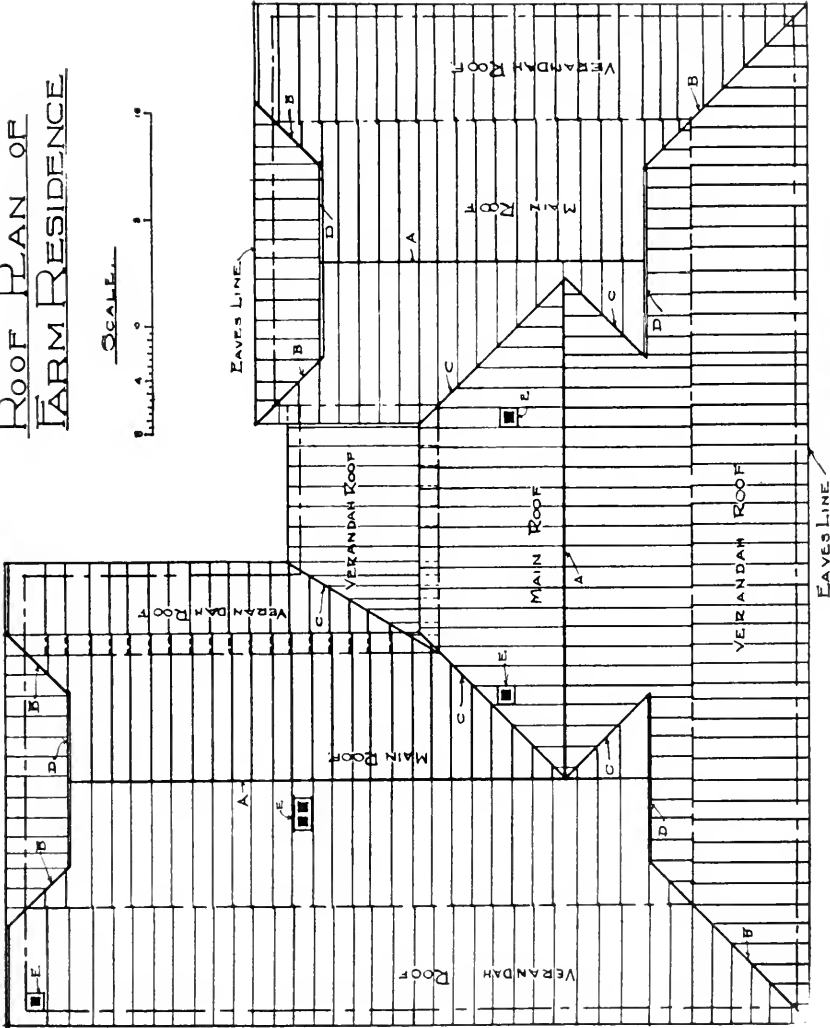
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ROOF PLAN OF FARM RESIDENCE



EXPLANATORY NOTE.

- A - RIDGE
- B - HIPS
- C - VALLEYS
- D - GABLE
- E - CHIMNEY SHAFTS

A BROOKS
 WORKS OVERSEAS
 DEPT. OF AGRICULTURE
 SYDNEY, N.S.W., AUSTR.

Fig. 3. — Roof Plan of a Farmer's Cottage Residence.

It should be noted that the plan shows the rafters at 18-inch centres as for a tile covering, but if corrugated iron is to be used, one-half of this number would be sufficient, *i.e.*, at 3-foot centres.

AN ATTRACTIVE RURAL HOME. (Figs. 4 and 5.)

The accompanying illustration and plan present a modern residence erected by Mr. J. Paekham, at 'Cherry Hill, Garra, which combines convenience, comfort, and attractiveness in a degree one would fain see more common.

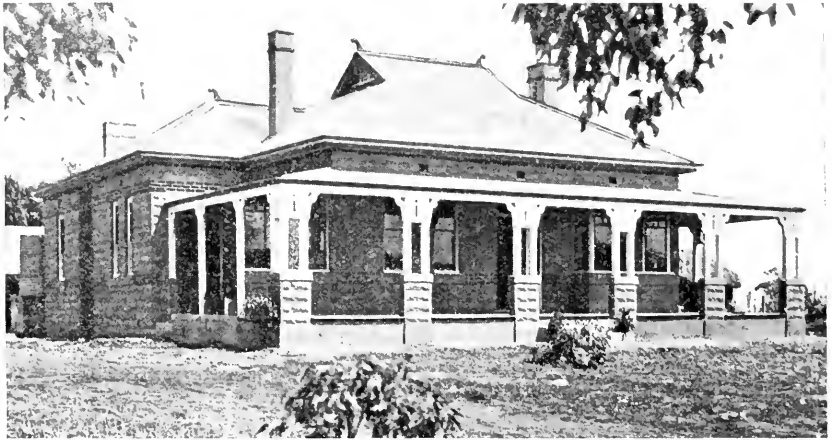


Fig. 4.—A Useful Type of Farm Home.

The materials used were cement concrete blocks made on the site, as suitable sand for this purpose was available about a mile distant. The dimensions of these blocks were 24 in. x 8 in. x 8 in., and the cost was about a quarter less than that of bricks, although these could be obtained about 7 miles away at Molong. The internal partitions are of smooth concrete blocks 6 inches thick, plastered on the inside.

PLANS OF STABLES, IMPLEMENT SHEDS, &c.

Substantially constructed buildings that facilitate work on the farm by the convenience of their arrangement, and that are yet within the financial resources of their owner, are most essential to the economical working of the farm. The Department is frequently asked to provide farmers with plans or designs for inexpensive buildings for various purposes, and is often able to make useful suggestions that effect important economies, but such structures are generally only economical for some special or localised reason, and under other conditions might not be so satisfactory. Hence it is necessary in presenting plans likely to be useful under the great majority of conditions, to select types of a better and more permanent character.

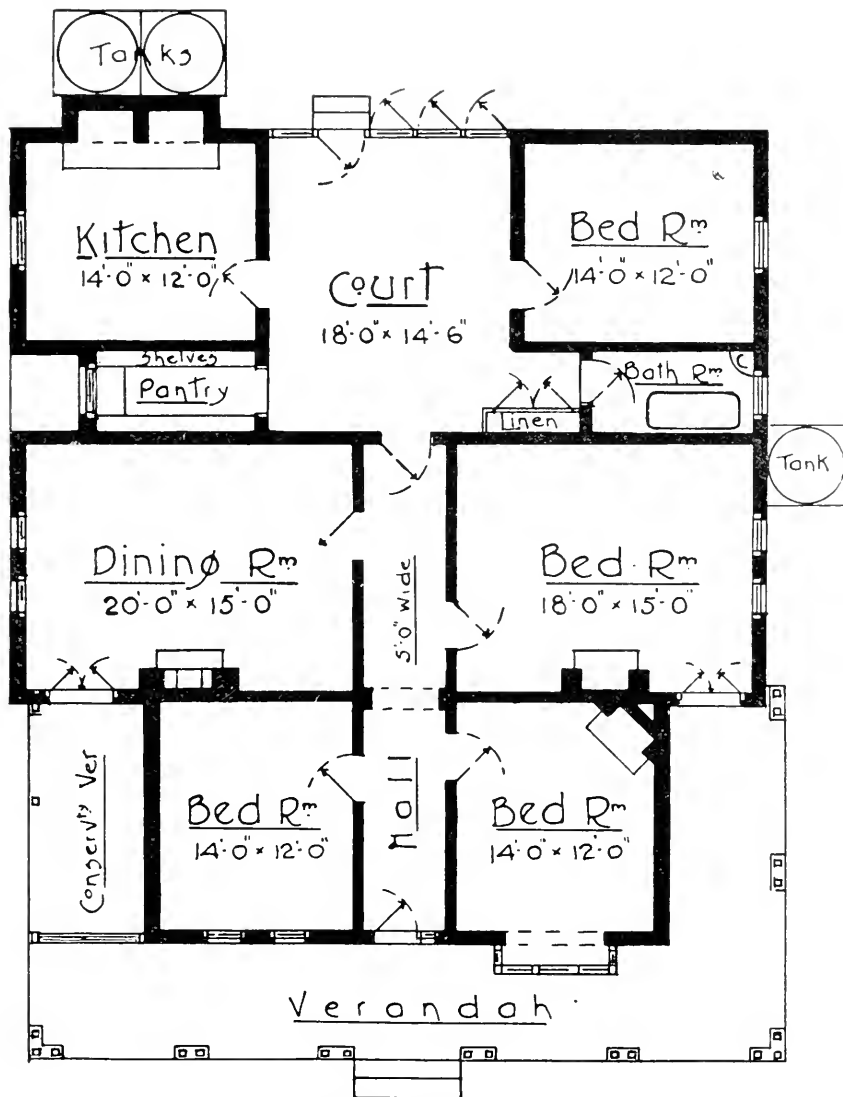


Fig. 5.—Plan of Farm Residence illustrated on page 196.

The accompanying plans are those which have been used quite recently in the erection of buildings on various Departmental farms. They have been selected out of a good many that have been prepared from time to time as being those most likely to be suitable to farmers' requirements—or at least those likely to be most suggestive to farmers who wish to erect something of this kind.

The specifications which accompany several of these plans are sufficiently explanatory. The plans comprise the designs for erection of the following buildings:—

- (1) Combined stables and implement shed (as erected at Griffith Viticultural Nursery)—six stalls.
- (2) Combined stables and implement shed (as erected at Glenfield Veterinary Station)—four stalls.
- (3) Combined stables and implement shed (as erected at Trangie Experiment Farm)—30 stalls.
- (4) Implement shed only (as erected at Wagga Experiment Farm).
- (5) Hay and corn shed (as erected at Glenfield Veterinary Station).
- (6) Shearing shed (as erected at Femora Experiment Farm)—three stands.
- (7) Sheep yards and dip (as erected at North Bangaroo Stud Farm).
- (8) Cow-bails for hand milking—six bails.
- (9) The lay-out of a dairy farm.

A Six-stalled Stable and Implement Shed. (Fig. 6.)

The specifications connected with the plan of a six-stalled stable and implement shed erected by the Department at Griffith Viticultural Nursery were as follows:—

Materials.—All timbers unless otherwise specified to be of Cypress pine.

Roof.—Construct pitched gable and roof as shown, rafters to be either 4 inches round timber, or 5 inch x 2 inch sawn with similar collar ties to each pair, and projecting rafters at gables, notched and projecting over top wall plates, and splayed to 6 inch x 1½ inch ridge board. Brace with 3 inch x 1½ inch battens, two to each end, well spliced to underside of rafters, ridge and wall plates. Batten for iron with 3 inch x 1½ inch, spaced not more than 30 inch centre. Rafters spaced as indicated or plan. Collar ties to be scarfed and bolted to rafters with ¾-inch bolts. Tie beams where indicated to be 6 inches round or 6 inch x 3 inch sawn, set into, and bolted to post heads as indicated on drawing. Over each fix struts of 4 inches and 3 inches to collar, tie and rafters, and spike to same.

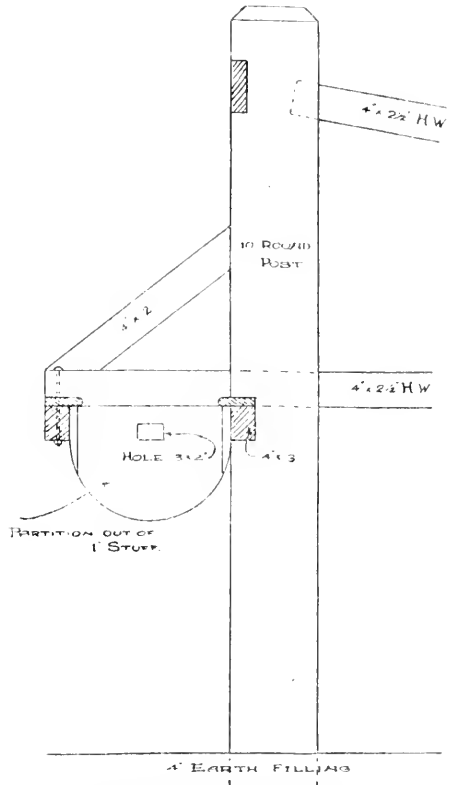
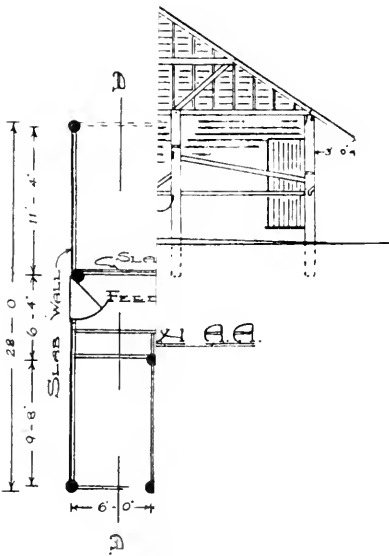
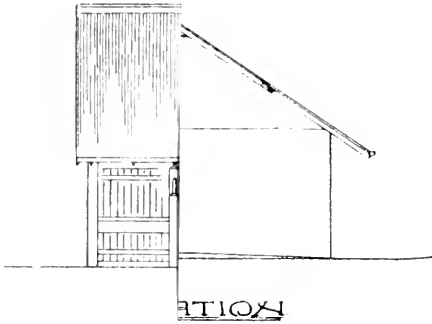
Walls.—Scarf out top of posts and secure with ½-inch cup head bolts and nuts, one to each post, 6 inch x 3 inch top plates to outer walls of stalls and implement shed. To gable and back wall of implement shed, fix to posts as indicated 4 inch x 3 inch rails, and cover same with vertical slabs, 8 inch x 1½ inch, close jointed and double spiked to rails. Walls of harness and food rooms to be constructed with 4 inch x 2 inch common studs spaced at 18 inch centres, set ⅝ inch deep into 4 inch x 4 inch bottom and 4 inch x 2 inch top plates, 4 inch x 4 inch corner studs, braced at angles with 3 inch x 1½ inch battens, halved and sunk flush in outer face, and covered with 6 inch x 1 inch rusticated weatherboards finishing against 3 inch x 1½ inch batten fillets, on corner studs and ¾ inch wrought and headed stops to doors and windows.

Trim for doors and windows as required. Fill in gables of roof with 4 inch x 2 inch studs spaced as before specified for walls, and cover with weatherboards cut close to underside of iron, and lapping over top ends of slabs.

Partition between two rooms to be covered with weatherboards on harness-room side up to top plate. In two rooms, weatherboards between feet of rafters to be cut to fit close to iron.

SHED. ETC.

ITH



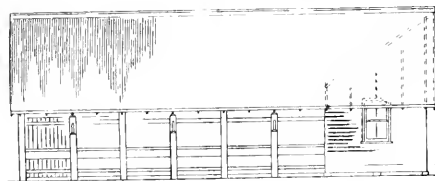
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To face page 13 Rural Nursery.

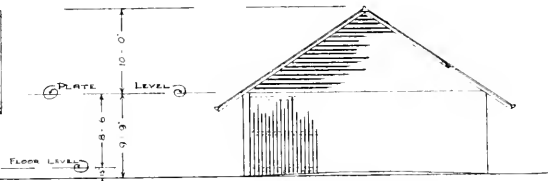
PLAN OF STABLES. IMPLEMENT SHED. ETC.

GRIFFITH

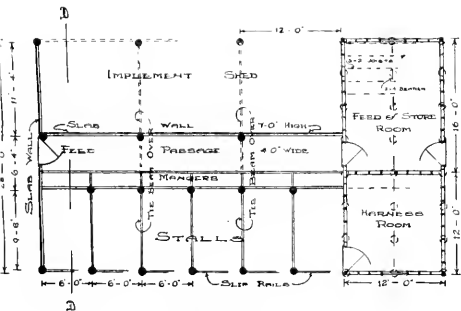
SCALE $\frac{1}{8}$ " = ONE FOOT



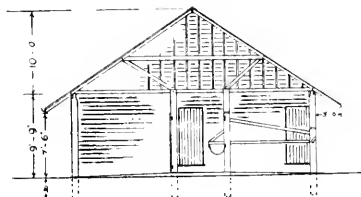
ELEVATION



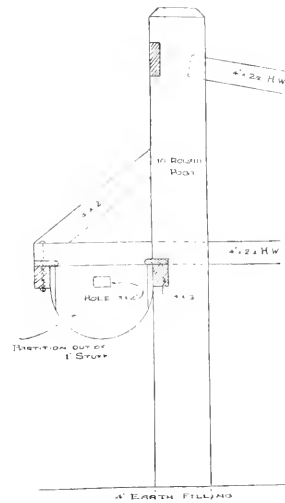
END ELEVATION



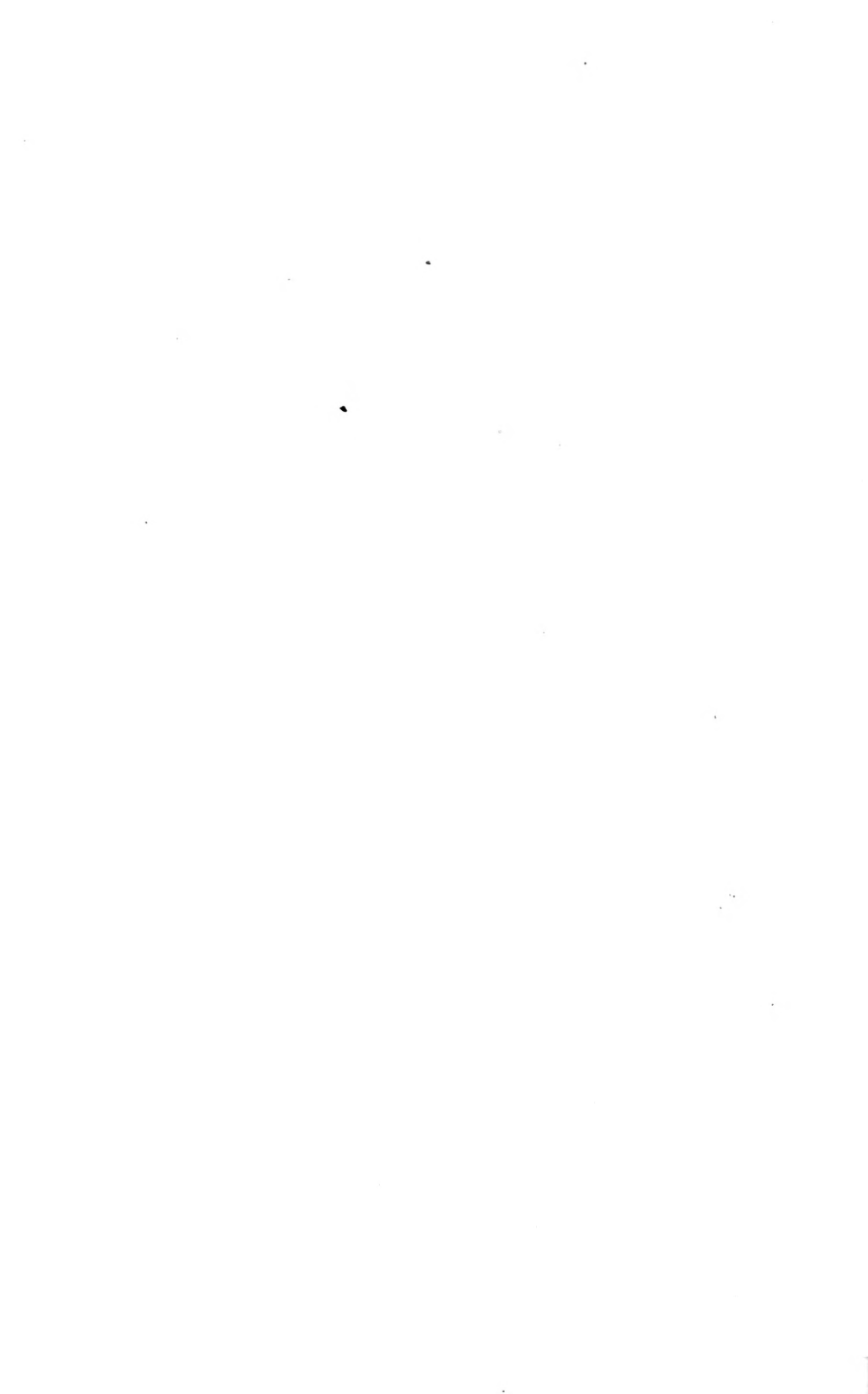
PLAN

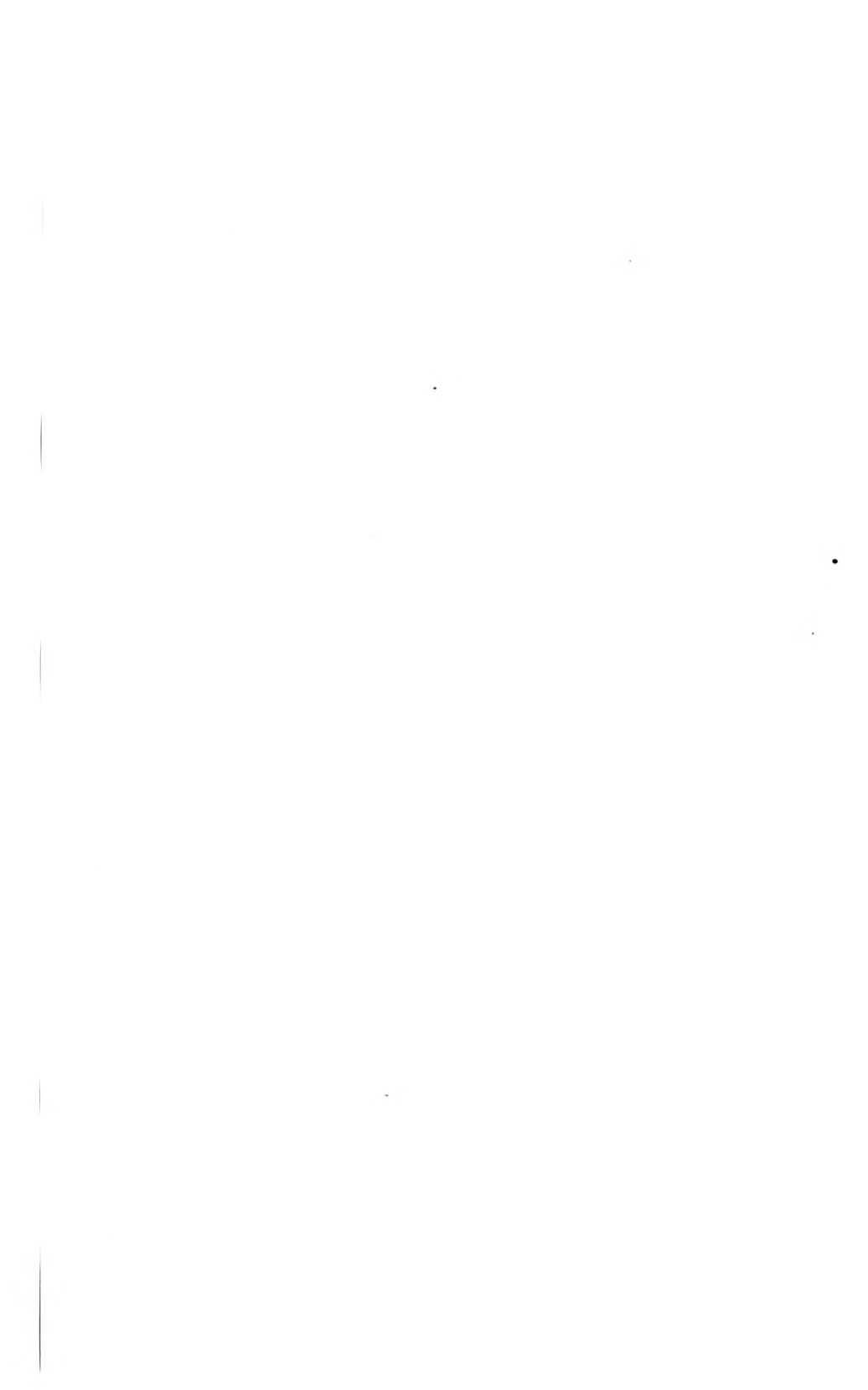


SECTION B-B



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SHED & STABLES

GOVT VETERINARY STATION

GLENFIELD

SCALE 3 FEET TO 5/8 INCH

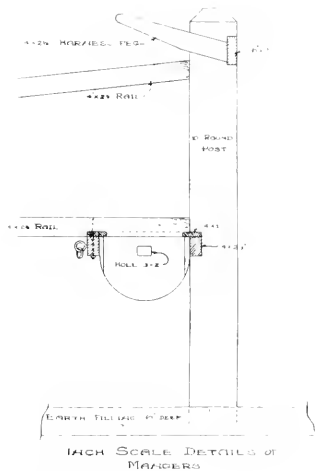
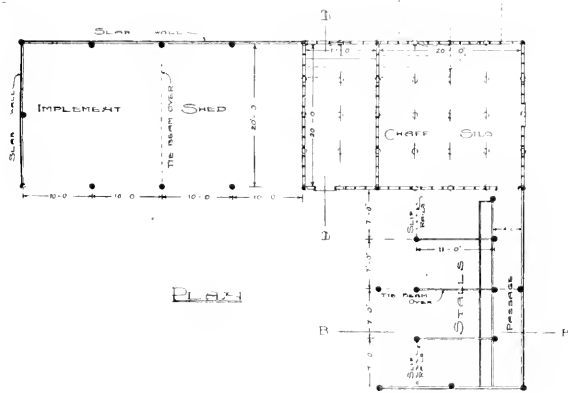
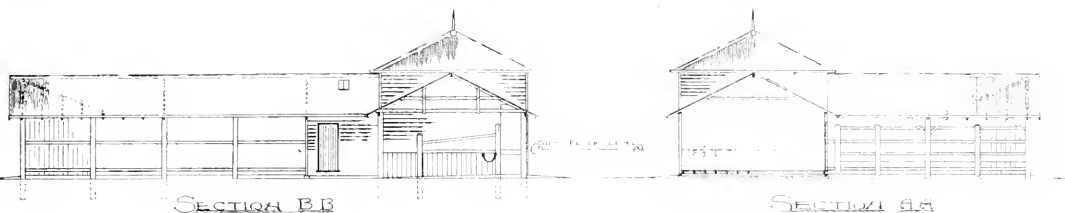


FIG. 7. Plan of Combined Stables (four stalls), Implement Shed and Chaff Silo, erected at Glenfield Veterinary Station.

Floors.—Floors of two rooms to be of 5 inch x 2 inch joists, spiked to 5 inch x 4 inch centre bearer and bottom plates, spaced as indicated, and covered with 4 inch x 1 inch tongued and grooved flooring, cut to fit close around studs and up to weather-boards, double nailed, punched, and flushed off at the joints.

Stalls.—Construct stalls with 10-inch diameter head and heel posts, trimmed on top as shown, 4 inch x 2½ inch hardwood sawn rails, set into posts, the lower rail to run through to carry manger as shown. Provide continuous 6 inch x 2 inch name-plate on outside of head-posts. Construct mangers (continuous) with 4 inch x 3 inch rails x 1 inch wrought capping, 4 inch x 2 inch stays, outer rail to be bolted to lower division rails with ½-inch bolts as shown.

Provide to each manger 1-inch division board of colonial pine, sliding-in fillets, as indicated in detail.

Provide to each stall 3 inch x 2 inch hardwood slip-rail, notched into posts as indicated on section AA.

Mangers to be of 24-gauge plain galvanised iron, fixed between rails with cone-headed galvanised screws.

Harness Fittings.—Provide and fix approved harness pegs, one to each stall, and six in each harness room of ¾-inch galvanised pipe 15 inches long, fixed as directed; also three saddle racks of 4 inch x 2 inch, with 4 inch x ¾ inch top board, well secured to wall studs in harness room.

Doors.—Provide and swing to studs (4) ledged and braced doors, 6 feet 8 inches x 2 feet 8 inches x 1 inch, made of 6 inch x 1 inch ledges, 4 inch x 1 inch braces and 4 inch x 1 inch tongued and grooved and V-jointed Dorrigo pine, wrought both sides, hinged with 14-inch japanned T hinges and secured with approved 6-inch rim lock and M.E. brass furniture.

Fit to each opening ¾-inch beaded stops of the required widths. Put noosed sills to each of 6 inches x 3 inches.

Windows.—Between studs, and over 2½-inch sloping sills, fit in 2 pairs of 5 feet 1½ inch x 2 feet 10 inch x 1½ inch light pine sashes, glazed with 21 oz. glass, and fitted with sash prop and fastener of approved pattern, stops to be fitted as for doors.

PLUMBER.

Cover the whole of the roof with 26-gauge galvanised corrugated iron, secured to battens with 1½-inch galvanised screws and lead washers as may be directed, sheets to have 1½ laps at sides and 6 inches at ends. Finish at gables with neat 2-inch rolls.

To eaves, provide and fix 5-inch quarter round guttering, 24-gauge, secured with stout galvanised brackets and top straps (one to each rafter), and lapped, riveted, and soldered on both sides at all joints. Provide and fix 2 stacks of 3-inch down-pipe, secured with straps, and fitted with proper shoes to deliver on the ground.

Cover ridge with 16 inch 26-gauge ridge capping, secured with screws to every fourth corrugation, and box in ends at gable.

PAINTER.

With best white lead and linseed oil paint in colours as will be directed (paint three coats) the whole of the external face of gable weatherboards and rafters, and one side and two ends of harness and feed rooms, also both sides of doors and windows. Paint in three coats with red oxide in oil the slabs on gable wall and the weatherboards on the stall and shed side of two rooms.

The implement shed in this plan could, with convenience, be increased in width so as to take a double row of implements.

A Four-stalled Stable and Implement Shed. (Fig. 7.)

The structure in this case is of a different type, being in the shape of an L with the chaff silo at the angle, instead of the whole being under one roof as in the foregoing plan. Only four horse stalls are provided for, but this could be increased as desired.

Any specifications in this case would be so similar to those for the previous plan that it is considered unnecessary to give them here.

Floors.—Floors of two rooms to be of 5 inch x 2 inch joists, spiked to 5 inch x 4 inch centre bearer and bottom plates, spaced as indicated, and covered with 4 inch x 1 inch tongued and grooved flooring, cut to fit close around studs and up to weatherboards, double nailed, punched, and flushed off at the joints.

Stalls.—Construct stalls with 10-inch diameter head and heel posts, trimmed on top as shown, 4 inch x 2½ inch hardwood sawn rails, set into posts, the lower rail to run through to carry manger as shown. Provide continuous 6 inch x 2 inch name-plate on outside of head-posts. Construct mangers (continuous) with 4 inch x 3 inch rails x 1 inch wrought capping, 4 inch x 2 inch stays, outer rail to be bolted to lower division rails with ½-inch bolts as shown.

Provide to each manger 1-inch division board of colonial pine, sliding-in fillets, as indicated in detail.

Provide to each stall 3 inch x 2 inch hardwood slip-rail, notched into posts as indicated on section AA.

Mangers to be of 24-gauge plain galvanised iron, fixed between rails with cone-headed galvanised screws.

Harness Fittings.—Provide and fix approved harness pegs, one to each stall, and six in each harness room of ¾-inch galvanised pipe 15 inches long, fixed as directed; also three saddle racks of 4 inch x 2 inch, with 4 inch x ¾ inch top board, well secured to wall studs in harness room.

Doors.—Provide and swing to studs (4) ledged and braced doors, 6 feet 8 inches x 2 feet 8 inches x 1 inch, made of 6 inch x 1 inch ledges, 4 inch x 1 inch braces and 4 inch x 1 inch tongued and grooved and V-jointed Dorrigo pine, wrought both sides, hinged with 14-inch japanned T hinges and secured with approved 6-inch rim lock and M.E. brass furniture.

Fit to each opening ¾-inch beaded stops of the required widths. Put noosed sills to each of 6 inches x 3 inches.

Windows.—Between studs, and over 2½-inch sloping sills, fit in 2 pairs of 5 feet 1½ inch x 2 feet 10 inch x 1½ inch light pine sashes, glazed with 21 oz. glass, and fitted with sash prop and fastener of approved pattern, stops to be fitted as for doors.

PLUMBER.

Cover the whole of the roof with 26-gauge galvanised corrugated iron, secured to battens with 1½-inch galvanised screws and lead washers as may be directed, sheets to have 1½ laps at sides and 6 inches at ends. Finish at gables with neat 2-inch rolls.

To eaves, provide and fix 5-inch quarter round guttering, 24-gauge, secured with stont galvanised brackets and top straps (one to each rafter), and lapped, riveted, and soldered on both sides at all joints. Provide and fix 2 stacks of 3-inch down-pipe, secured with straps, and fitted with proper shoes to deliver on the ground.

Cover ridge with 16 inch 26-gauge ridge capping, secured with screws to every fourth corrugation, and box in ends at gable.

PAINTER.

With best white lead and linseed oil paint in colours as will be directed (paint three coats) the whole of the external face of gable weatherboards and rafters, and one side and two ends of harness and feed rooms, also both sides of doors and windows. Paint in three coats with red oxide in oil the slabs on gable wall and the weatherboards on the stall and shed side of two rooms.

The implement shed in this plan could, with convenience, be increased in width so as to take a double row of implements.

A Four-stalled Stable and Implement Shed. (Fig. 7.)

The structure in this case is of a different type, being in the shape of an L with the chaff silo at the angle, instead of the whole being under one roof as in the foregoing plan. Only four horse stalls are provided for, but this could be increased as desired.

Any specifications in this case would be so similar to those for the previous plan that it is considered unnecessary to give them here.

Stables for Thirty Horses. (Figs. 8 and 9.)

The plan given in this case is likely to be of use on a large farm which employs a number of teams. It is the plan actually adopted for Trangie Experiment Farm, being erected while the present Chief Inspector of Agriculture, Mr. A. H. E. McDonald, was manager there, and it has proved a most satisfactory building to work. The specifications follow:—

Timber.—Cypress pine will be used throughout for all framing, and Oregon and Colonial pine will be used for doors, shutters, linings, &c. Round posts are to be trimmed as may be directed and carefully selected for their respective positions. All exposed corners of timbers throughout the whole building to be neatly arised off before fixing.

Floor Levels.—The finished level of all floors (except silo) to be 4 inches above the highest point of the site, and the filling in must extend to a line 5 feet beyond the building all round.

Foundations.—Under walls of chaff silo, grain bin, and harness room set round blocks 2 feet into the ground, and to the height shown on section to take 5-inch x 4-inch bottom plates, set on edge and spiked to blocks. All posts to be set into the ground to the depths shown, those where so indicated to be fitted with sole plates of 6 inch x 3 inch strutted with 4 inch x 2½ inch, set solid on ground.

Walls.—Where so indicated on plan, outer walls of stable and implement shed to be closed in with 8-inch x 1½-inch sawn slabs, fixed to top rail 6-inch x 2½-inch, and two others of 4 inch x 2½ inch, the bottom ends to be cut to a line on finished floor level. Note, the rails to be supported up to a straight line while slabs are being nailed on.

All slabs are to be closely jointed together, and scribed to round posts wherever necessary.

Silo grain bin and harness room walls to be of 5-inch x 2½-inch studding and top plates, with 5-inch x 5-inch corner studs, framed up as indicated on drawing, braced with 3-inch x 2-inch halved and sunk flush in outer face, trimmed for doors, &c., as required, and covered with rusticated weatherboard, nailed close together, and finishing against 3-inch x 1½-inch angle stops wrot for painting. All studding to be at 18-inch centres, the ends tenoned through and housed ¾-inch deep into plates, and securely spiked through plates.

Continue gable of harness room up to roof iron with 4-inch x 2-inch studding and cover with weatherboards as specified for walls.

On foundation blocks under harness room floor, fix part sheets of galvanised iron set into the soil to retain filling in, and punch ventilation holes in as will be directed.

For break in floor level from silo to harness room, trim off face of blocks to line with wall studs, and set 5-inch x 4-inch bottom plate in between to carry harness room joists, filling in short studding between the plates as required.

Under top plates where indicated, set in struts, scarfed and bolted or housed in and spiked to plates and posts as shown on plans.

Stall Divisions.—Construct as shown on plans, with two 4-inch x 2½-inch rails, both ends set into the posts not less than 3 inches deep, the top rail flat rounded off on top edge, and corners neatly arised off.

Tops of alternate heel and head posts to be neatly pointed off as indicated finished for painting. To head posts where shown scarf into and spike to posts 6-inch x 2½-inch head rail as shown on detail of mangers.

Mangers.—These to be continuous of plain galvanised iron, curved as shown, and fixed at edges between 5-inch x 2½-inch rails, with capping, and division fillets as indicated on detail. Divisions to each to be of 1-inch Colonial pine boards, cut to shape and fixed under each lower dividing rail, the manger iron to be secured to same with cone-headed screws. To each manger fix head stall ring and bolt.

Harness Fittings.—To each stall, make and fix as will be directed, two collar pegs of 4-inch x 1½-inch hardwood firmly set into rail over head posts, or to heel posts as may be directed. In harness room fit up twelve similar pegs, also ten cart saddle brackets, made of 4-inch x 2-inch frame and 4-inch x ¾-inch cover boards, all wrot and neatly finished.

Roof.—Construct the roofs as shown on plans. To stables (main roof) and implement shed, put 5-inch x 2½-inch rafters at 2-feet 10-inch centres with 4-inch x 2-inch and 4-inch by 2½-inch collar ties respectively scarfed and bolted with ¾-inch bolt nut and

PLAN OF STABLES & IMPLEMENT SHED

EXPT. FROM TRIANGLE

SCALE 5 FEET TO AN INCH

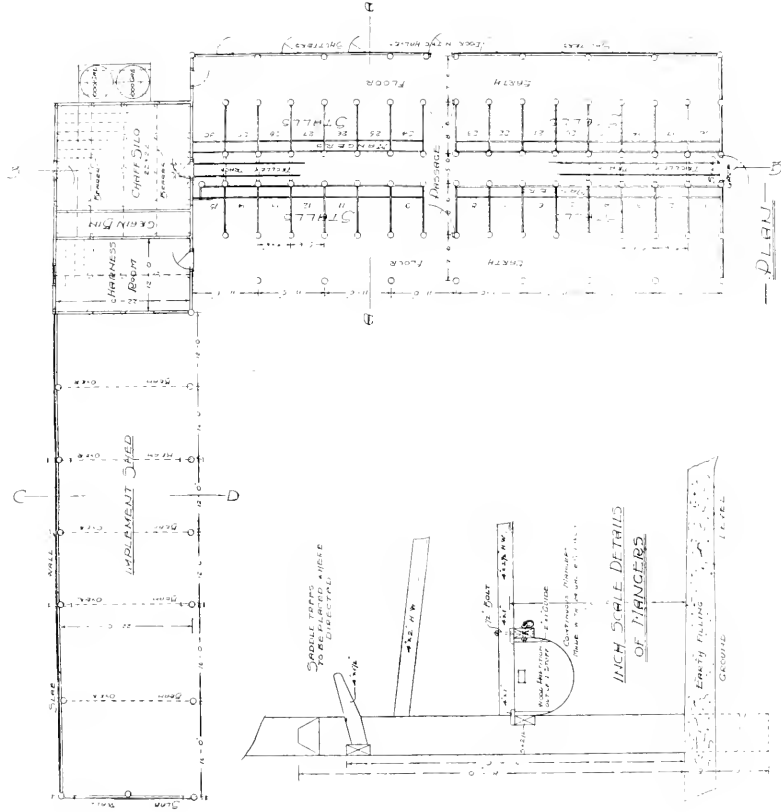


Fig. 8. Plan of Combined Stable (thirty stalls), Implement Shed, &c., erected at Triangle Experiment Farm.



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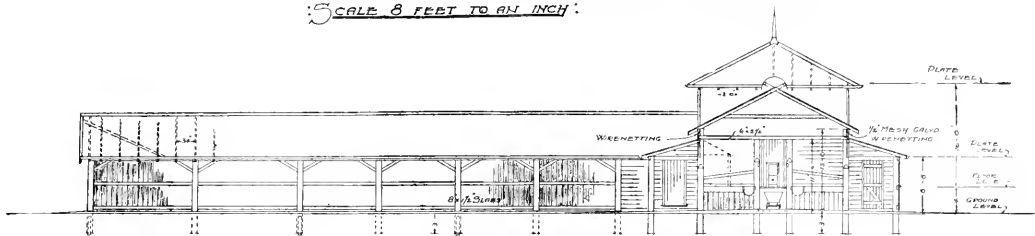
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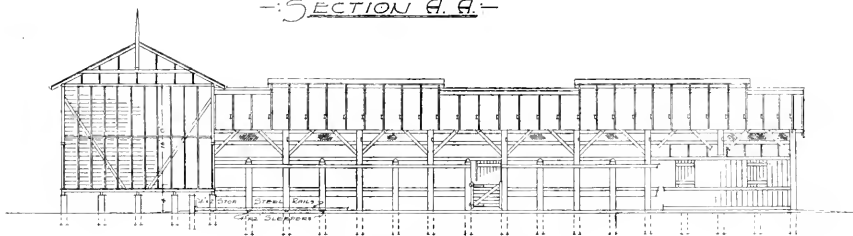
: PLAN OF STABLES & IMPLEMENT SHED :

EXPT. FARM, TRANGIE :

SCALE 8 FEET TO AN INCH :

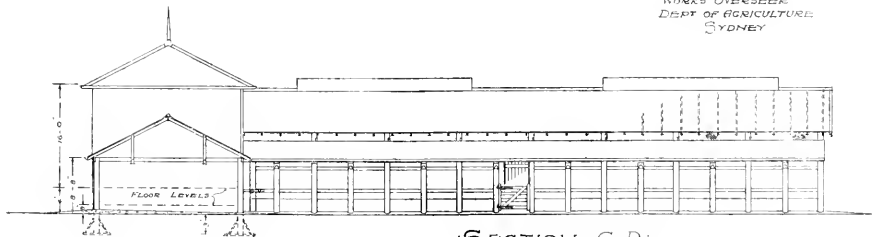


- SECTION A. A. -



- SECTION B. B. -

G. BROOKS
WORKS OVERSEER
DEPT. OF AGRICULTURE
SYDNEY



- SECTION C. C. -

washer to each end. To verandahs of stable put 4-inch x $2\frac{1}{2}$ -inch rafters, notched over 6-inch x $2\frac{1}{2}$ -inch top wall plates and splayed to top plate as indicated on drawing. All feet of rafters to be neatly cut to plumb and arrised off before fixing.

Roof over silo to be of 4-inch x $2\frac{1}{2}$ -inch rafters, 8-inch x $1\frac{1}{2}$ -inch hip boards with collar ties as may be directed also trim and fix 5-inch x 5-inch final pointed away as shown, set into sole plate on collar ties.

Gables to have one pair of projecting rafters, finishing with roll on iron and $1\frac{1}{2}$ -inch quarter round or square fillet under. Ridge of stable roof to have vent constructed as indicated with crossed, halved and bolted rafters, and 4-inch x 2-inch plates notched and spiked on to take curved iron, which is to be enclosed at each end. The ridge boards beyond to be 8 inches x $1\frac{1}{2}$ inch.

If roof covering is galvanised iron 3-inch x $1\frac{1}{2}$ -inch battens to be nailed on at 30-inch centres secured with 4-inch and 3-inch nails.

If covered with Malthoid, the whole roof to be sheeted with 6-inch x $\frac{3}{4}$ -inch boarding double nailed to each rafter.

Gable ends of roof to be studded up, and covered with weatherboards as specified for walls.

Brace and stay roof as may be directed with 3-inch x $1\frac{1}{2}$ -inch or 3-inch x 2-inch from ridge to top plates, scarfed and spiked as required.

To implement shed roof put Oregon tie beams 7-inch x $2\frac{1}{2}$ -inch notched $\frac{3}{4}$ -inch down on to top plates and bolted to rafter feet, also put 4-inch x 2-inch hangers as indicated on section of drawing.

Feed Truck and Track.—Construct hopper-shaped feed truck 5 feet x 2 feet 6 inches x 21 inches deep inside, made of 6-inch x 1-inch tongued and grooved boards ledged all round on outside and with 3-inch angle fillets on inside corners, set on 4-inch x $2\frac{1}{2}$ -inch frame and mounted on 8-inch flanged wheels, running on light iron or 3-inch x $2\frac{1}{2}$ -inch hardwood rails set on 4-inch x $2\frac{1}{2}$ -inch sleepers as indicated on drawing. Fix track for truck as indicated. The whole to be wrot and neatly finished for painting and to run under silo floor to stop block as shown.

Doors, Shutters, and Gates.—To silo, harness room, grain bin, and stables, make and hang to posts or studs, with hinges as provided, ledged and braced doors, the stable doors to be in two parts as shown. To upper door in silo fix weatherboard on bottom to throw rain off to platform. Provide and fix stops to each as may be directed.

Sills to be fixed to all outer doors, rooms, and stables as will be directed. All shutters to be similarly made and hinged where shown on plans. Sheeting of all doors and shutters to be 6-inch x 1-inch tongued, grooved and bevelled both sides, on 7-inch x $1\frac{1}{2}$ -inch ledges and 4-inch x $1\frac{1}{4}$ -inch braces, all wrot and put together as will be directed.

To passage through stalls make and hinge light pine gates of 3-inch x 2-inch Oregon frame, with 3-inch x 1-inch pickets (not as shown) hinged with T hinges and fitted with spiral springs to hanging styles.

Windows.—To grain bin and harness room fit up stock size sashes 5 feet $1\frac{1}{2}$ inches x 2 feet 10 inches, to slide between studs, set on 2 feet sloping sills and to have outer stops finishing to weatherboards and inside stop beads and parting slips, fastener to each pair.

Flooring.—To silo grain bin, and harness room set 5-inch x $2\frac{1}{2}$ -inch joists at 18-inch centres on 5-inch x 4-inch bearers, securely spiked at ends, and cover same with 4-inch x 1-inch tongued and grooved closely cramped flooring, double nailed, punched and flushed off at joints.

All flooring to be cut close up to weatherboards.

To each door set 7-inch x $2\frac{1}{2}$ -inch sill, rounded on nosing edge and projecting $1\frac{1}{2}$ inches.

Tank Stands.—Construct stand for two 1,000-gallon tanks as indicated with $4\frac{1}{2}$ -inch brick walls on 9-inch footings, set in cement mortar, with 4-inch x 3-inch plates bedded to take 2-inch thick decking, all set as continuous, for the two tanks.

PLUMBER.

Fix to all eaves where shown 5-inch guttering on bracket and top stay to each rafter, the joints to be riveted and soldered, and outlets to down pipes provided. Fix to ridges and hips 16-inch capping, screwed to battens as may be directed. To ridge over stable fix curved iron, trimmed on edges and screwed to plates bolted where necessary at lap joints.

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Roof over silo to be of 4-inch x 2½-inch rafters, 8-inch x 1½-inch hip boards with collar ties as may be directed also trim and fix 5-inch x 5-inch final pointed away as shown, set into sole plate on collar ties.

Gables to have one pair of projecting rafters, finishing with roll on iron and 1½-inch quarter round or square fillet under. Ridge of stable roof to have vent constructed as indicated with crossed, halved and bolted rafters, and 4-inch x 2-inch plates notched and spiked on to take curved iron, which is to be enclosed at each end. The ridge boards beyond to be 8 inches x 1½ inch.

If roof covering is galvanised iron 3-inch x 1½-inch battens to be nailed on at 30-inch centres secured with 4-inch and 3-inch nails.

If covered with Malthoid, the whole roof to be sheeted with 6-inch x ¾-inch boarding double nailed to each rafter.

Gable ends of roof to be studded up, and covered with weatherboards as specified for walls.

Braze and stay roof as may be directed with 3-inch x 1½-inch or 3-inch x 2-inch from ridge to top plates, scarfed and spiked as required.

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Feed Truck and Track.—Construct hopper-shaped feed truck 5 feet x 2 feet 6 inches x 21 inches deep inside, made of 6-inch x 1-inch tongued and grooved boards ledged all round on outside and with 3-inch angle fillets on inside corners, set on 4-inch x 2½-inch frame and mounted on 8-inch flanged wheels, running on light iron or 3-inch x 2-inch hardwood rails set on 4-inch x 2½-inch sleepers as indicated on drawing. Fix track for truck as indicated. The whole to be wrot and neatly finished for painting and to run under silo floor to stop block as shown.

Doors, Shutters, and Gates.—To silo, harness room, grain bin, and stables, make and hang to posts or studs, with hinges as provided, ledged and braced doors, the stable doors to be in two parts as shown. To upper door in silo fix weatherboard on bottom to throw rain off to platform. Provide and fix stops to each as may be directed.

Sills to be fixed to all outer doors, rooms, and stables as will be directed. All shutters to be similarly made and hinged where shown on plans. Sheeting of all doors and shutters to be 6-inch x 1-inch tongued, grooved and bevelled both sides, on 7-inch x 1½-inch ledges and 4-inch x 1¼-inch braces, all wrot and put together as will be directed.

To passage through stalls make and hinge light pine gates of 3-inch x 2-inch Oregon frame, with 3-inch x 1-inch pickets (not as shown) hinged with T hinges and fitted with spiral springs to hanging styles.

Windows.—To grain bin and harness room fit up stock size sashes 5 feet 1½ inches x 2 feet 10 inches, to slide between studs, set on 2 feet sloping sills and to have outer stops finishing to weatherboards and inside stop beads and parting slips, fastener to each pair.

Flooring.—To silo grain bin, and harness room set 5-inch x 2½-inch joists at 18-inch centres on 5-inch x 4-inch bearers, securely spiked at ends, and cover same with 4-inch x 1-inch tongued and grooved closely cramped flooring, double nailed, punched and flushed off at joints.

All flooring to be cut close up to weatherboards.

To each door set 7-inch x 2½-inch sill, rounded on nosing edge and projecting 1½ inches.

Tank Stands.—Construct stand for two 1,000-gallon tanks as indicated with 4½-inch brick walls on 9-inch footings, set in cement mortar, with 4-inch x 3-inch plates bedded to take 2-inch thick decking, all set as continuous, for the two tanks.

PLUMBER.

Fix to all eaves where shown 5-inch guttering on bracket and top stay to each rafter, the joints to be riveted and soldered, and outlets to down pipes provided. Fix to ridges and hips 16-inch capping, screwed to battens as may be directed. To ridge over stable fix curved iron, trimmed on edges and screwed to plates bolted where necessary at lap joints.

To gables against silo provide flashing by turning up the roof covering 6 inches against the studs under the weatherboards. To finish on chaff silo roof fix lead flashing, properly dressed into chasing around finial and 8 inches down on to roof. Fix down-pipes to conduct water to the two tanks where shown. Flash where necessary over exposed doors and windows, with either plain iron or lead as may be required.

Roof, if covered with iron, to have all sheets fixed with screws and washers, properly put in, and as may be directed to each sheet. The iron to be closely fitted to ridge and hip boards, the hollows turned up if necessary. All to be fixed with $1\frac{1}{2}$ inches lap at sides and 6 inches at ends. If with Malthoid the required lengths to reach from eave to eave, to be cut off and laid over roof to stretch before fixing, then to be fixed with solution on the joints and nails at 3-inch centres, all as specified in manufacturers instructions issued with each roll of Malthoid. Set on prepared stand two tanks, and fit overflow to conduct water to the ground.

PAINTER.

All weatherboards and slabbing to have two coats of stain and oil as will be directed. All doors, shutters and sashes to be painted both sides with white lead and colour paint, three coats, and all barge rafters, rafter feet finial to be painted three coats, white paint.

An Economical Implement Shed. (Fig. 10.)

In this case, the design, which was prepared for Wagga Experiment Farm, provides for an implement shed of six open bays, constructed with round posts, and roofed with cypress pine frame and galvanised corrugated iron.

The specifications follow:—

Timber.—The timber throughout to be of first-class cypress pine, and spaced as indicated on the drawings.

Posts.—Posts to be of uniform shape not less than 9 inches diameter at small ends, spaced as indicated on drawings, set 3 feet into the ground and well rammed. To the six posts shown on plan, put 6-inch x 3-inch sole plates and 4-inch x 2-inch struts well spiked at joints and to posts. All timbers sunk into the ground to be first coated with a heavy coat of hot tar, the tar to be dried hard before the holes are filled in. Tops of posts to be scarfed out to take top plates and collar ties, holed for $\frac{1}{2}$ -inch bolts.

Roof.—Construct roof with 7-inch x 3-inch wall plates, secured to posts with $\frac{1}{2}$ -inch cup head bolts and nuts, 4-inch x 3-inch struts under, toed into plates and to posts, 5-inch x 2-inch rafters, birdmouthed over plates and cut and spiked to 8-inch x $1\frac{1}{4}$ -inch ridge board, 5-inch x 2-inch collar ties scarfed $\frac{3}{4}$ inch on to alternate pairs of rafters, 4-inch x 2-inch braces to collar ties, also 4-inch x 3-inch centre piece supporting ridge board from centre posts, all bolted together with $\frac{3}{8}$ -inch cup head bolts through crossings and top of centre posts. Brace ends of roof on all sides with 2-inch x $1\frac{1}{4}$ -inch diagonal braces spiked to under side of rafters.

Walls.—Enclose each end of shed, including gables, with 4-inch x 2-inch studs at 18 inch centres, shouldered $\frac{3}{8}$ inch, and tenoned 2 inches into 4-inch x 4-inch bottom plate and 4-inch x 3-inch plate. Bottom plates to be supported with 9-inch diameter wood blocks set 18 inches into the ground. Brace studs, with 3-inch x $1\frac{1}{2}$ -inch diagonal braces halved and sunk flush, or $1\frac{1}{4}$ -inch x 16-gauge galvanised hoop iron, nailed to each stud. Line over studs with 6-inch x 1-inch rusticated weatherboards neatly cut against posts and double nailed on each stud.

Guttering.—Provide and fix to eaves on strong long-tailed galvanised iron brackets (one to each rafter) 5-inch quarter round 24-gauge galvanised iron gutters with lapped, rivvted, and soldered joints and the necessary stop ends.

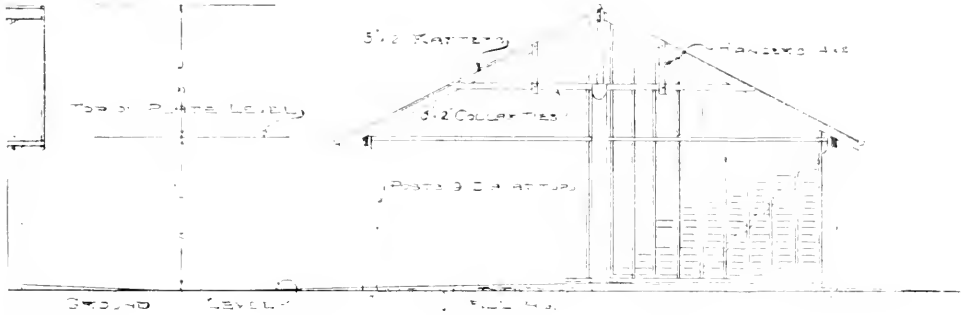
Down Pipes.—To each end of guttering fix 3-inch 24-gauge galvanised iron down pipes, securely strapped to posts and provided with shoes to discharge on to the ground where directed.

Roof Iron.—Cover the whole of the roof with 26-gauge galvanised corrugated iron fixed to 3-inch by $1\frac{1}{2}$ -inch battens with $1\frac{3}{8}$ -inch galvanised screws and lead washers, four to each batten in each sheet. To have $1\frac{1}{2}$ corrugations lap at sides and 6-inch lap at ends. Finish with 2-inch roll over rafter at gable ends, and fix 3-inch by $1\frac{1}{2}$ -inch batten under rolls.

Ridge Capping.—Cover ridge with 16-inch 24-gauge galvanised ridge capping boxed in at gables, and screwed down at every fourth corrugation.

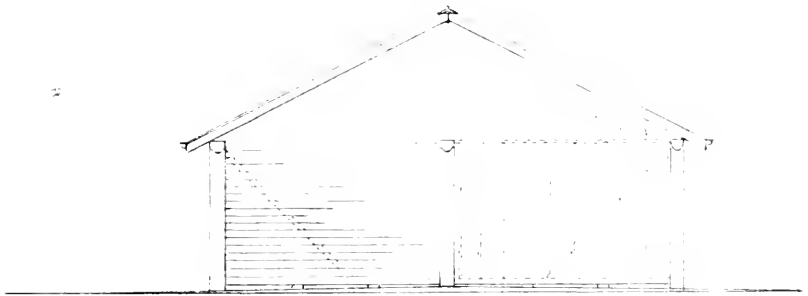
Painter.—With boiled linseed oil, and one-sixth part varnish added; paint with two coats all weatherboards to gable ends of building.

FARM



FRONT
PLATE

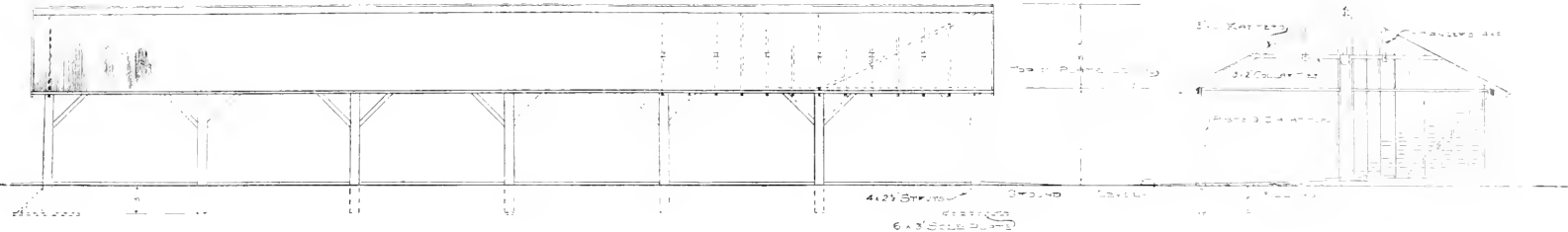
SECTION



FRONT ELEVATION

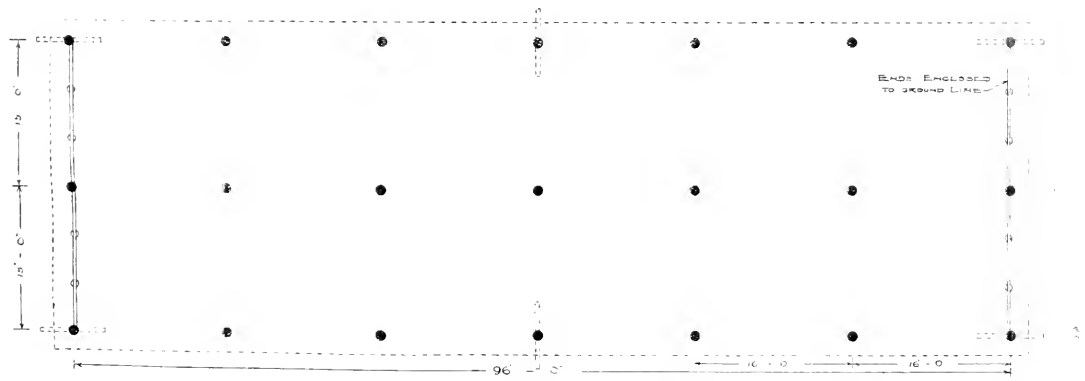
IMPLEMENT SHED FOR EXPT FARM WAGGA.

SCALE 1/8 INCH = ONE FOOT.



SIDE ELEVATION.

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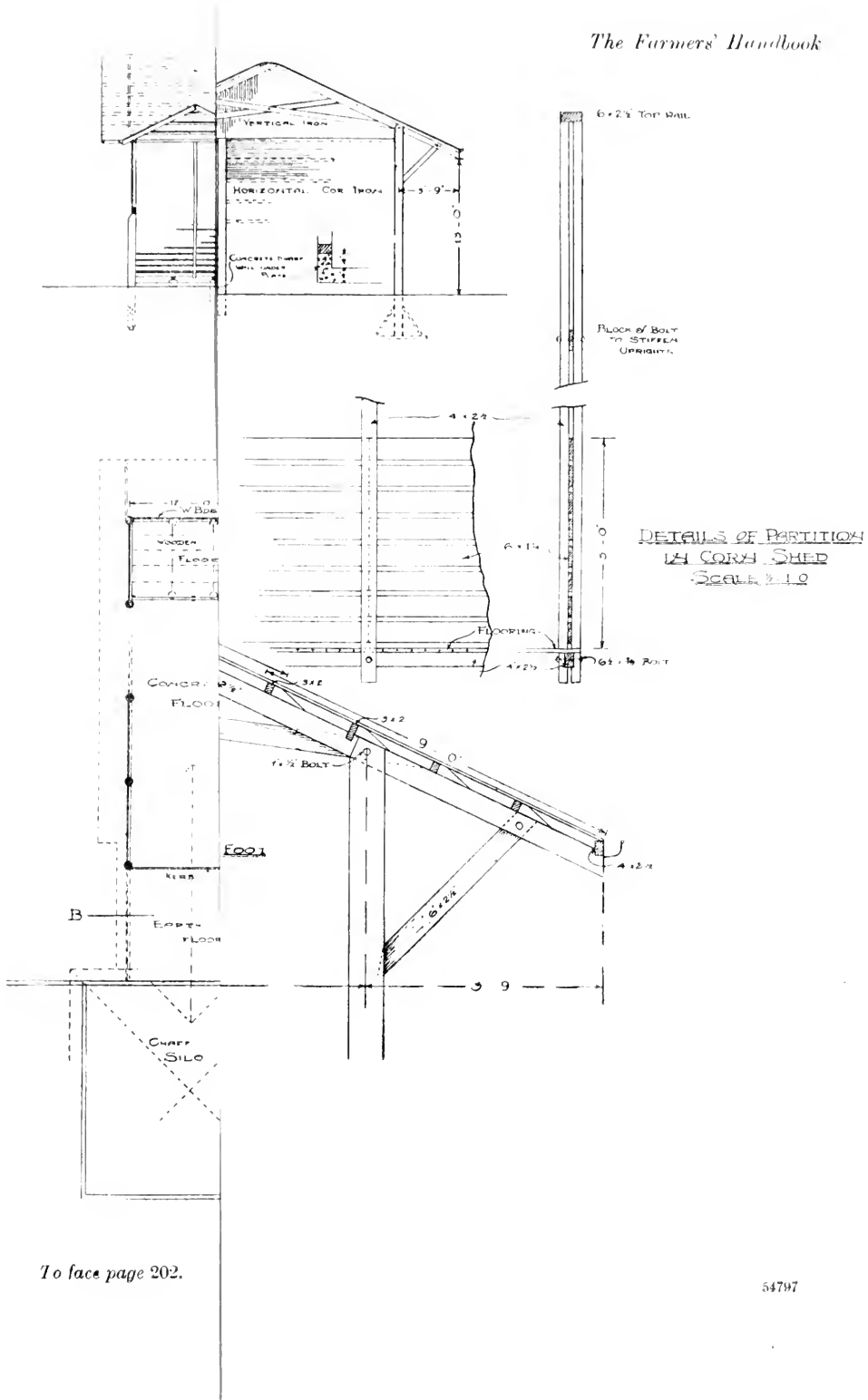


PLAN.

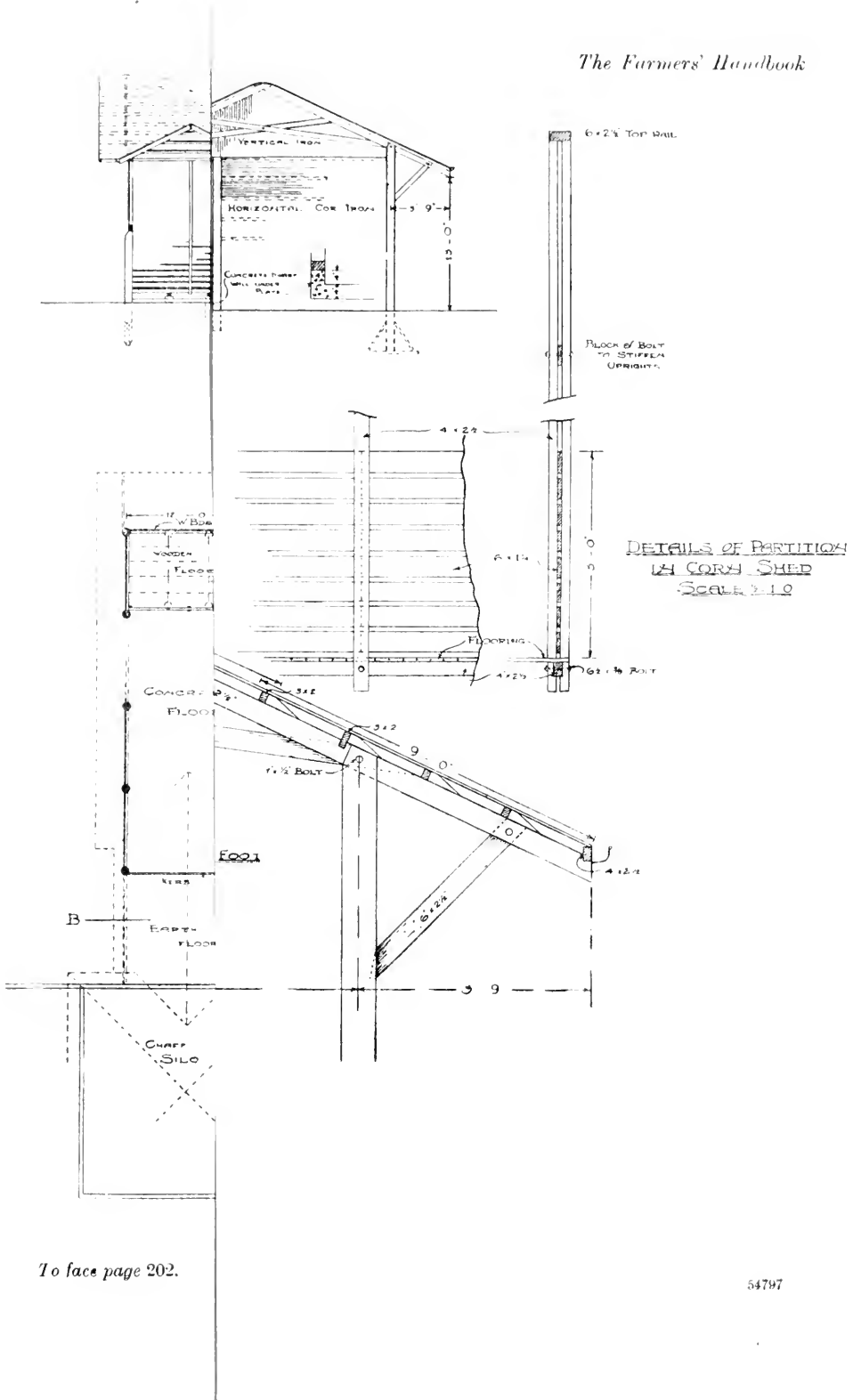


END ELEVATION

Fig. 10. Plan of an Implement Shed erected at Wagga Experiment Farm.



To face page 202.



To face page 202.

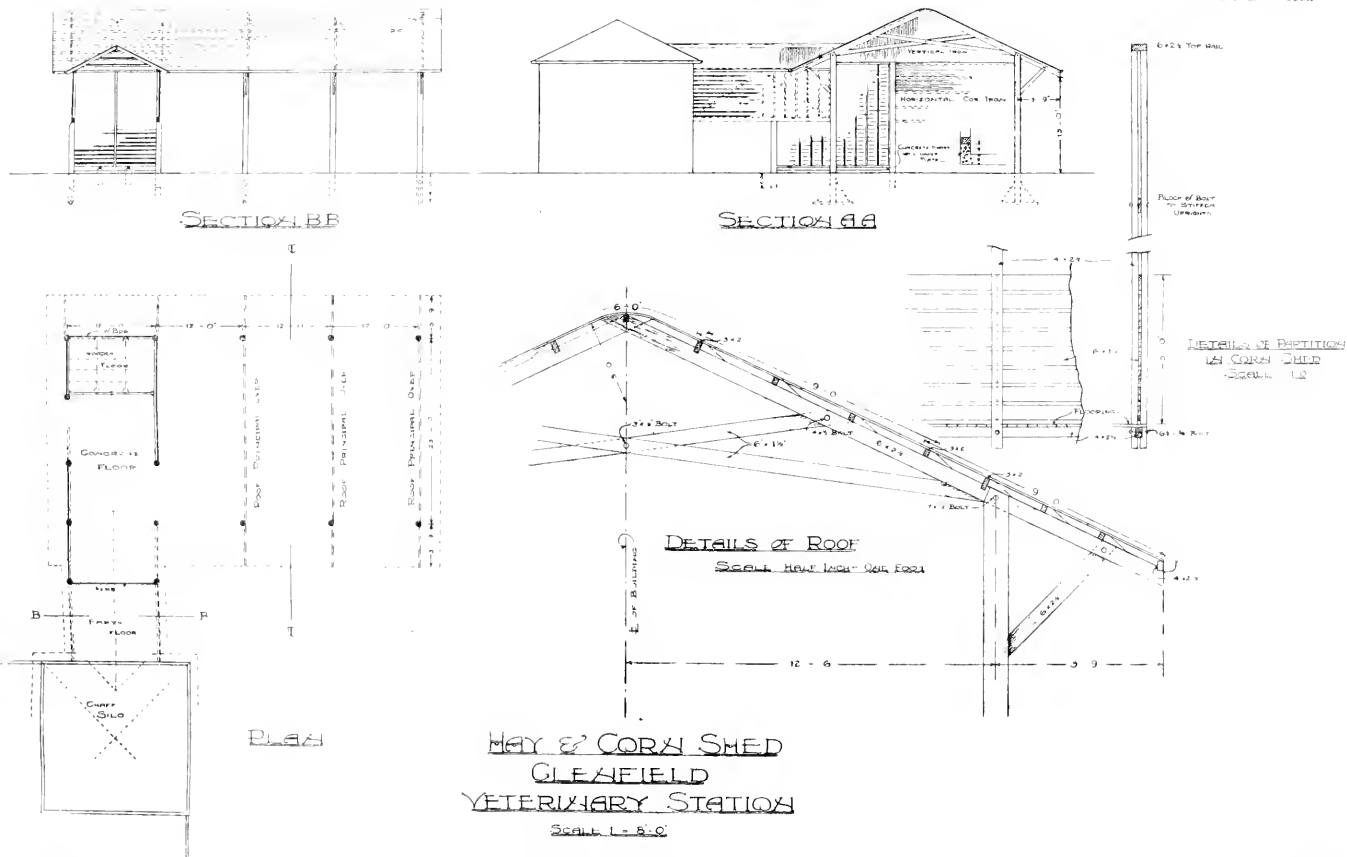


Fig. 11.—Plan of Hay and Corn Shed erected at Glenfield Veterinary Station.

Hay and Corn Shed. (Fig. 11.)

This was another shed that was designed for the new Glenfield Veterinary Station. The specifications for the job would be very similar to those for the stables, &c., at Griffith (page 198).

As a matter of fact, the building referred to in this plan (Fig. 11) comprises one block with that shown in Fig. 7, the whole having been arranged in that way to reduce the labour of cutting and distributing the feed to the horses, so that one man can manage the whole of the work.

A Small Shearing Shed. (Figs. 12 and 13.)

The shed (erected at Temora Experiment Farm) was designed on the L-shape principle. It is built on piles and has an elevation of 4 feet. The counting-out pens have an easterly aspect, so that the sheep shorn in the early morning may have the benefit of the sun. The ideal situation is on a slope, but where the ground is flat the building will require to be raised. When built on a slope, by making a slight excavation at the rear, the sheep may be got into the shed on the ground level. But in situations where the ground is flat, and the shed has to be built on piers, this will have to be done by the means of ramp. With a natural slope, the space covered by the boarded floor may be utilised as storage, whilst at the farthest point of the incline may be erected the loading stage. The sheep are got underneath through a gate, which is situated to the right of the loading-race and under the landing at the side entrance of the shed. The battens which comprise the floor space set apart for the sweating and catching-pens are set $\frac{5}{8}$ inch apart, and in order to ensure firmness of tread for the sheep, are constructed of pine laid alternately in widths of $3 \times 1\frac{1}{2}$ and $2 \times 1\frac{1}{2}$. Allowing 4 square feet per sheep as a fair basis, a shed of these dimensions would be capable of holding 275 sheep on the battens and, roughly, 310 underneath the floor space. Under anything like normal conditions with the number of shearers that the shed provides for, it would be possible therefore to complete the whole shearing without loss of time through wet weather.

It would be hardly worth any shearer's while to engage to shear under 1,000 sheep. This number has therefore been made the minimum basis in deciding the number of stands, and in working out proportionately the various appointments of the shed.

The main idea incorporated in the plan was to have the whole interior working of the shed immediately under notice. The wool tables and bins are placed in close proximity to the shearing-board. The press is handy so that from the corner of the shearing-board the combined operation of shearing, skirting, and classification of both fleeces and pieces, as well as pressing and branding of bales, come directly under observation. The fleece bins are built on the line with the shearing-board, thereby the floor space of the wool room is not encroached upon except for such work as entails the handling of fleeces, and which it should be reserved for. The wool table is placed immediately in front of the bins, and as the man engaged there can also undertake the classing of the wool as the fleeces are rolled, they may be at once placed in the bins.

The rolling-table has been made 12 feet long x 4 feet 3 inches wide. At it, all necks and fore parts of the fleece may be treated, while at the end, to the right, under the window, another small table, with bins on each side, is fixed, and where the breeches or posterior portions of the fleeces, on being

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The rolling-table has been made 12 feet long x 4 feet 3 inches wide. At it, all necks and fore parts of the fleece may be treated, while at the end, to the right, under the window, another small table, with bins on each side, is fixed, and where the breeches or posterior portions of the fleeces, on being

removed, may be also dealt with. With the work thus concentrated there should be no accumulation of "pieces," which is one of the chief drawbacks to the successful handling of wool, especially where proper conveniences have not been supplied.

The specifications which follow include also the specifications for the yards and dip connected with the building.

Materials.—All materials to be supplied by the contractor are to be of the best quality and description of their respective kinds and subject to the approval of the supervising officer.

Timber.—The whole of the timber, unless otherwise specified, to be of cypress pine; cut square to the full sizes specified, and sound in all respects. Oregon pine where specified to be free from shakes, large or loose knots, and clean sawn.

Walls.—Construct the walls with 4-inch x 4-inch corner, door and angle studs, 4-inch x 2½-inch common studs at 18-inch centres, tenoned and housed ⅜-inch into 5-inch x 4-inch bottom, and 4-inch x 2½-inch top plates, and well spiked braced at all angles, or where so directed with 3-inch x 1½-inch halved and sunk flush into outer face of studs.

Trim for all windows, doors, and other openings shown or specified all tenoned and housed at ends as for studs.

Bottom plates to be supported with wood blocks, spaced not more than 5-feet centres or less than 2 feet into the ground, corner, and intersection blocks not less than 12 inches diameter; others 9 inches at small end.

Line over all studs externally with 6-inch x 1-inch rusticated weatherboards fixed in long lengths, and finishing at angles to 3-inch x 1½-inch wrought stops, and to door and window linings.

Top boards to be cut to fit close round rafter feet, and up to iron or batten set in position to suit.

Roof.—Construct roof with 5-inch x 2½-inch rafters, fixed at 3-feet centres, birdsmouthed to wall plates, cut plumb at foot, and splayed against 8-inch x 1½-inch ridge board, or crossed and halved together, and have 4-inch x 2-inch pole plate fixed to ends of rafters to take curved iron ridging, as indicated. To each crossing put ⅜-inch bolt for nut and washer.

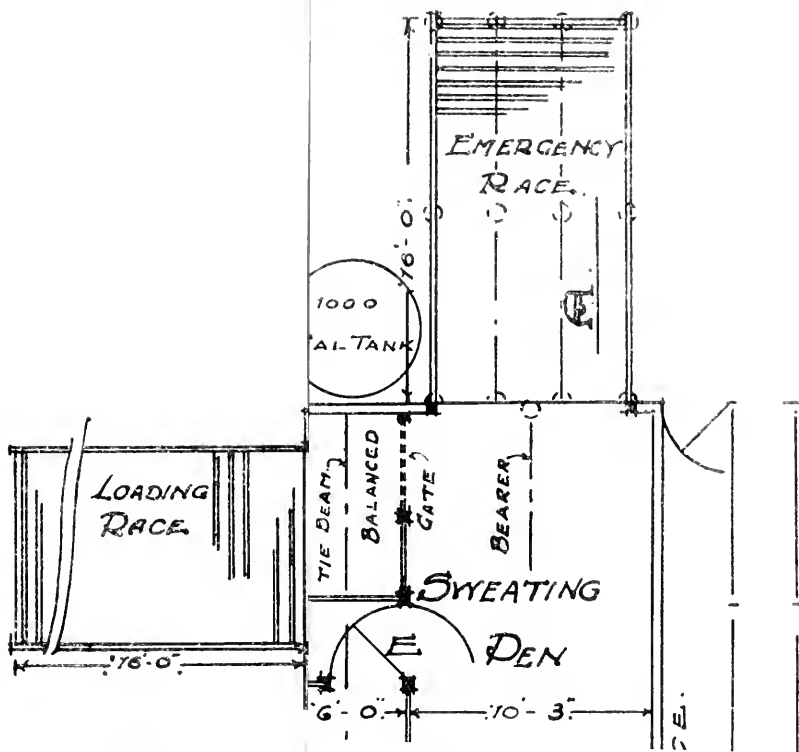
To each pair of rafters put 5-inch x 2-inch collar tie, scarfed out ⅜-inch at ends, and bolted and nailed to rafters with ⅜-inch bolts as before.

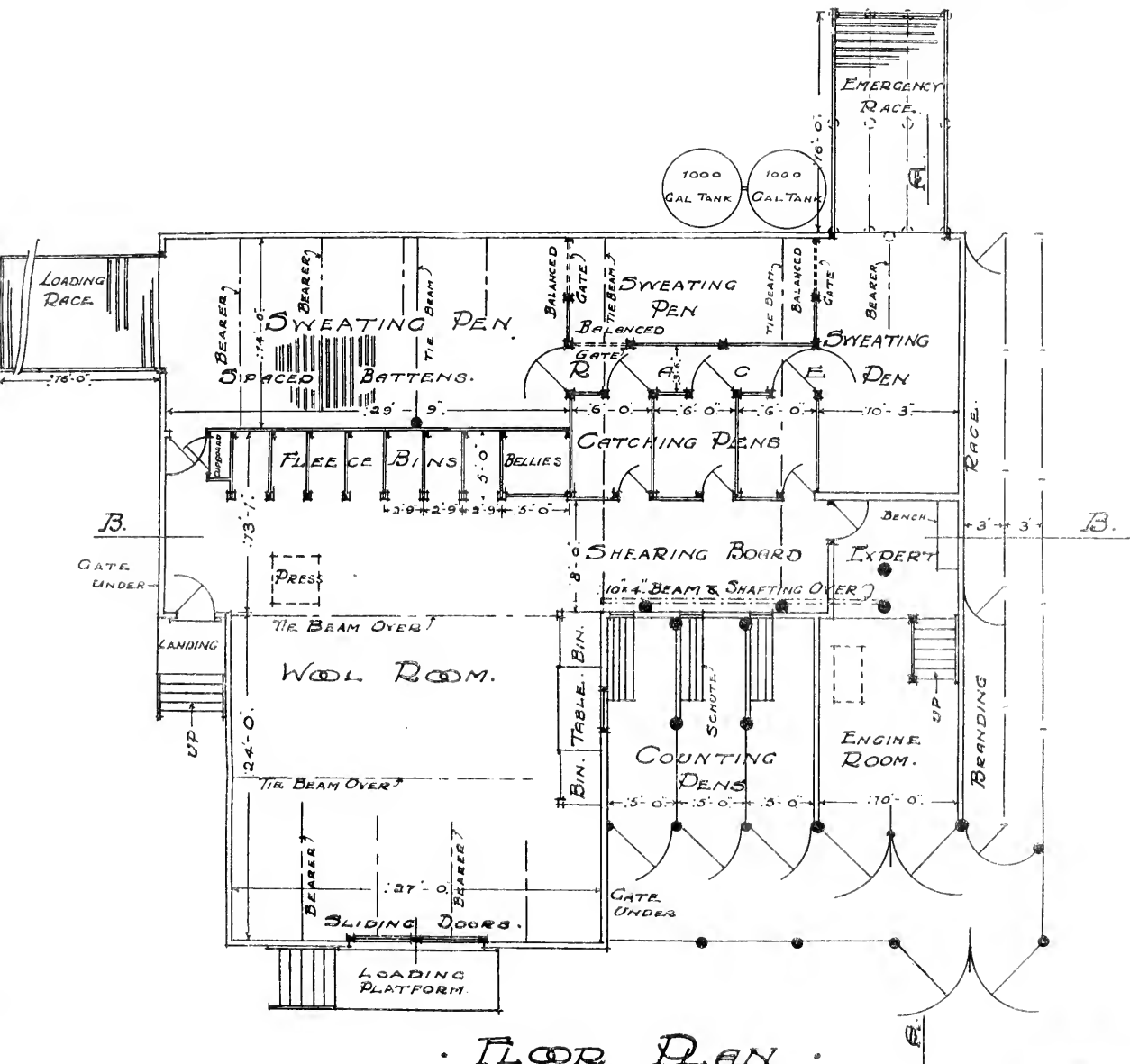
Provide and fix with bolts at ends 7-inch x 2½-inch oregon tie beams and fit to each two hangers of 4-inch x 2-inch, scarfed ⅜-inch on and bolted with ⅜-inch bolts. Put similar rafters to engine room lean-to roof. Finish at each gable with 8-inch x 1¼-inch wrought redwood roof boards with 1½-inch scotia planted under iron roll. To each gable of pitched roof, provide and set in 4-inch x 2-inch with 6-inch x 3-inch sill, louvre, ventilator frame, filled in with 24-gauge plain iron louvres, set in saw cuts at 1⅜-inch spaces, and turned up and down at edges ½ inch. Finish with 7-inch x 1-inch redwood wrought barge boards and scotia as before, brace roof diagonally as may be directed with 3-inch x 1½-inch battens firmly spiked to underside of rafters from ridge to wall plates or where directed.

Intersection of tie beams, under valleys and to outer walls to be supported by round post, where indicated, and ridges over to be supported from top of same.

Fix at 30-inch centres, 3-inch x 1½-inch battens to take iron. Set to valleys 8-inch x 1¼-inch oregon valley boards.

Floors.—On 5-inch x 4-inch bearers well spiked to supporting blocks, and to bottom plates, fix 6-inch x 2½-inch joists at 18-inch centres, cutting down at outer doors to receive 7-inch x 2½-inch door sills. Trim where and as required for chute doors, wool press, and to take studs of partition framing as may be directed. Cover the whole of the wool room, expert's room and shearing board with 4-inch x 1-inch tongued and grooved flooring, cut close all round studs, and up to weather boards, double nailed at each crossing, punched, and all joints properly planed off flush.

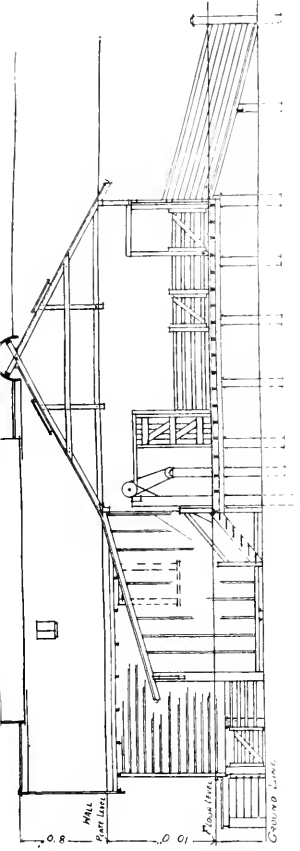




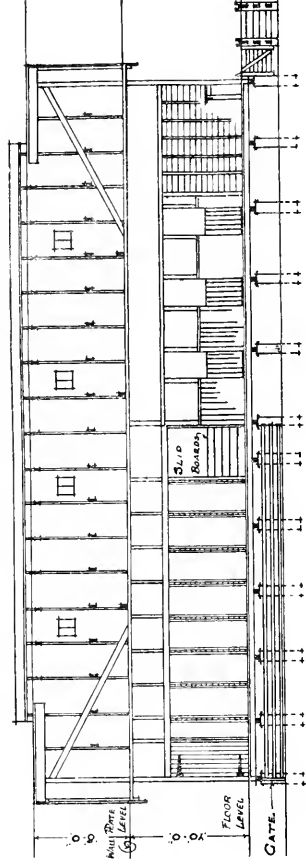
FLOOR PLAN

Fig. 12.—Floor Plan of Shearing Shed erected at Temora Experiment Farm.

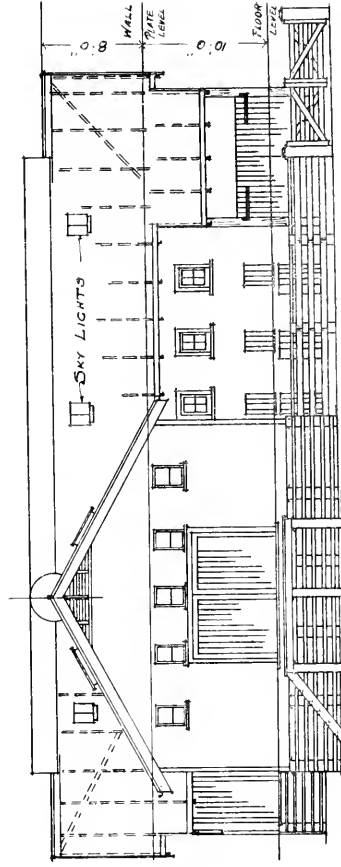
at each crossing, punched, and all joints properly planed or flush.



Section A of Fig. 2.



Section B-B of Fig. 2.



Elevation to Avon.

Fig. 13. Sections and Elevation of Shearing Shed erected at Tomera Experiment Farm.

To face page 204.

Cover the whole of the landings with 4-inch x 1½-inch shot edge board and the sweating pens, catching pens, and race, with 2-inch x 1½-inch and 3-inch x 1½-inch alternate battens, spaced ½ inch apart, and arised on corners cut close around all posts, studs, &c., as required.

Emergency and leading races.—Construct inclined races with 10-inch round posts, set 18 inches into the ground, faced as required to take side boarding 6 inches x 1½ inch close together the full height. Fix 5-inch x 4-inch bearers, and 6-inch x 2½-inch joists at 24-inch centres, and cover with 2-inch x 1½ inch and 2-inch x 2-inch battens spaced as for pen floors (three 2 inch x 1½ inch and one 2 inch x 2 inch). Over face of side boarding fix 1 inch hoop-iron strap, and over head of post.

Enclosure under Floors.—Enclose all round building with 4-inch x 1½-inch battens, nailed to round blocks, neatly notched on face as may be required to give good line. In a similar manner batten on foundation blocks to enclose off the whole space under the tongued and grooved flooring of wool room, &c. All battens to be spaced 6 inches measuring from the ground, and all to be neatly arised. Trim for gates where indicated.

Counting Pens.—Where indicated on plan, construct dividing fences 3 feet 9 inches high with 9-inch diameter posts, three 6-inch x 1½-inch sawn rails, and 4-inch x 3-inch top rails, all set neatly into posts at ends, and arised.

Chutes.—Construct chutes from shearing board to pens, each with four 6-inch x 1-inch tongued and grooved boards on bottom, curved as indicated, fixed to 4-inch x 3-inch bearers, bolted at ends to round posts set on each side of chute, the lower end to be 4 inches above the ground. Trim inner face of side posts and line up the full height with 6-inch x 1-inch tongued and grooved boards, nailed to posts, and having straps of 1-inch galvanised hoop-iron nailed over the whole.

Top ends of side boarding to be fixed to fillets nailed on to weatherboards.

Landings and Steps.—Construct landing platform and landing near wool press with 5-inch x 4-inch bearers, set on round blocks, as before specified, and 6-inch x 2½-inch joists at 16-inch centres, covered with shot edge flooring. To each of these, also to floor of experts room from engine-room, construct steps as indicated of 10-inch x 1½-inch threads, housed ¾ inch at ends into 9-inch x 2-inch strings, to be footed to round blocks carrying bottom treads. To engine-room steps put 4-inch x 4-inch newels, and 4-inch x 2½-inch hand-rail, neatly rounded over as directed.

Partitions.—Construct partitions to sweating and catching pens 3 feet 4 inches high with 4-inch x 4-inch studs, 4-inch x 2½-inch top plates or rails and 6-inch x 1½-inch intermediate rails, all properly framed together, the studs housed into rails at tops, trimmed to bearers or joists at bottom and mortised to receive the intermediate rails, set up as indicated on the plan or as may be directed. Studs for sliding gates to be built up with 1½-inch pulley styles and ¾-inch lining (see details).

Partition on shearing board and front of catching pens to be formed up with 4-inch x 1½-inch rails, covered with 4-inch x ¾-inch tongued, grooved, and beaded lining capped over ends on top rails with 1-inch stuff, neatly rounded over, the face of lining being flush with 4-inch x 4-inch posts.

Partition to expert's room to be 6 feet 9½ inches high to top of rail and close lined on rails, as before specified, the full height. Provide and fit in partition where directed, set of nine, 5-inch x 5-inch pigeon holes made of ¾-inch stuff and 6 inches deep.

Fleece Bin.—Construct where indicated on plan, bin 5 inches deep, and the height shown, with 6-inch x 1-inch front top rail, 4-inch x 1-inch double studs back and front, and in centre of divisions, one on each side of boarding. Cover back and partitions and with 6-inch by ¾-inch tongued, grooved, and beaded boarding, the ends showing to front to be flush. Form where shown bin for belly pieces with front 3 feet high of movable boards.

Cupboard.—At end of fleece bin, fit up cupboard 12 inches deep, with 1-inch colonial pine wrot shelving tongued and grooved ledge door, hinged with 14-inch ice hinges, and secured with cupboard lock. Fit up cupboard with three shelves, exclusive of the bottom one, at 4 inches over the floor, and form base to floor.

Cover the whole of the landings with 4-inch x 1½-inch shot edge board and the sweating pens, catching pens, and race, with 2-inch x 1½-inch and 3-inch x 1½-inch alternate battens, spaced ½ inch apart, and arised on corners cut close around all posts, studs, &c., as required.

Emergency and leading races.—Construct inclined races with 10-inch round posts, set 18 inches into the ground, faced as required to take side boarding 6 inches x 1½ inch close together the full height. Fix 5-inch x 4-inch bearers, and 6-inch x 2½-inch joists at 24-inch centres, and cover with 2-inch x 1½ inch and 2-inch x 2-inch battens spaced as for pen floors (three 2 inch x 1½ inch and one 2 inch x 2 inch). Over face of side boarding fix 1 inch hoop-iron strap, and over head of post.

Enclosure under Floors.—Enclose all round building with 4-inch x 1½-inch battens, nailed to round blocks, neatly notched on face as may be required to give good line. In a similar manner batten on foundation blocks to enclose off the whole space under the tongued and grooved flooring of wool room, &c. All battens to be spaced 6 inches measuring from the ground, and all to be neatly arised. Trim for gates where indicated.

Counting Pens.—Where indicated on plan, construct dividing fences 3 feet 9 inches high with 9-inch diameter posts, three 6-inch x 1½-inch sawn rails, and 4-inch x 3-inch top rails, all set neatly into posts at ends, and arised.

Chutes.—Construct chutes from shearing board to pens, each with four 6-inch x 1-inch tongued and grooved boards on bottom, curved as indicated, fixed to 4-inch x 3-inch bearers, bolted at ends to round posts set on each side of chute, the lower end to be 4 inches above the ground. Trim inner face of side posts and line up the full height with 6-inch x 1-inch tongued and grooved boards, nailed to posts, and having straps of 1-inch galvanised hoop-iron nailed over the whole.

Top ends of side boarding to be fixed to fillets nailed on to weatherboards.

Landings and Steps.—Construct landing platform and landing near wool press with 5-inch x 4-inch bearers, set on round blocks, as before specified, and 6-inch x 2½-inch joists at 16-inch centres, covered with shot edge flooring. To each of these, also to floor of experts room from engine-room, construct steps as indicated of 10-inch x 1½-inch threads, housed ¾ inch at ends into 9-inch x 2-inch strings, to be footed to round blocks carrying bottom treads. To engine-room steps put 4-inch x 4-inch newels, and 4-inch x 2½-inch hand-rail, neatly rounded over as directed.

Partitions.—Construct partitions to sweating and catching pens 3 feet 4 inches high with 4-inch x 4-inch studs, 4-inch x 2½-inch top plates or rails and 6-inch x 1½-inch intermediate rails, all properly framed together, the studs housed into rails at tops, trimmed to bearers or joists at bottom and mortised to receive the intermediate rails, set up as indicated on the plan or as may be directed. Studs for sliding gates to be built up with 1½-inch pulley styles and ¾-inch lining (see details).

Partition on shearing board and front of catching pens to be formed up with 4-inch x 1½-inch rails, covered with 4-inch x ¾-inch tongued, grooved, and beaded lining capped over ends on top rails with 1-inch stuff, neatly rounded over, the face of lining being flush with 4-inch x 4-inch posts.

Partition to expert's room to be 6 feet 9½ inches high to top of rail and close lined on rails, as before specified, the full height. Provide and fit in partition where directed, set of nine, 5-inch x 5-inch pigeon holes made of ¾-inch stuff and 6 inches deep.

Fleece Bins.—Construct where indicated on plan, bins 5 inches deep, and the height shown, with 6-inch x 1-inch front top rail, 4-inch x 1-inch double studs back and front, and in centre of divisions, one on each side of boarding. Cover back and partitions and with 6-inch by ¾-inch tongued, grooved, and beaded boarding, the ends showing to front to be flush. Form where shown bin for belly pieces with front 3 feet high of movable boards.

Cupboard.—At end of fleece bin, fit up cupboard 12 inches deep, with 1-inch colonial pine wrot shelving tongued and grooved ledge door, hinged with 14-inch ice hinges, and secured with cupboard lock. Fit up cupboard with three shelves, exclusive of the bottom one, at 4 inches over the floor, and form base to floor.

Fleece Tables.—Construct one wool sorting table 12 feet long 4 feet 6 inches wide and 3 feet high, having six 5-inch x 5-inch legs, 5-inch x 2½-inch top rails, 3-inch x 2-inch centre rail, 4-inch x 1½-inch stays and braces, and the top rail filled in with 1½-inch x 1½-inch spars set on corner at 2¾-inch spaces, the ends housed into rails. Fix around bottom of legs on floor, movable 12-inch x 1-inch boards, to fit in fillets. The whole of the above to be wrot oregon.

Under window at counting pens, where shown on plan, fit up piece bins, with centre table top to lift out, each bin to be 4 feet 6 inches long x 4 feet wide, made similar to wool table, to slide in fillets fixed to inner ends of bins. Bins to be formed up with 6-inch x ¾-inch tongued, grooved, and beaded lining fixed to corner studs, top rails, and cleats, finished on top edges with 3-inch x 1½-inch capping rounded off.

Experts' Bench.—Construct in expert's room a side bench 5 feet long with 5-inch x 5-inch legs, 6-inch x 1½-inch rails, and 18-inch x 2-inch wrot oregon top screwed down. Fix on back to studs 12-inch x 1-inch wall board.

Shafting Beam.—Where indicated over shearing board and to heads of 12-inch round posts fix 10-inch x 4-inch wrot oregon beam, 6 feet 9½ inches clear of floor fixed with ½-inch bolts. In expert's room, set short round post 12 inches diameter to take grinder, as shown on Section AA.

Wool Press.—Set for wool press where shown four extra heavy round blocks on 8-inch x 3-inch sole plates 12 inches under the ground, and fix 5-inch x 4-inch bearers as may be required to take the press.

Doors.—All doors to be wrot on both sides, the framed doors of oregon styles and top rails, other rails colonial pine and sheeting of oregon. Plain ledge doors of oregon sheeting on colonial pine ledges and braces, the outer boards to be screwed to ends of ledges.

Doors at loading platform to be framed and ledged 2 inches thick, 10 feet wide, in two halves, the meeting styles to be rebated and beaded, doors hung at top with McCabes steel track and guides to floor and secure with 10-inch galvanised hasp and staple, chain and drop pin on inside.

Doors to small landing, at end of fleece bins, and to expert's room to be plain ledge 6 feet 8 inches x 2 feet 8 inches x 1 inch hinged with 14-inch tee hinges, and secured with 6-inch carpenter's lock. Doors to engine room to be the full width, 6 feet 6 inches high in two leaves hinged to corner studs with 18-inch Scotch tee hinges secured with 10-inch tower bolt at top, 10-inch galvanised hasp, staple and 2-inch padlock.

Doors to be inclined to pens, to be also in two leaves, the full width, hinged as before, to open out against the sides of races, secured inside with 10-inch bolts, and each leaf provided with strong cabin hook to fasten against sides of races. Doors to catching pens to be in one leaf, 2 feet wide, hinged with double acting spring hinges of approved make. Chute doors to be made 2 feet 7 inches high x 22 inches wide, of ½-inch tongued and grooved Baltic lining on 4-inch x 1-inch ledges, fitted to slide upwards over face of sashes, and each fitted with 4-inch tower bolt to secure them open or shut.

All doors to be fitted with suitable wrot steps of the required width and thickness, and all ledge doors to be properly braced to suit the openings, braces 4 inches wide, those in two leaves to have 4-inch x ¾-inch chamfered cover strip screwed on the closing half.

Gates.—All gates (except where shown balanced gates) to sweating, catching, and counting pens, also two gates under wool-room to be of the sizes shown, made with 3-inch x 1½-inch oregon double styles halved over 3-inch x 1½-inch oregon rails, braced and bolted at crossings with ¾-inch cuphead bolts, nuts and washers, hung with 18-inch tee jap hinges and fastened with slide, batten centre style and two braces hung with 18-inch x 2-inch x ¼-inch wrought-iron hinges, bolted to gates, and with suitable hooks. Gates on counting pens to have 18-inch x 1½-inch x ¼-inch wrought-iron hinges as above.

Balanced gates to be constructed similar to others, hung in box frame, formed as already specified, having heavy axle pulleys, sash cord, and suitable cast-iron or lead weights, as required.

Windows.—Window over table in wool room to be double hung sashes twelve-light 1¾-inch thick redwood, in box frame of 1-inch pulley styles and linings, cedar beads 7 inch x 3 inch sunk and weathered tallow-wood sill finished under outer edge with ¼ round. Sashes to be hung with No. 6 Sampson's spot cord, cast-iron weights, and fitted with approved fastener and lifts.

Windows over shearing-board, to be single four-light sashes $1\frac{1}{4}$ inch redwood, pivot hung, with suitable stops, sloping sills, No. 4 cord and iron cleats, and each sash provided with tower bolts to secure, also all sashes to be glazed with 21-ounce glass.

Wall lights, as indicated in each gable, to be of $\frac{1}{4}$ -inch mill-rolled glass two sheets, set in proper stops, between studs, each having sloping sills $2\frac{1}{2}$ inches thick. The two sheets in each opening to be fixed with 2-inch lap and $\frac{5}{8}$ -inch space at centre.

Tank Stands.—Build up stand for two 1,000-gallon tanks alongside of emergency race, with ten round block supports, 12 inches diameter, set firmly 18 inches into the ground, and supporting 6-inch x 4-inch hardwood bearers, and 4-inch x 2-inch hardwood decking, spaced 2 inches apart, spiked to bearers. All timbers to be coated with hot coal tar before being fixed.

Shutters.—In both side walls of engine-room, provide and hinge with 16-inch tee hinges 3 feet x 3 feet wide, tongued and grooved ledged shutters, each openings to have sloping $2\frac{1}{2}$ -inch sill and suitable $\frac{3}{4}$ -inch stops and 1-inch linings, and secure each with 6-inch tower bolt.

PLUMBER.

Cover the whole roof with 26-gauge corrugated galvanised iron, secured to battens with plenty $1\frac{1}{4}$ -inch galvanised screws and lead washers as may be directed, and having $1\frac{1}{4}$ -inch corrugation lap at sides, and not less than 6 inches at ends, all sheets fitting close up to ridges. At crossing of rafters under curved iron, slightly turn ends of sheets, and burr up hollows of corrugations. At all gables turn 2-inch roll overhanging scotias on barge-boards. All eaves to be neatly to line, and $1\frac{1}{2}$ -inch into gutters, also at valleys to show 5 inches wide.

To valleys lay 18-inch wide plain 24-gauge galvanised iron, with edges turned to battens. Flash over all external openings with similar iron of suitable widths, secured under weatherboards.

To all eaves provide and fix on stout galvanised brackets, one to each rafter 5-inch quarter round guttering lapped, rivetted and soldered both sides at joints, and provided with 3-inch outlets to down pipes, to tanks, &c. Provide 3-inch 24-gauge down pipes to tanks, &c.

In roof provide and fix nine Malley's patent roof lights glazed with $\frac{3}{16}$ -inch mill-rolled glass fixed, placed as indicated or directed.

Provide and set on prepared stand two 1,000-gallon 24-gauge galvanised corrugated tanks, fitted with manhole, strainer, overflow, and 1-inch range cock connected together with $1\frac{1}{2}$ -in. galvanised connecting pipe and corrugated iron flanges. From tanks lay on 1-inch service to stand pipe at sheep dip as will be directed.

PAINTER.

Paint to be composed of Berger's white lead and Meggitt's oils. All stopping to be done with oil putty put in after priming coat.

Paint in three coat work, all doors, sashes, barge boards, door jambs, linings, and shutters, and other wrot wood work usually painted, in colours as will be directed. All weatherboards to be given one coat of Bloss oil stained with sienna, and afterwards one coat of half oil and half hard varnish.

DRAFTING YARDS AND DIP.

The whole of the timber for fences to be cypress pine. For gates hardwood styles Oregon rails, stays, and hardwood fasteners, and must be clean sawn timber.

All gate and corner posts to be 10 inch to 12 inch diameter at small ends, others 9 inch to 10 inch set 30 inches and 24 inches into the ground respectively, well rammed, mortised or notched as required to receive the sawn rails, and tops of posts neatly trimmed about 1 inch on corners.

Top rails to be 4 inch x 3 inch set on flat $\frac{1}{4}$ inch arrised on top corners fitted into slotted heads of posts, and fastened as shown with No. 8 galvanised fence wire. The lower rails to be 6 inches x $1\frac{1}{2}$ inch in lengths of two panels, the butt joints broken as indicated on drawing, and secured in posts with No. 8 wire crossed and twitched on back of posts, and all rails to be spiked to each post; no panel to exceed 9 feet in length.

The sides of branding race, race to check pens, crush pen, and race and exit at sheep dip to be close boarded the full height with 6-inch x 1-inch tongue and groove boards, and their gates to be made of light tongued and grooved boarding as will be directed.

All gates (other than those already specified) to be of the sizes indicated on plans made of 3-inch x $1\frac{1}{4}$ -inch styles, notched to receive 3-inch x 1-inch rails and braces, bolted at each crossing with $\frac{3}{8}$ -inch cuphead bolts, nuts and washers. Provide to each sliding fastener to ride on a $\frac{3}{8}$ -inch bolt, the end setting into a 4 inches long mortise in gate post as will be directed.

All gate timbers to be painted in the joints when being put together, with white lead paint.

All hinges to be 2 inches wide for 8 feet gates, and $1\frac{1}{2}$ inch x $\frac{1}{4}$ inch thick for others, all 20 inches long, bolted to gates, and with suitable hooks to posts, the top hooks to nut through.

If so directed provide at closing post, stop to all gates.

DIP AND DRAINING PENS.

Dig out to take 9-inch brickwork for the walls of dip to the dimensions shown, and carefully refill behind brickwork as the walls are raised. Spread at sides, and to draining pens all loose earth as may be directed, graded and packed tightly.

Build dipping bath in 9-inch work, all set in cement mortar of three parts clean sharp and one part Portland cement, mixed properly together and used fresh.

All bricks to be well wetted as laid, the mortar joints not more than $\frac{3}{8}$ -inch thick, each course carefully grouted flush, the faces left rough for plastering, and all built in old English bond. Pave floor of bath with brick on edge and of draining pens, either with brick on flat, with brick on end borders, or approved cement concrete, and properly graded to draining wells to dry the floors.

Form draining wells 14 inches x 14 inches x 6 feet deep, and set in each $\frac{1}{2}$ -inch thick galvanised iron plates, well perforated with $\frac{1}{4}$ -inch holes, set 2 inches below surface of floor. Lay from these wells to bath as indicated 2-inch galvanised iron 22-inch gauge pipe with good fall.

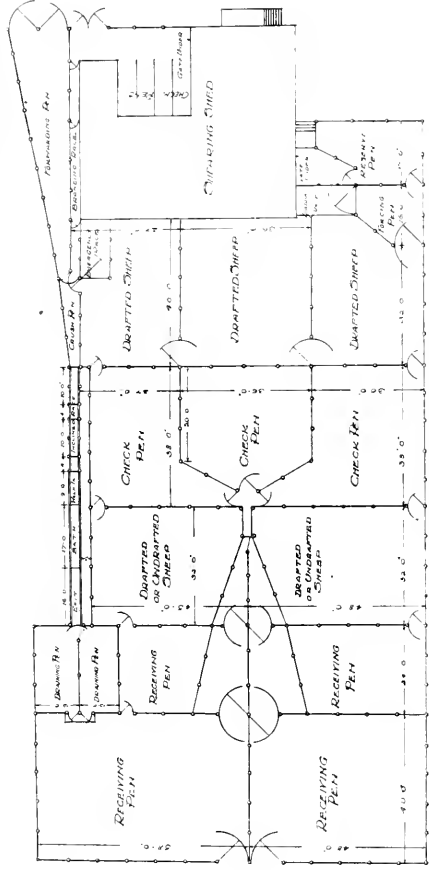
Render with cement mortar as specified for brickwork the whole of the inside face of bath, over the top and down to the ground level on outside, also floor of draining pens with $\frac{1}{2}$ -inch thick, well-floated and trowelled, finished with smooth face; all arrises to be neatly camphered off. On the exit slope of bath floor lay cement cleats of 2-inch x $\frac{3}{4}$ -inch, shortened at ends, to all drainage, to run down as indicated on plan.

The walls of draining pens to be set in between 9-inch round posts, 8 feet high, cut off square on top and covered with tin or other approved weather covering.

All rails where not mortised into posts to be neatly scarfed flush on inner face and well spiked on. At exit gates from draining pens form brick-paved or timber slopes, cleated for foot-hold as may be directed.

Sheep Yards and Dips. (Fig. 14.)

The main idea embodied in these yards (actually erected at North Bangaroo Stud Farm) is to provide ample room in the various subdivisions, to conserve space where possible, to accelerate the free movement of the sheep, and to make the whole structure fit in with the special requirements and design of the shearing-shed. Wherever it has been possible to make a compartment fulfil



General Plan of Sheep Yards and Dip.

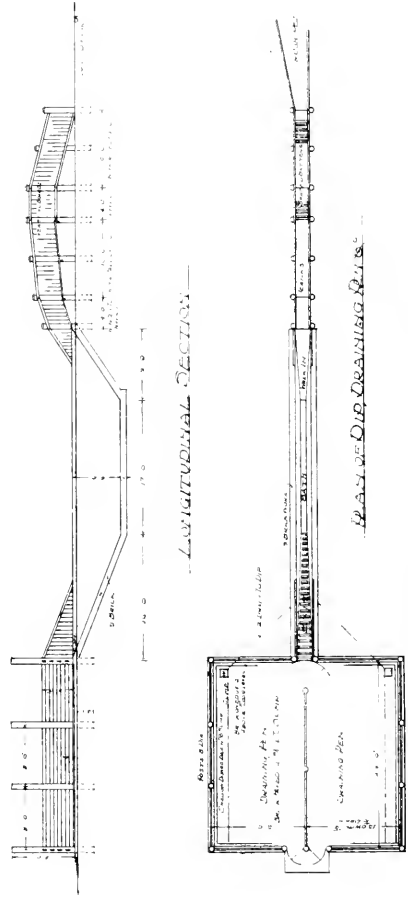
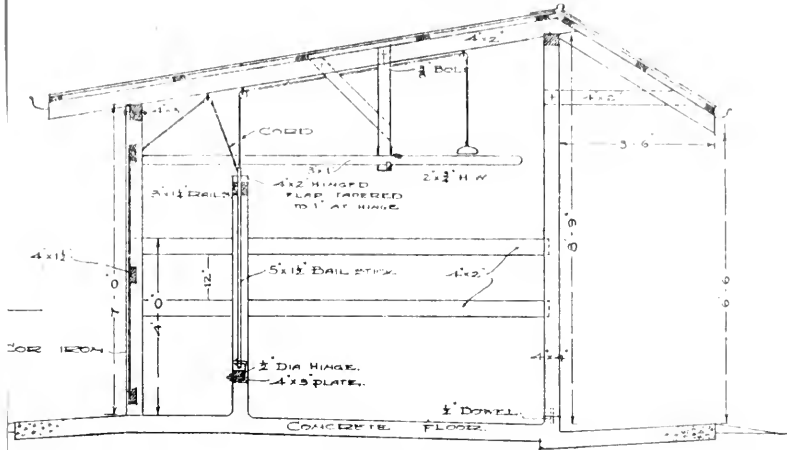
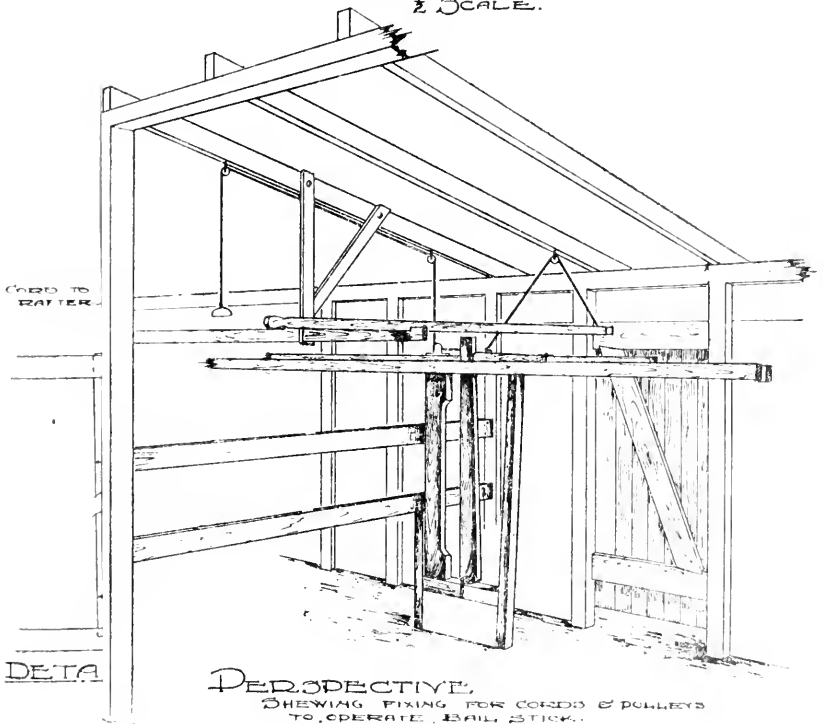


Fig. 14.— Plan and Sections of Sheep Yards and Dip at North Bangaroo Stud Farm.



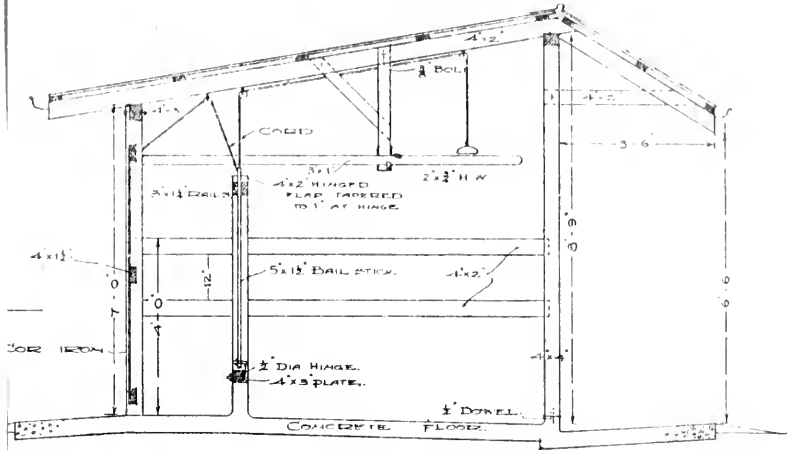
CROSS SECTION
1/2 SCALE.



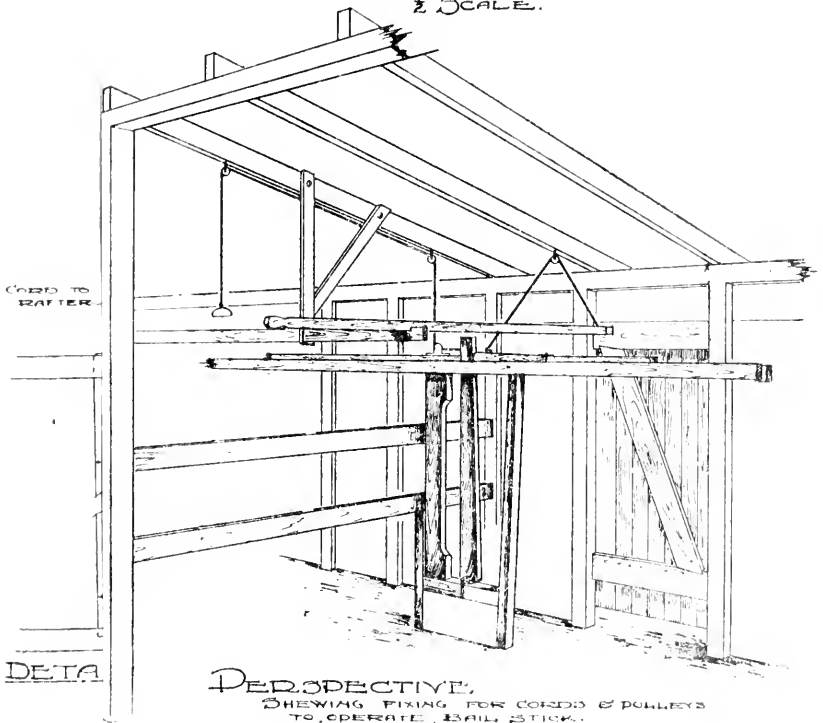
DETAIL

PERSPECTIVE,
SHOWING FIXING FOR CORDS & PULLEYS
TO OPERATE BAIL STICK.

To face



CROSS SECTION
 1/2 SCALE.



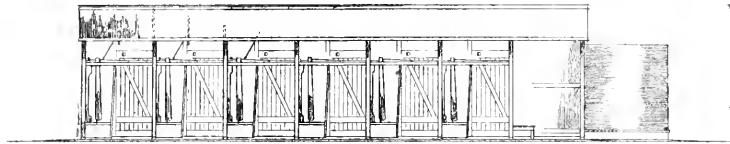
To face

COW BAILS FOR HAND MILKING

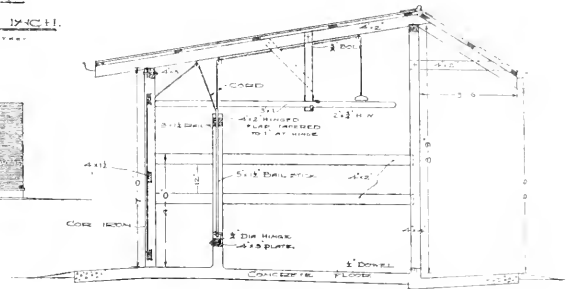
A BOOK BY
WALTER OVERBERG
DEPT. OF AGRICULTURE
SYDNEY.

SCALE 4 FEET TO AN INCH.

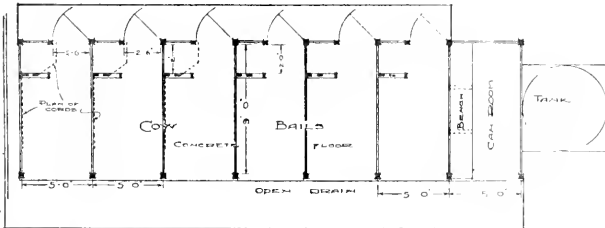
REGISTERED TRADE MARK



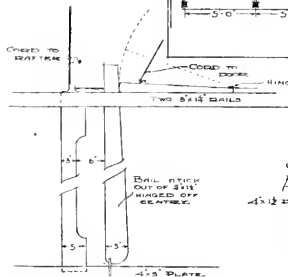
SIDE ELEVATION.



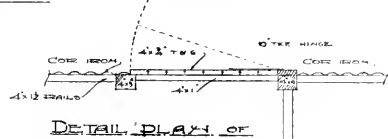
CROSS SECTION
SCALE.



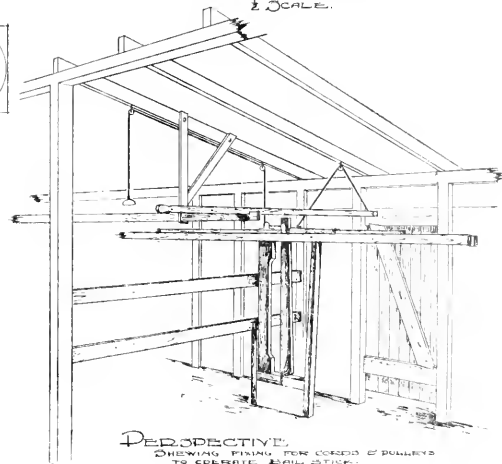
PLAN



DETAIL OF BAILS.



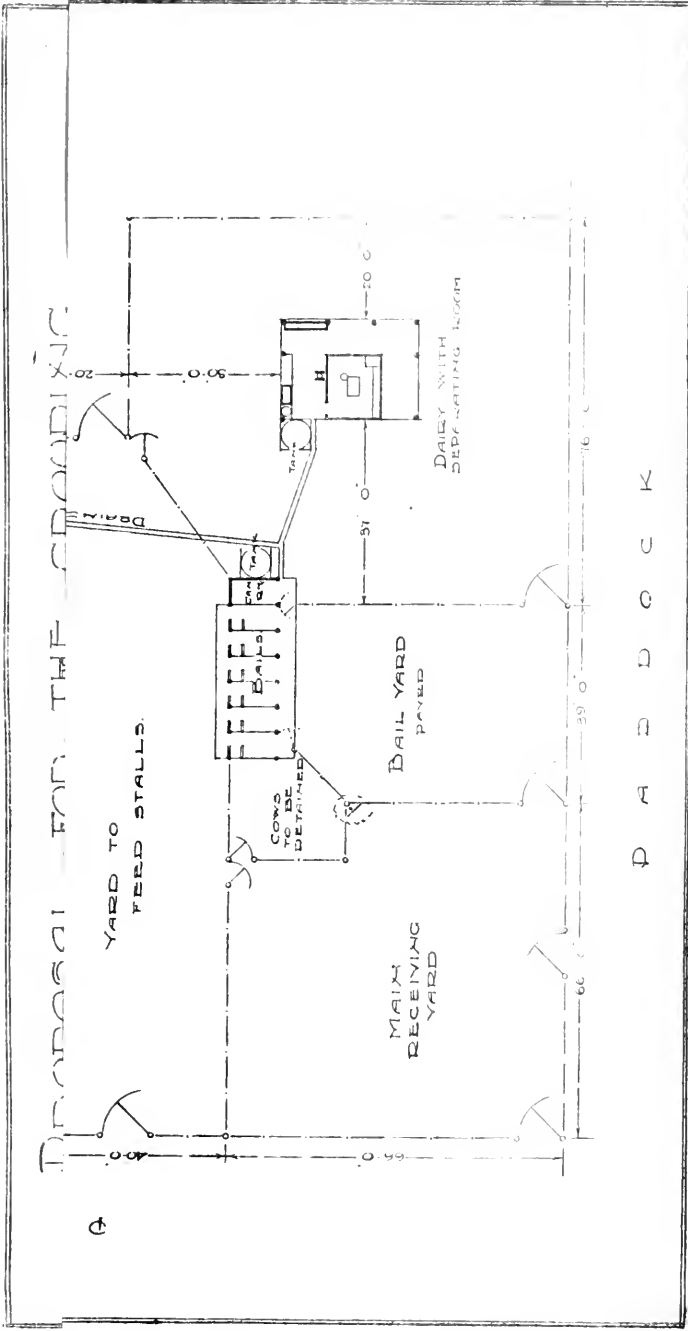
DETAIL PLAN OF
DOORS TO BAILS
SCALE.



PERSPECTIVE.
SHOWING FINISH FOR CORNER & BULLHEADS
TO COMPLETE BAIL STICK.

To face page 218.

Fig. 15.—Plan and Details of Cow Bails for Hand-milking.

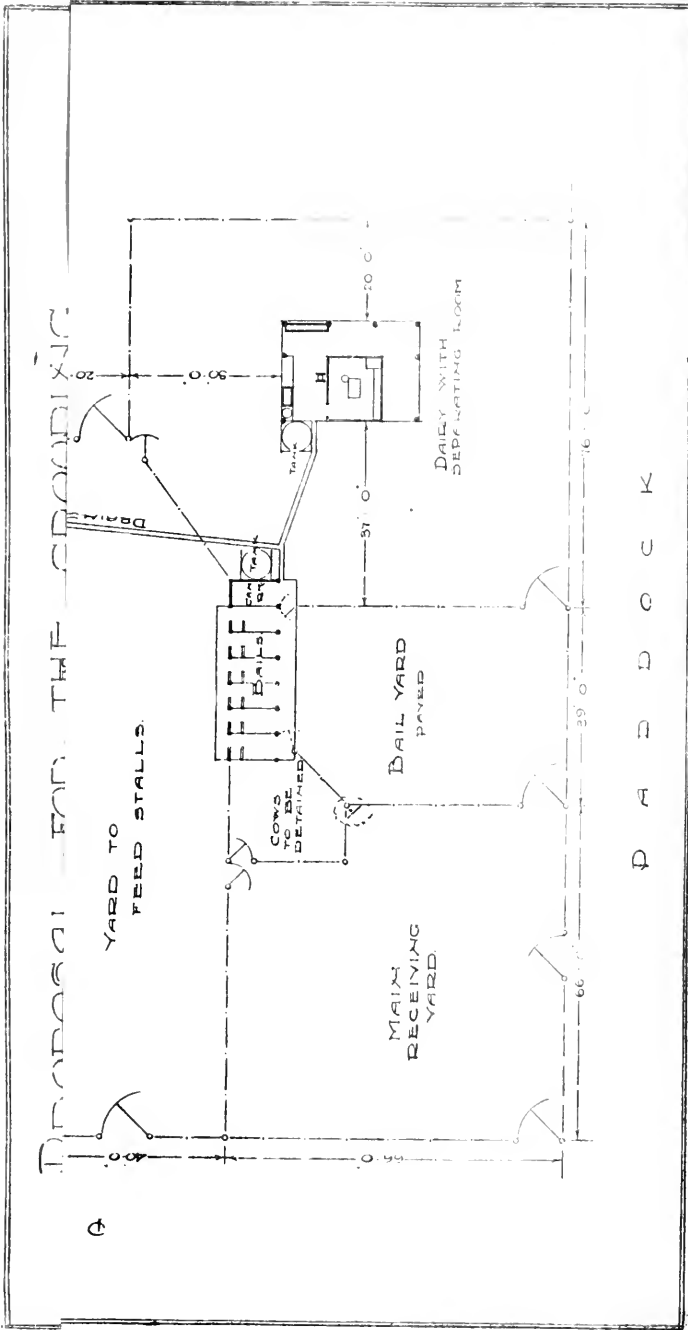


P A R D C U K

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Fig. 16.—Ground Plan for lay-out of a Dairy Farm.



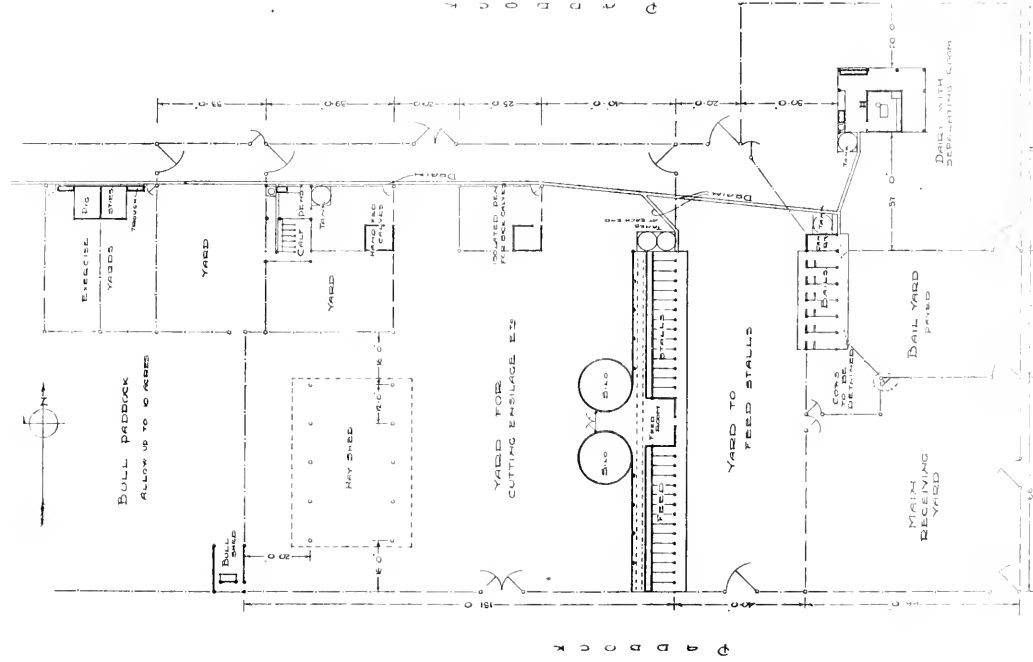


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Fig. 10.—Ground Plan for lay-out of a Dairy Farm.

PROPOSAL FOR THE GRADING OF DAIRY FARM BUILDINGS

SCALE 1" = 10' 0"



D A I R Y F A R M

a twofold purpose this has been done. For example, the space apportioned to the outer receiving yards also serves as a convenient enclosure for the sheep that are released from the draining-pens of the dip. Again, the space under the floor of the wool room and shearing boards is utilised to shelter the sheep, and so provides against loss of time occasioned by wet weather.

The lines on which the yards have been designed allow of the sheep being drafted three ways. To meet the requirements of this mode of construction two drafting gates are necessary; these are decidedly preferable to the obsolete method of the single gate. The use of the double gate not only protects the sheep from being knocked about, but expedites the work of drafting. The two gates are hung one from each of the middle posts of the inner check-pen, and when in line serve a twofold object. The drafting gates are held in position by staples which may be removed at will, and so permit the gates to be thrown back.

As those well versed in the work can tell, one of the most difficult tasks of all is to provide means that will induce the sheep to enter the dip. Various contrivances have been tried. We have examples of the "walk-in principle," the "slip-side," "false floor," and various devices of decoy pens, but none seem to have proved satisfactory.

The plan has been designed to allow the sheep to be released in the yard beyond the branding race, or to be transferred to the crush-pens at the approach to the dip as required. It also admits of the dip being used independently of the other structure in the event of dipping being undertaken at a later interval. To provide for this the forwarding-pens have been extended at right angles beyond the line of the drafting-race. The sheep may be accommodated in the drafting yards and brought round the shed to the approach to the dip in numbers as required.

Cow Bails for Hand-milking. (Fig. 15.)

This plan needs little explanation. It provides for a convenient shed capable of stalling six cows, but it could be extended to any desired number. As in all modern dairies, the cows enter at the front and take their places in the stalls, where they are detained in the bails, sufficient details of those contrivances being given to enable any one to erect them. When milking is finished, the milker simply pushes the 2 x $\frac{3}{4}$ -inch batten, releasing the bail stick and opening the door in front of the cow, and she passes through into the yard beyond. The door is then closed again by pulling back the batten, the bail remaining open ready for the next cow.

The floor is of concrete, and the construction is designed to clean easily and to offer as little opportunity as possible for dirt of any kind to remain in the bails.

Lay-out of a Dairy Farm. (Fig. 16.)

This plan is included in the hope that it will indicate how dairy farm buildings, yards, &c., can be disposed to best advantage. No description is needed, the plan being self-explanatory in all respects, though perhaps it should be mentioned that owing to the lay of the land, &c., it may be necessary to alter the relative positions of the buildings; this might make the drainage a little more difficult, but each case would have to be considered on its own merits.

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ASH CONCRETE.*

Portland cement concrete is an artificial compound, generally made by mixing cement, stone, sand, and water together in such proportions as will form a solid conglomerate.

To make the strongest and heaviest concrete, the stone must be hard, rough, and somewhat porous, affording a rough surface to which the cement mortar will readily adhere.

Technically the stone is called the aggregate, and the mortar made from the sand, cement, and water is known as the matrix.

For many classes of work, such as small farm buildings, cottages, floors, surface drains, &c., heavy concrete is not necessary, and for such purposes there are other materials that provide a suitable aggregate. Amongst these is the ash, generally a waste product obtainable from coke ovens, foundries, gasworks, and railway loco. sheds. This is generally found to be of a mixture that requires only the addition of the cement and water to make good concrete. Generally speaking, however, it is found desirable to add a proportion of sand, as it is always safer to have a little too much than too little matrix in the mixture. All materials used in the manufacture of concrete must be clean, and free from any vegetable matter.

Sand that is of a loamy nature, although good for mortar, is not suitable for concrete; for which purpose it should be sharp and gritty. The quality of the cement is assured, and may be procured with the certificate of the Government tester attached. The local manufacture is equal in quality to the best imported cements, and for convenience is put up in bags containing about 128 lb. It would, however, be much more convenient if it were put up in bags containing exactly 1 cubic foot, as all concrete is mixed by measure. Until it is to be used the cement must be kept perfectly dry; as it is very sensitive to even slight moisture, it should be laid on planks or boards raised a few inches from the ground, so that the air can pass freely under it.

Often it will be found that a bag of cement out of the stack will have become apparently solid, from pressure only. This does not injure it in the least, as it is quite easily knocked into powder again; but if the hardening is due to moisture it is quite useless—not even fit to be broken up and used with the aggregate.

When water is added to cement it becomes pasty, and will remain so for about twenty minutes (if not exposed to the sun); after this time it begins to harden or set. To disturb it after this has taken place weakens the mixture, and to do so after it has set destroys it altogether. It should not, during the first five or six days after setting, be exposed to the hot sun or wind, but if possible be shaded and wetted at least twice daily. If this be done the concrete will be thoroughly hard all through; while if not, it will become chalky, easily damaged, and appear to have insufficient cement in the mixture.

* A. Brooks, Works Overseer, Department of Agriculture.

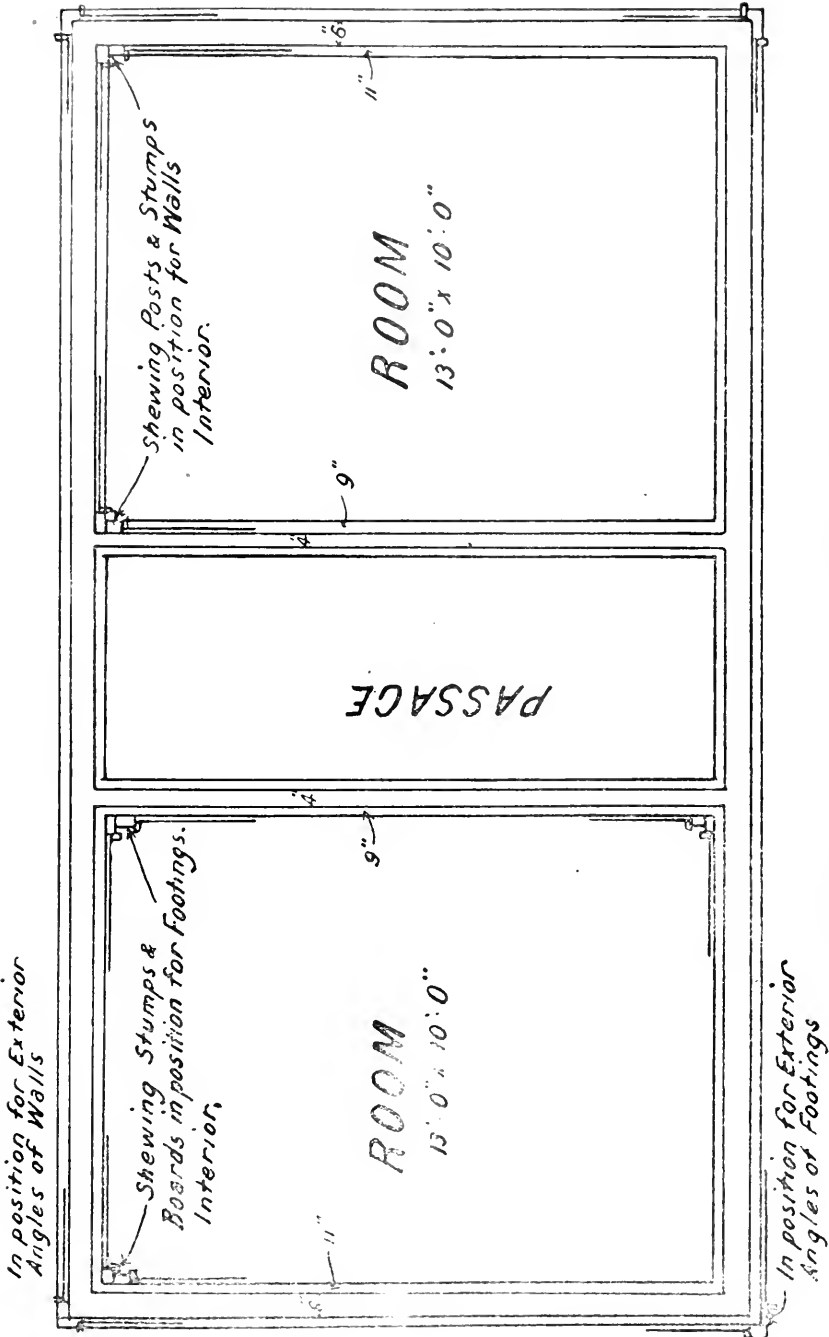


Fig. 17. Plan showing position of stumps, posts, and boxing ready for concrete.

Mixing Platform and Gauge Boxes.

Having selected the proper materials, the next step is to provide the plant and tools for mixing, and these should be just as carefully attended to.

For instance, it is of little use to have clean sand and water if the concrete is to be mixed up on the bare ground, where it is certain that the earth will be picked up with the shovels and mixed with the concrete.

It is absolutely necessary to have a clean wooden floor or platform for mixing on, and this may be of boards from 1½ inches thick and about 9 inches wide, laid solid on a thin bed of sand, and close at the joints. If the boards are a little open they should be filled up with a poor quality of mortar before the mixing is started. On one side and end of the platform a board, say 6 inches wide, should be set up on edge to prevent the materials spreading off the boards.

A handy size for ordinary work would be 10 or 12 feet long by 8 feet wide, and it should be laid level on the surface, and as handy to the work as possible. To ensure the correct proportions of materials in each batch gauge boxes should be made of the size to hold the quantities specified for each mixing. These boxes should have sides and ends only so that they can be lifted, and allow the contents to fall out on to the platform.

A good water supply is absolutely essential, and where it cannot be laid to a point near the mixing board by means of pipes from a storage tank, it should be in an open-top tank sunk into the ground, so that the water can be dipped out with buckets.

Miscellaneous Tools.

In addition to the mixing board and the measuring boxes, the following tools are required for hand mixing:—

- Two No. 3 square-mouth shovels.
- One deep-bodied wheelbarrow.
- One garden rake.
- Two 2-gallon water buckets.
- One 4-gallon watering-can.
- Light rammers for packing the concrete.

Where the water is laid on, a length of rubber hose is useful.

Method of Mixing.

The ashes should first be measured on the board, and the heap spread out to about 3 or 4 inches thick. Then the sand and cement should be mixed together separately, and afterwards spread over the whole area of the ashes. The whole should then be turned over in shovelfuls, and as the shovel is turned it should be dragged towards the feet of the mixer, which causes the materials to be more properly mixed. It may be mentioned that concrete cannot be too well mixed. Usually the materials are turned over twice while dry and twice while being wetted. The watering is best done by means of the watering-can, although this requires an extra hand on the board, and to do the mixing properly three hands are required. There are a number of different machines in use for mixing concrete, but it does not pay to use them unless the job is a large one.

When mixed the concrete should be loaded into the wheelbarrow, taken to the work, and carefully placed in the moulds, or wherever it is to be used, and lightly tamped in.

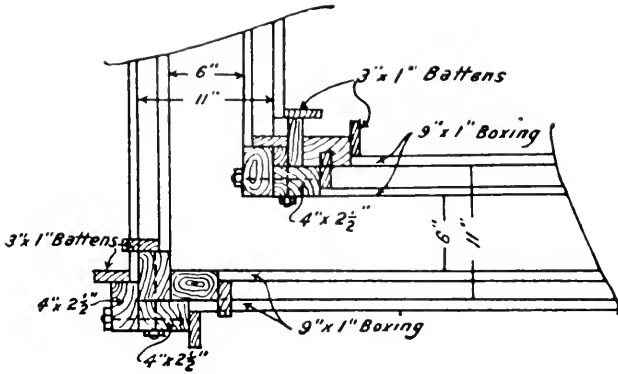


Fig. 18.—Plan showing posts, stumps, &c., at interior and exterior angles.

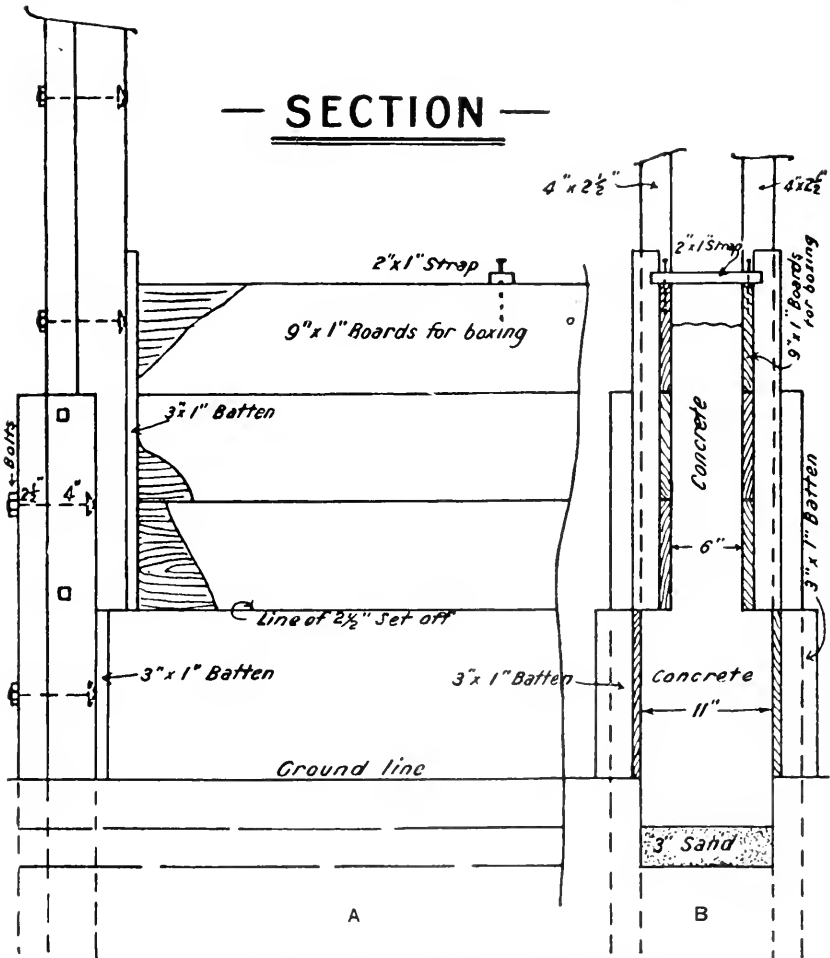


Fig. 19.—Showing A, exterior elevation at angle, and B' section.

Ash concrete should not be made too wet, but just enough to make it pack solidly together, by using the rammers lightly, when it will be noted that the water will come to the surface. A fair idea of the correct consistency may be had if a handful is pressed and retains its ball-like shape when the pressure is released.

Forms or Moulds for Concrete.

Concrete is a plastic material, and before it hardens takes the shape of anything against which it is placed, so that the making of the forms or moulds is a most important item in the success of the job.

Almost any material that will support its weight will serve as a form. For instance, in trenches made for foundations it will be found that the earth sides are sufficient to hold the concrete up to the ground line.

When an extremely smooth finish is desired galvanized iron is used, and these are more easily cleaned and last longer than wooden moulds. But timber is more often used, and where we require scantling sizes for the frame-work of roofs and ceilings, and boards for the floors, these can be used to build the forms with, and afterwards used for their special purpose. In this way there is no extra cost for material for the forms.

They should be correctly planned and carefully made, and with good joints, otherwise difficulties will be met with when they have to be taken down.

For ordinary work, such as the walls of cottages, dairies, stables, &c., there is no necessity for any heavy framing, but simply studs at each corner and angle of the walls, so placed as to form guides for the ends of the boards to slide between. On the lower ends of these studs a short piece is attached, forming a break, equal to the projecting distance of the footing course beyond the walls.

Where the building is only a small one, such as a separating room for a dairy, this may be omitted, and the studs put straight into the ground, in which case when the frame is removed holes the size of the studs will be in the foundation, which can afterwards be filled up; but for larger buildings the foundations should not be so cut into.

Details of Construction.

The accompanying plans (Figs. 17, 18, and 19) show the arrangement of the framing and the details of the construction suitable for the erection of farm buildings or cottages.

It may be here stated that where the boards are being shifted as the work proceeds the surfaces must be cleaned of any cement that may adhere to them, and the same applies to all tools used in the work. Nothing is better for this than an old dandy brush from the stable.

Fig. 20 shows the framing around a double fireplace in a cottage being erected, the openings having semi-arches over each, the boarding in the foreground being that for the hearth walls.

Fig. 21 shows a building which is a portion only of a cottage, being the back rooms, with the bathroom on the verandah, the intention being to add the remainder at a future date. The method of staying the studding and tying the framework together at the tops is clearly depicted, and the various lengths of the timbers show that they are those intended for other parts of the building when the walls are completed.

Fig. 22 shows a small dairy finished, giving a fair idea of the neat and solid appearance of these ash concrete buildings when completed. The plastering is ruled out to represent stone blocks of 2 feet x 1 foot outside, but the inside is plain. The floor and the cream-can vat are of the same material, the sides of the latter being only 3 inches thick, but having a little extra cement in the mixture to make it hold water securely.

For foundations and other parts where greater strength is desired, to each five measures of ashes mix one of sharp sand and one of cement: for the first 3 feet of height in the walls over the floor-line use six parts of ashes, and for the remainder use seven parts of ashes, with the same quantities of sand and cement all through.

The Foundations.

The width of the trenches should be 5 inches wider than the thickness of the walls to be erected, and where the ground is solid, affording a good foundation, the depth need not be more than 6 inches, in which it is recommended that from 2 to 3 inches thick of sand be placed under the concrete. If, however, the ground is of an unreliable nature and it is necessary to go deeper to get a solid bottom a thickness of 6 inches of sand should be put in. This should be evenly spread and wetted before the concrete is placed. To strengthen the foundation, at a distance of 3 inches from the bottom of the concrete place under the outer walls three rows and under inner walls two rows of $\frac{3}{4}$ -inch round iron rods well lapped and hooked at joinings, and turned at angles.

Walls, Frames, and Finishing.

The walls at the set-off for footings at the level of window-sills and at the heads of openings should have a continuous row of wire-netting binding, secured to frames where they cross.

All door and window-frames should be secured with wire or hoop-iron ties, the ends being turned into the concrete. Ventilators for underfloors and ceilings are made of $\frac{3}{4}$ -inch timber boxes, having wire-netting and gauze tacked on.

Where holes require to be provided for pipes, bolts, &c., in stone concrete buildings, it is necessary to make provision for these as the walls are erected, otherwise some hard cutting has to be done, but in ash concrete the cutting is an easy job, and a hole can be bored with a brace and drill.

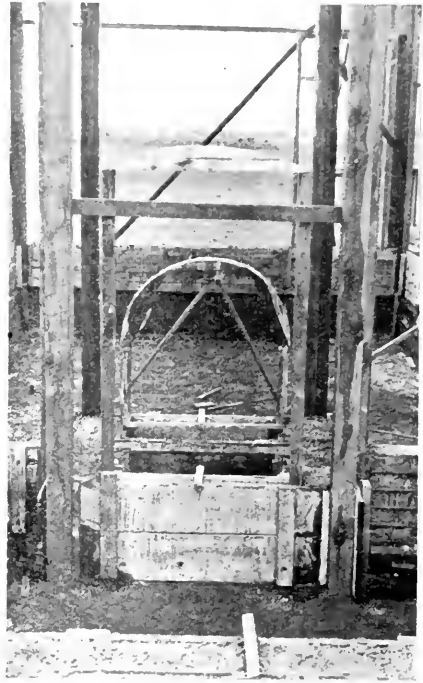


Fig. 20.—Framing over a double fireplace in cottage.

Plugging for nailing is also unnecessary, as the concrete holds nails well, and picture rails, architraves, skirtings, &c., can be nailed directly on to it. Fine nails should, however, be used.

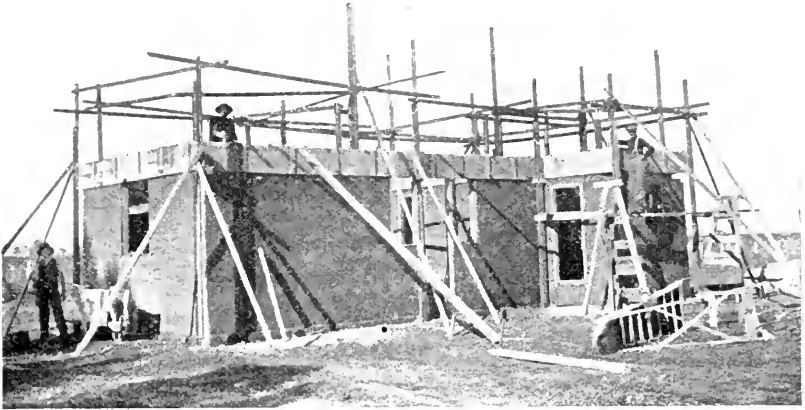


Fig. 21.—Portion of a cottage in course of erection.

For plain buildings, and especially if protected by a verandah, a good face can be put on with a mere skimming of cement mortar, rubbed on with a piece of bagging held tightly over a piece of board, similar to a plasterer's floating trowel. For better-class work a thicker coat is desirable, but not more than $\frac{3}{8}$ inch thick anywhere.



Fig. 22.—A small dairy built of ash concrete. Note the neat and solid appearance.

Lime plastering may be applied to the inside where desired and finished with a coloured putty coat, as is usual in brick buildings. It is, however, desirable to use a little cement in the first coat of the plaster, which makes it withstand nails and knocks, without damage to the face of the walls.

The Cost.

The cost of materials varies considerably according to the locality, the distance they have to be conveyed, and so on. The ashes are usually obtainable at 2s. per ton, and if they are reasonably dry there should be about 45 cubic feet in each ton. Sand may be anything from 3s. to 15s. per cubic yard, and cement 5s. to 8s. 6d. per bag, if a full truck-load is taken. The cost of the materials would have to be worked out when it was ascertained how many cubic yards of concrete have to be used. Usually there are about 50 cubic yards in a cottage having four rooms and kitchen.

The cost of labour, including the making of the forms, the digging of the foundation trenches, and cleaning down on completion may be stated at 13s. per cubic yard, where the walls are not less than 4 inches nor more than 6 inches thick. When the walls are thicker the cost per cubic yard will be less, and if thinner, more than 13s. Plastering costs for bagging as described about 8d. per superficial yard, and if $\frac{3}{4}$ inch thick 1s. 6d. for labour and materials. From the above figures it can be ascertained what the finished walls will cost.

The cost of similar work done on the Department's experiment farms has been at least 2s. per square yard less than weatherboard buildings would cost, and the work has been quite satisfactory in other ways.

Remarks.

The uses to which this concrete may be put on the farm are almost unlimited, once the farmer or his handy man has mastered the making of forms and the mixing and placing of the material.

Feed and water troughs (either fixed or portable), slabs for paving, fence and gate posts, steps for doorways, pipes for drains, and blocks for buildings may be made on wet days when other work cannot be done. The thing is to have the materials on hand ready for the wet days.

For most of the above items the concrete must be strengthened or reinforced, for which purpose old fencing wire or wire-netting may be used, placed near to the outer surfaces.

All finishing coating—that is, the plastering—should be put on while the concrete is green, but if it should be dry on the surface, wetting before plastering will assist the suction. The mixture for this finishing coat should usually be three parts sand to one of cement.

Concrete Floors.*

The materials required for making concrete floors are old bricks, blue metal, or sandstone broken to 1½-inch or 2-inch gauge, clean, sharp sand, Portland cement, and clean water; a gauge-box (Fig. 23), made of boards, 12 inches deep, measuring 4 ft. 6 in. x 3 ft. inside, is also required. This is laid on a prepared platform of planks bedded flat and close together. Set the box on the platform, fill it with the stone, and again nearly half-full of sand; mix these together, then add one and a half bags or half a cask of cement, and mix all together dry, by turning over with shovels *twice*; then turn a third time, and while this is being done one man should sprinkle the water over from a watering-can; this heap should again be turned over, when any dry stuff should be wet as before. Care must be taken not to use too much water, as the concrete must not be sloppy; and after it is laid it should be lightly rammed with a flat rammer, say 12 in. x 10 in. on the face.

* A. Brooks, Works Overseer, Department of Agriculture.

A Cheaper Concrete for Cow-bail or Pig-sty Floors.

Spread and ram down to the required levels the dry stone or other aggregate to be used, which need not in this case be broken to any particular gauge. Mix a batch of stone lime mortar, using three parts sand to one of unslaked lime. This may be made up by opening out the centre of the heap of sand and placing the unslaked fresh lime in the

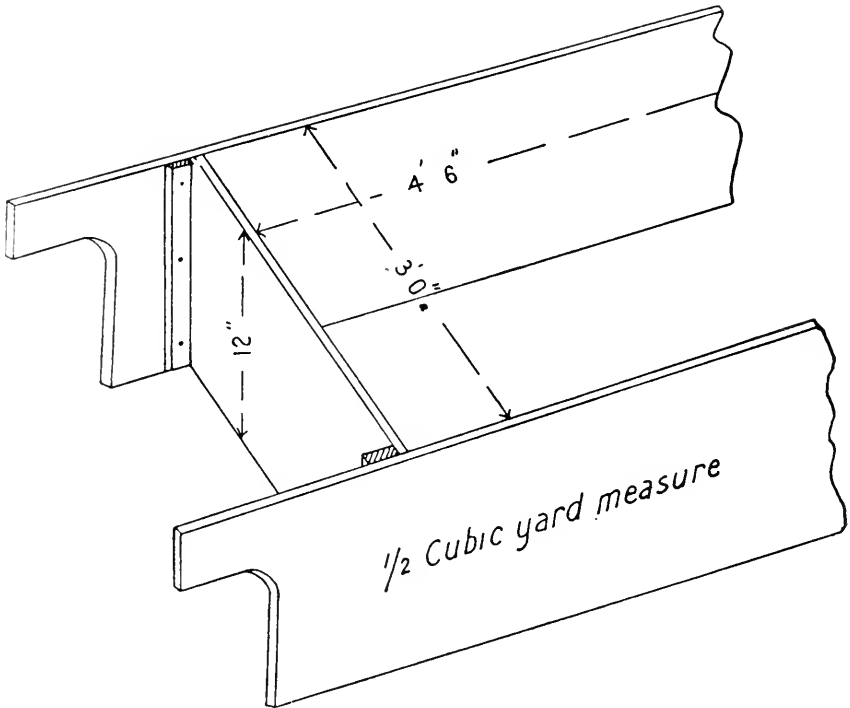


Fig. 23.

centre; then sprinkle enough water on to reduce the lime to a powder, add enough water to make it like milk, and gradually mix in the sand; knock the lot into a heap, cover with a little dry sand, and let it stand for a week. Mix up this into a grout or liquid mortar, and pour it over the dry stones until all the spaces are filled in, and next day render or plaster the top off with a coat of cement mortar $\frac{1}{2}$ inch thick, ruled straight and trowelled hard.

Rendering.

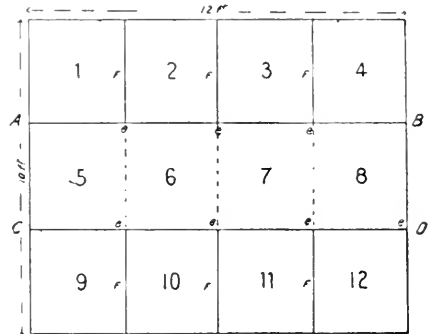
This is the term given to the finished coat applied to walls or floors, and is usually done with cement mortar made of two parts clean sand to one part Portland cement, worked together through a fine sieve before being wetted for use. Care should be taken not to wet up any more than can be used within a half hour, as some cements set quickly (an indication they are not the best).

Mixing and Laying Concrete Floors.

A few hints as to how to mix and lay cement concrete, especially for such as pig-sty floors, may prove useful, and are given here in the hope that they may prove so.

Laying concrete floors requires two distinct operations—first, laying and ramming (lightly) the concrete in position, and then rendering or top-dressing with cement-mortar made of clean sand two parts to one part Portland cement, evenly laid and trowelled hard to a smooth finish. Concrete that is to be so top-dressed must never be allowed to dry before the rendering is put on, otherwise it will not adhere together, and no floor should be laid in large areas, but in small, easily worked slabs, otherwise the floor is sure to crack in various directions. This is more likely with floors of less than 6 inches thick.

To lay a concrete floor, say 12 ft. x 10 ft. and 4 inches thick, to be top-dressed (rendered) to a smooth finish, determine the height to the finished surface, and drive in pegs at the four corners; with a straight-edge or levelling rule, laid on the top of these pegs, measure down and cut out the soil to a hard, even surface, using the spade or square-mouthed shovel only, 4 inches below the straight-edge in every direction. This will make room for a slab of concrete 4 inches thick all over. Then divide the area into, say, twelve squares of 3 ft. 4 in. x 3 ft., as in the accompanying diagram, numbered 1 to 12, and



using boards 4 inches wide, with the upper edges straight, lay one from A to B and another from C to D, and drive pegs in the centre space behind them, as at *e, e, e*; then using short boards 3 ft. 4 in. long, place them three on each side, as at *F, F, F*, and fix them in position with pegs as before. Note that these pegs are not to be in the spaces to be filled with concrete; it is sometimes necessary to have them so, but they must be removed, and the holes filled in with cement mortar as soon as possible.

Having the concrete mixed, fill in slabs Nos. 1, 3, 9, and 11, keeping the surface lightly rammed down $\frac{1}{2}$ inch below the edges of the boards, to allow for the top-dressing. These should be allowed to set for, say, twenty-four hours, when the top may be finished off, trowelling hard with a steel trowel for a smooth face, or with a wood float or trowel if required for a rough face. Cut off the corners half V shape; then take up the short boards and place a strip of strong brown paper against the edges of the finished slabs; fill in Nos. 2, 4, 10, and 12, allow to set, and finish as before, then Nos. 5 and 7, then 6 and 8, and the floor is laid in twelve separate blocks that will, if the stuff has been properly mixed and a liberal amount of elbow-grease used, never crack or wear out. The quantities of material required for this floor would be—

1½ cubic yards stone, broken to 1½-inch gauge.

¾ cubic yard clean sand.

6 bags or two casks Portland cement.

TREES FOR SHADE AND SHELTER.

One thing that strikes the observer about the homes of many of our farmers and settlers is the absence of shelter or shade trees. Everyone will readily admit that the country homestead where judicious tree-planting or preservation of natural trees has been practised, has a more attractive appearance than the bare, sun-burnt, wind-swept spot unfortunately so commonly met with. Nor has the necessity of conserving or planting shade and shelter trees in the subdivision paddocks yet received the attention that it deserves.

That shade and shelter is appreciated by man and beast is beyond dispute. Apart from naturally timberless country, the bare appearance of the homestead and of the open, wind-swept paddocks is due to various causes. Want of foresight in the original clearing operations, and lack of knowledge of what kind of trees will grow and provide the desired shade and shelter, are probably the chief causes.

The stock-owner should recognise the value of shade and shelter. A little rough hill on the property, covered with stunted gum-trees, is worth more to the farmer as it stands for shelter purposes than the small amount of grass it will grow should he decide to have it rung. To the settlers in naturally clear country, judicious planting is a necessity. Some of our native trees lend themselves for shelter purposes admirably, while some species from other parts of the world adapt themselves to the same purpose.

Preparatory Work.

Before planting, the ground should be well worked to a depth of 12 to 15 inches. Where this can be done by ploughing and subsoiling the initial cost for shelter breaks is reduced. The area proposed to be planted should be broken up early in the autumn months, leaving the surface rough. When ready to plant, the harrows should be run over it. If the ploughing has been done early in the season, the ground should now be in good tilth and in proper working condition.

Open out holes sufficiently large to give room to spread the roots of the young trees evenly. In opening out the holes, put the surface soil on one side. When refilling the hole, the surface soil should be again put on top. Nothing is gained by bringing up the subsoil to the surface round the young plant. Loosen the subsoil as much as possible, but leave it underneath the surface.

Planting Operations.

The distance apart that the trees should be planted for shelter belts varies considerably with the variety of tree to be planted. However, the distance apart is not of such vital importance in shelter belts; the object is to get a breakwind as quickly as possible. Close planting forms a denser shelter than more open planting, but if the trees are to develop, thinning out must be done in the future. Thin early, before the bottom branches die off.

Assuming that the area to be planted is now ready, and the young trees are at hand, carefully spread the roots evenly in the hole. Fill in with surface soil, and tramp the ground firmly round. If water is available, leave a slight depression round the tree; put a spadeful of soil round the collar or

neck of the plant; then fill up the hollow with water. After the water has thoroughly soaked in, fill up the depression with dry soil, leaving it as loose as possible. It acts as a mulch and retards evaporation. A tree so treated will have a certain amount of moisture near the roots for a considerable time afterwards. It is a good plan to dip open-rooted plants—*i.e.*, plants received from the nursery with no soil attached—in a stiff clay puddle before planting. Young trees taken from pots should have the ball of earth attached loosened at the bottom, and some of the roots spread out.

Pack the soil thoroughly up to plants taken from pots when planting. Young trees are often lost through neglecting this necessary packing of the soil to the plant. Young trees which are struggling to get a hold of the soil begin to grow after a simple trampling of the soil firmly round them. Inexperienced planters are liable to fall into this error often from a mistaken fear of causing injury.

Best Time to Plant.

The months of June, July, and August are the usual months of the year for planting, but no hard-and-fast rule can be laid down. For trees that shed their leaves during the winter, the months mentioned are the only ones. Evergreen sorts, usually sent out by nurserymen in pots, can be planted either much earlier or later.

Getting the planting done as early as possible is sound practice. The young trees thus get the benefit of the winter rains, and stand a much better chance of becoming established before the heat of summer is due. In districts subject to severe frosts, planting operations may extend up to early in October. One advantage, however, of early planting is that should a tree fail, the failure may be noticed in time to replant again with a fair chance of success.

Care of Young Trees.

The young trees must be protected from stock, either by a system of tree-guards or, if planted in shelter belts, by running a line of fence round them. This protection should be afforded till the trees are sufficiently grown to be out of the reach of large animals. Rabbit-infested country will require closer protection by wire-netting the plantations. Any attention given, such as keeping the surface loose and free from weeds, will repay the trouble taken; it will serve a double purpose, assisting the growth of the trees and reducing the risk of injury by fire.

Some Useful Kinds for Various Districts.*

Not the least important consideration in planting trees for shade and effect in parks and reserves, or for shade and shelter of stock, is the choice of the right kinds. Planting close to the sea, but with shelter on the ocean side, is quite a different matter from planting on the ocean front. The low-lying areas, or those under 300 feet above sea-level, must be content with a smaller assortment than is available for higher altitudes. Residents of coastal areas cannot expect to grow the beautiful native trees of the western plains; nor will the plains raise the rich vegetation of the coast, however kind the cultivation may be. Districts with long frost periods must have special consideration, and all these several considerations are varied by exceptions, some districts having a large range of possibilities.

* E. N. Ward, Superintendent, Botanic Gardens, Sydney.

Wherever any extensive planting is being considered, careful note should be taken of trees that are already growing well in the district in private or public places, and failing evidence of this kind, the advice of experts should be obtained.

Trees to Plant in Warm Coastal Districts.

In making a few suggestions as to trees that may be planted in various parts of the State, it is convenient first to deal with the warm coastal districts, comprising such places as Nowra, Gosford, Newcastle and West Maitland. Brief descriptions of those trees that are suitable for planting in this district (which must be distinguished from the actual coastline, which is somewhat bleaker) are given below.

Yellow Box (*Eucalyptus melliodora*) is a beautiful, quick-growing shade tree that will grow in almost any soil. While this species belongs to the tablelands there are some fine specimens near Sydney.

Lemon-scented Gum (*Eucalyptus citriodora*) makes a fine avenue along a road where there are no overhead wires to interfere with head room, especially if planted running east and west, so that they cast a shadow at midday across the road. Its clean straight stem, beautiful foliage, and shapely pyramidal head also make a very fine specimen tree.

Tallow-wood (*Eucalyptus microcorys*) for actual avenue or country road work will probably outdo the above two gums for utility, for it will stand the knife and may be kept within bounds as a shapely tree, while its dark, dense foliage when so treated is more pleasing than even the popular brush box (*Tristania conferta*) of the Sydney suburbs. It should not be thought that because these are native plants that grow wild in the bush they need little or no attention. When they are required to withstand the heavy handicap of hot and dusty road life they want all care for satisfactory results.

Silky Oak (*Grevillea robusta*), in poor soil, deeply worked, makes a fine tree unpruned, but if the soil be rich then its beauty is fleeting.

Camphor Laurel (*Cinnamomum camphora*), if the position is sheltered, very useful tree, amenable to hard pruning, and capable of standing long periods of dry weather.

Palm (*Cocos plumosa*) is most useful in single rows, and so is the Lilly Pilly (*Eugenia Smithii*) in districts where scale insects do not overwhelm it.

Swamp Mahogany (*Eucalyptus robusta*), as the name implies, grows in moist, boggy places, or in places that are brackish, and it is suitable for a shelter break.

Grey Ironbark (*Eucalyptus paniculata*) responds readily to culture in rich, heavy soil; while in clayey ironstone, the Woollybutt (*Eucalyptus longifolia*) is a quick grower, and on account of the leafy shade it affords makes a suitable tree for almost any kind of planting.

Bloodwood (*Eucalyptus corymbosa*) should be commonly planted in districts where bee farming is common.

Cootamundra Wattle (*Acacia Baileyana*) makes an excellent and showy shelter; in fact, as a nurse until other slower-growing trees are sufficiently established to fend for themselves, this wattle cannot be beaten. A double belt planted fairly close breaks the wind perfectly; its foliage seems to be just the right kind for the purpose. The trees or shelter brakes are usually planted far too close (in many cases only 8 feet apart); 20 feet is not

too far apart. The trees can then develop into branching specimens, suitable not only to shelter stock on the lee side of the break, but in time, underneath the trees themselves.

George's River Wattle or Coast Myall (*Acacia glaucescens*) makes a quick-growing shelter and as a tree up to 30 feet high.

Cape Chestnut (*Calodendron capensis*) is only partially deciduous; its foliage is pleasing and dense, and once a year it is clothed profusely with handsome heads of flowers. Although this subject is rather slow at first, it is well worth waiting for.

Australian Wheel Tree (*Stenocarpus sinuatus*) is an upright, shapely, dark foliaged and evergreen tree, with brilliant scarlet wheel-shaped flowers. It is slow in growth in its early treehood, but extremely hardy when established.

One of the New South Wales pine family, the Native Plum Tree (*Podocarpus elata*) makes a fine upright tree, with pleasing outlines, and does not look so sombre as do most pines. This subject is useful for all purposes, either as specimen, avenue, windbreak, or for stock shelter in groups.

Bleak Situations and Close to the Sea.

For exposed spots on the coast that have to be planted rather from necessity than choice, the following have proved themselves to be suitable with a little protection during their early stages of growth.

The Bangalay of New South Wales (*Eucalyptus botryoides*) can be grown and pruned like the Tallow-wood. One of the Apple trees (*Angophora lanceolata*), well planted and cared for, will make good and respond to the pruning knife. The Norfolk Island Pine and a variety of the Hoop Pine of Queensland (*Araucaria excelsa* and *Araucaria Cunninghamii glauca* respectively) are well known in the Sydney district. The Port Jackson Fig (*Ficus rubiginosa*), if taken care of until established, will make one of the best trees on our beaches, and in very bleak spots the Moreton Bay Fig (for which all gardeners have such a hatred) should be planted.

For sheer hardiness a Rata of New Zealand (*Metrosideros tomentosa*) takes some beating. Its fine dark foliage, with brilliant scarlet flowers at Christmas time, have given it the name of New Zealand Christmas tree. Growing right on the beach at Newcastle, this bushy tree lends grateful shade and protection as a breakwind. *Pinus insignis* is useful in bleak places, but inland it should only be planted for box-timber purposes; there are enough planted for ornamental purposes already. The White Oak (*Lagunaria Patersonii*) is often used to advantage. Planted with some kind of shelter, it is surprising how hardy it really is.

Coral Tree (*Erythrina indica*) may be planted like the White Oak, and it will stand cutting about in a wonderful way. The only objection to this tree is the litter it makes when it is shedding its leaves. As shelter for pigs and poultry yards it is excellent.

Probably the finest subject for the beach, if proper attention is given it, is the Canary Island Palm (*Phoenix canariensis*). If it were realised that this palm tree (for it really is a tree) would in twenty-five years' time possess a bold single trunk supporting a head of graceful palm leaves spreading 15 to 18 feet from the stem and high enough to drive under, it would be planted more widely. The mistake is often made of not planting them far enough apart—40 feet is quite near enough. Many try to make a stem before the palm is ready for it by cutting away the bottom fronds, but

nothing is more injurious to any palm than taking away its foliage before it has decayed naturally; such treatment stunts the plant, and makes a shrub of it instead of a tree.

For shelter groves the New Zealand Karaka (*Corynocarpus laevigata*) is recommended. For low land breaks or hedges the New Zealand Karamu (*Coprosma Buckeri*), used largely in Sydney and Melbourne, where it is known as "The Looking-glass Tree," is excellent; so indifferent is this plant to the effects of the coastal bleakness that it seems to flourish best when in reach of the ocean spray.

The Oleander of Africa (*Verium oleander*) is very hardy as a windbreak on bleak places, but it is not recommended for stock shelter on account of its foliage being poisonous when wilted.

For group planting for either shelter or ornamentation the Sydney Golden Wattle (*Acacia longifolia*) and the Sally (*A. floribunda*) are quick growers. They flower profusely in mid-winter, and should also be planted as nurses to slower and longer-lived subjects.

Maiden's Wattle (*Acacia Maidenii*) is more branched, grows to a greater height than the former, and lends itself to grouping in poor rocky soils; and the White Wattle (*Acacia binervata*) is useful for ornamentation, shade and shelter.

Grey Gum (*Eucalyptus punctata*) makes a handsome tree close to the sea, growing as it does in rough stony places, overlooking gullies or tidal waters.

Red Mahogany (*Eucalyptus resinifera*) is a well-foliaged tree, free-flowering, of symmetrical shape, and stands the knife.

Blackbutt (*Eucalyptus pilularis*) grows quickly into small or large trees according to the depth and richness of the soil, is free-flowering, and makes an excellent subject, planted rather thickly, for grove shelter purposes. On low-lying and flat areas the Broad-leaved Ironbark (*Eucalyptus siderophloia*) is a suitable tree for shade in groups, or specimens.

For quick-growing groups the two *Casuarinas*, *stricta* and *glauca*, are both useful and ornamental, the latter preferring brackish water.

The Tablelands.

In this section may be included Goulburn, Moss Vale, Bathurst, Scone, Glen Innes, Armidale, Tamworth, and all similar places.

Some of the finest trees for these districts are those growing naturally. The Yellow Box (*Eucalyptus melliodora*), for instance, which has also been recommended for the coastal districts. The Apple (*Eucalyptus Stuartiana*) is growing at most of the places mentioned above, as Apple chiefly, but in some places as Peppermint, Woollybutt, Sally, or Pepperwood. No tree is better suited for ornamental planting than this beautiful white-branched and graceful-leaved gum.

Mountain Gum (*Eucalyptus goniocalyx*) makes a fine subject for street planting; it stands pruning, its large and long leaves afford plenty of shade, and young plants respond readily to cultural treatment. Another handsome street tree is the Cider Gum (*Eucalyptus Gunnii*); its long, dark green and shining leaves hanging from white stems fully compensate for its one dirty habit of shedding its bark. This gum also responds quickly after the knife. For country road work, the Red Stringybark (*Eucalyptus eugenioides*) grows into a large tree, densely foliaged, and will stand pruning into shape as it grows. Very handsome in habit is the Narrow-leaf Peppermint (*Eucalyptus radiata*), with its pendulous stems and willow-like leaves. It responds quickly after pruning, and makes a good subject for all purposes. Two

other pendulous species of Eucalyptus are recommended for street work in *E. aggregata*, as graceful as a Weeping Willow, and the Camden Woollybutt (*E. Macarthurii*), which is more branched than the former, and can be pruned with impunity.

For grouping, groves, or coppice work for shelter purposes, the following eucalypts respond readily to cultivation, and their quick growth and spreading habit render them specially suitable for this purpose:—

Mountain Bloodwood (*E. eximia*), so well known to visitors to the Blue Mountains.

Mountain Ash (*E. Sieberiana*), another free-flowering tree; in fact, it flowers nearly the whole year round.

Snapping Gum (*E. Bancroftii*), grows well in rocky but moist places.

An Ash (*E. Smithii*), a much-foliaged and ornamental tree.

The most attractive of all wattles is *Acaciaolata*, the Cedar Wattle. Its foliage is extremely handsome, as dense as the Pepper tree, thus making it an ideal shade tree on hot dusty roads. In these districts it is not so subject to the borers that so readily attack other wattles. For quick shelter in groups and belts there are several wattles suitable for the tablelands, that grow into small trees almost as serviceable as the Cootamundra Wattle. A few are—*Acacia fimbriata*, known as the New England Wattle; *A. decurrens* var. *normalis*, quick growing, with ornamental foliage, and free flowering; *A. spectabilis*, the Mudgee Golden Wattle, which has fern-like leaves of a pale glaucous colour, and is probably the most handsome of all wattles.

Plane Tree (*Platanus orientalis*) is a difficult tree to improve upon, if we except, perhaps, the Sweet Gum (which is not a gum) of Canada (*Liquidambar styraciflua*). These trees are shapely in habit, hardy and quick growers, and almost free from disease in this State.

Where conditions are very dry the Honey Locust (*Gleditsia triacanthos*) makes a fine upright avenue tree with light ornamental foliage, resembling the Robinia without its suckering propensities. This tree also makes fine hedges and groups for sheltering stock. The Pin Oak (*Quercus palustris*), with its wonderful autumn-coloured foliage, is one of the best street trees known.

There are several other trees suitable for tableland districts, but the difficulty is they are not easily procurable.

There are also some non-suckering poplars well suited for these places, but nurserymen's stocks appear to be very low.

Extremely Cold Districts.

In places such as the Monaro, where the cold is such that trees (and, in fact, all plants) enjoy a complete rest, or what the gardener calls a dormant period, one cannot do better than imitate a European style of planting. A visit to such a place as Mount Wilson would serve as a good object lesson. There Chestnut, Oak, Lime, Beech, Catalpa, Elm, Ash, Poplar, Sycamore, Zelkova, all revel in the rich soil and congenial climate.

There are, however, a few of our native trees, especially gums and wattles, that should not be overlooked. The following four eucalypts make excellent street trees:—

Blue Gum (*E. Maidenii*).—A quick grower, and can be pruned to almost any size.

Tasmanian Blue Gum (*E. globulus*).—Known the world over for this work; its pleasing silvery foliage in its early treehood makes it always a popular tree.

E. Stuartiana, recommended also for the tableland, is also hardy enough for these extremely cold places; while the Red Box (*E. polyanthema*) is pleasing from its youth till it is old and gnarled.

For grouping for shelter, the Argyle Apple and the White Gum (*E. cinerea* and *E. coriacea* respectively), planted thickly, are both effective and useful, and for the same purpose the following acacias have been well tried:—

A Silver Wattle (*A. dealbata*); Blackwood (*A. melanoxylon*); Native Hickory (*A. pennivervis*); Narrow-leaved Wattle (*A. nerifolia*); and Lady's Finger Wattle (*A. Cunninghamii*).

For further grouping, the various hawthorns are hardy and showy in flower and in berry. The Mountain Ash or Rowan Tree (*Pyrus aucuparia*) and the Service Tree (*Pyrus sorbus*) are useful, as is the Strawberry Tree (*Arbutus canariensis*).

Hot and Arid Districts.

Here is the place for the Pepper Tree (*Schinus molle*). It is doubtful whether a more graceful or more suitable tree could be found; and though overplanted in places, many way-back towns would look very hot, dry, and dreary were it not for their Pepper trees. There are, however, several trees that may be grown with the Pepper.

The Carob (*Ceratonia siliqua*), well suited for a hot, dry climate, is rather slow in growth. The White Cedar (*Melia Azedarach*) is also a good subject, and if the ground is well worked the Kurrajong (*Brachyachiton populaceum*) takes some beating. The Tree of Heaven (*Ailanthus glandulosa*) is useful; and where there is some water to spare, the Oriental Plane Tree again becomes useful, as does the Live or Evergreen Oak (*Quercus virginiana*). The Bunya-Bunya (*Araucaria Bidwilli*) makes a change; and if the soil has a retentive wet bottom, the Date Palm (*Phoenix dactylifera*) and the Weeping Willow are useful. The Sugar Gum will grow well for a while, but becomes diseased if it receives a check of any kind.

There are several eucalypts that seem to revel in these arid places, but rarely do you see them put to practical use for shade or shelter or even ornamentation planting. They are as follows:—

New England Blackbutt (*E. Andrewsii*).—A tall and quick grower, with pleasing foliage.

Red or Narrow-leaf Ironbark (*E. crebra*).—A graceful tree with long willow-like leaves, densely foliaged, affording good shade, and flowers freely.

E. bicolor.—Large weeping trees, suitable for moist boggy places in the west.

The profuse, flowering White Box (*E. lemnifolia*, var. *albena*) is excellent for bees, will stand a fair amount of pruning, and has distinct coloured foliage slightly pendulous.

Silver-leaf Ironbark (*E. melanophloia*) makes a pleasing street tree with its black stem and silvery white foliage.

For dry and exposed places *E. elatophora* does remarkably well.

There are a few wattles I would like to see tried as street trees. I have only the habit and longevity of the trees to guide me in this recommendation, and as they are strictly western trees or trees of the interior, it is left to tree lovers of these dry arid districts to give them trial:—*Acacia difformis* (Sally), I feel sure, would respond to cultivation and grow up to 30 feet high. The Yarran (*A. homalophylla*) should make another pleasing tree. *A. doratoylon* (Currawang) flowers freely and is well foliaged; while on the black soil country the Myall (*A. pendula*) would make an avenue of trees worth travelling there to see.

Wattles recommended for groves for shelter are *A. cultrijformis*; *A. aneura* (the Mulga), a fairly large and much-branched shrub; and *A. Kempiana*, also a well-foliaged and much-branched wattle.

The Northern Rivers.

In very warm and moist situations many trees can be recommended for avenues that in other places could only be used as specimen trees. For such places *Jacaranda ovalifolia* stands out as a charming tree for both foliage and flower. The Illawarra Flame Tree (*Brachychiton acerifolia*) makes a fine contrast to the blue of the *Jacaranda*.

In wet places *Melaleuca leucadendron* makes an ideal street tree. The Native Teak (*Plindersia australis*) should be one of the first; and the South African *Harpephyllum caffrum* makes one of the most dense and symmetrical trees known. The several figs *Ficus Benjaminia* (Weeping Fig); *Ficus Hillii* (White-stemmed Fig); and *Ficus Cunninghamii* must also be included.

There are some handsome eucalypts suitable for street and road work on the rivers. Spotted Gum (*Eucalyptus maculata*) and its variety *citriodora* (the Lemon-scented Gum) are excellent, the latter, with its clean stem carrying a well-shaped pyramidal head of pleasing foliage-making one of the best of street trees. The Tallow-wood (*E. microcorys*) is hard to beat for shade and ornamental planting. It can be pruned to any shape at any season of the year. When clothed with young growth the contrast with mature foliage is as pleasing as the *Eugenia*s at the same stage. *E. planchoniana* will grow in bleak and rocky places near the ocean at these warm places, and makes a pleasing tree of medium size. The Sydney Blue Gum (*E. saligna*) makes a tall tree of a greyish colour, which for belting and grouping for shelter is both ornamental and useful, and for the same purpose the following acacias are useful:—

A. aulacocarpa (Hickory Wattle) is quite distinctive; *A. complanata* makes a small glabrous tree; the *pauciglansulosa* variety of *A. decurrens* is a medium-sized tree with light soft foliage; nothing could be more ornamental than a breakwind of *A. podalyriaefolia* (the Queensland Wattle), its quick growth of mealy whiteness, its exceptionally free flowering, and the manner in which it breaks away after severe pruning, making this species very popular.

The Native Coogera (*Nephelium divaricatum*) and the Tulip-wood (*Harpullia pendula*) are equalled by none when fully grown. Such places as Lismore, Byron Bay, and Grafton could be made the Riviera of Australia, for the range of trees available is legion. The possibilities are such that if the residents only realised them no place in Australia could catch them up in æsthetic tree-planting.

There may be a few trees named among the foregoing that nurserymen do not stock in quantity, but generally no tree has been recommended that cannot be procured.

In many parts of Australia men have ruthlessly destroyed trees to make room for other vegetation, for houses and highways. There is, however, a growing tendency to preserve and replant; and graziers are beginning to realise that, apart from the beauty of the trees, the grateful shade they afford is economically beneficial to man and animals alike.

It will be noted that most of the trees recommended are natives of Australia.

SECTION IV.

Wheat Culture.*

THE present important position of wheat-growing in New South Wales is the result of a development extending over the past thirty years. In 1891 the area devoted to this cereal was only one-third of a million acres; to-day it is more than ten times that. In 1891 wheat occupied less than 40 per cent. of all our cultivated lands; to-day it represents over 80 per cent.

Upon the factors that have influenced this development it is impossible to dwell here, but two or three may be briefly indicated.

In the first place, wheat is a staple article of food with all white peoples, and the number of consumers is being steadily increased, not alone in obedience to natural law, but by other races becoming eaters of bread. An assured market thus awaits the grower, and for the most part at a payable price.

The comparative ease with which wheat can be grown has also influenced the rapid extension of our wheat areas. To be sure, the day when the seed was sown on land prepared in a rough and casual manner is passing, but farmers know that—however much better they might do with improved agricultural methods—crops of 10 to 12 bushels are reasonably assured under average conditions at no greater outlay than is necessary for a single ploughing, a couple of strokes of the harrows, and perhaps 56 lb. super-phosphate.

While the inducement and the opportunity have thus been presented, two other factors of much significance have also operated; first, the production of improved varieties, and, second, the evolution (for such it has largely been) of better cultural methods and of better machinery. For the first of these the late Mr. William Farrer was notably responsible. By the crossing of numbers of varieties, he and his successors in this work produced wheats of such yielding capacity under dry conditions as Federation, Hard Federation, Canberra, Bomen, Firbank, Florence, and Clarendon, thereby enabling large areas hitherto considered outside the wheat belt to be brought under cultivation. Improved farm methods and modern machinery have done hardly less for this industry in New South Wales than the first. It may be anticipated that the practice by which two years' rainfall can be made to serve for the growth of one crop will enable still further extension of our wheat-growing areas into dry districts, while considerable improvements in the machinery used for sowing and harvesting the crop have acted as some set-off against the increasing rates of wages and prices of necessary commodities. It is hoped that the following pages will induce growers to employ only the best varieties and the best methods.

* This section, originally compiled by Mr. H. Ross, now Manager of Wagga Experiment Farm, has been revised by Mr. Ross, Mr. A. H. E. McDonald, Chief Inspector of Agriculture, and several other field officers.

The Wheat Districts of New South Wales.

The districts of New South Wales in which wheat is grown may, for convenience and for purposes of easy identification, be classified briefly as follows:—

1. Coastal (embracing those districts bordering on the coast, and which are specially subject to rust).
2. Northern Tableland (of which Glen Innes is representative).
3. Central Tableland (of which Bathurst is representative).
4. South-western Slopes and Riverina (of which Wagga is representative).
5. Central-western Slopes (of which Narromine, Dubbo, Gilgandra, Wellington, Cowra, Grenfell, Forbes, and Parkes are representative).



Progressive Methods in the Wagga District.

6. North-western Slopes (of which Tamworth and Gunnedah are representative).
7. Black Soil Plains (of which Coonamble is representative).
8. Western Plains (of which Nyngan is representative).

The soils in these districts vary considerably from both mechanical and chemical points of view; it would be quite impossible here to make any attempt at classification, and it is sufficient to state that they are usually of either basaltic or granitic origin, the granite formation prevailing.

Grey and yellow box, pine, apple-tree, kurrajong, belar and she-oak are the timbers most commonly met with in those western districts where grain production is largest, and it is these which land-seekers usually look for in selecting their prospective homes. Yet timber alone does not determine the suitability or otherwise of land for wheat-growing, and many other aspects, such as subsoil, rainfall, &c., have to be taken into consideration. Reference to these will be made further on.

The purposes for which wheat is grown differ a good deal in different parts of the State. The moist, humid conditions on the coast preclude the production of grain, except in small areas and in favoured localities, and of the area there devoted to this cereal over half is cut for hay, and quite

10 per cent. for green feed, while on the Tablelands quite half the total area is also at present used for hay. On the Western Slopes and Riverina the vast bulk of the wheat sown is reserved for grain, the proportion of hay rarely reaching one-fifth in an average season. In the far western districts, represented by Nyngan Experiment Farm, hay is again the chief consideration. For these different districts and purposes, as will be apparent in the following pages, different varieties are specially adapted, and farmers should be careful to make their selections accordingly. In view of the preponderating importance of the grain crop, it is fitting that its production should receive the greater consideration, although the adaptation of the same general principles to drier districts, and for purposes of hay and green feed, will be found easy, and, indeed, essential to the best results.

Clearing Land for Wheat-growing.

Two methods are employed in clearing wheat land for the plough: First, grubbing out the trees and roots to a depth of 6 or 9 inches; and second, burning off the timber and stumps just 1 or 2 inches below the surface. The latter method is generally referred to as "Yankee grubbing." On land cleared by the former process a set-plough is used; in the latter case a stump-jump plough is necessary.

The cost of Yankee grubbing depends entirely on the length of time the timber has been ringbarked. Thus, a paddock in which the timber has been rung, say, for seven or eight years will cost far less to clear than a paddock in which the timber has only been rung for three or four years.

The usual procedure is to stack small wood and limbs against the ringbarked trees, and then to fire the pile. March is considered the best time for burning off.

Land can be cleared in this way, ready for the stump-jump plough, at from 12s. 6d. to 25s. per acre, according to the length of time the timber has been rung. The cost of clearing land for the set-plough—that is, grubbing stumps and roots to a depth of 9 to 12 inches—will be just double in most cases, while in some instances where the paddock is very thickly timbered it will be considerably more.

Yankee grubbing is the method employed by many wheat-growers. The man who is just making a start frequently cannot afford the extra cost of clearing thoroughly, and as he is anxious to get as much crop in as possible during the first year, he cannot afford the time to thoroughly rid the paddock of all stumps and roots.

The general opinion held by wheat-growers is that the yields from a Yankee-grubbed and from a thoroughly cleared paddock, other conditions being equal, are about the same.

At Glen Innes the method has been adopted of grubbing the roots near the surface and then pulling down the tree with the grubber. In this way it is possible to clear to a depth of 8 inches.

The stump-jump plough works well on the stony land on the Northern Tablelands. It breaks the soil up thoroughly, though not so neatly perhaps as the set plough. The disc plough is used to some extent in that portion of the State.

The cost of ploughing with a stump-jumper does not exceed that of ploughing with a set-plough. The former is certainly a little heavier, but this can hardly be taken into consideration. As to the respective merits of the work performed by the two kinds of ploughs, there is not much to choose; but for obvious reasons a stump-jump plough is only used on Yankee-grubbed land.

The foregoing refers to country carrying grey box, yellow box, stringy-bark, pine, bull-oak, belah, buddah, and apple-tree. It in no way refers to tree or whipstick mallee, in which country the method of clearing is entirely different, though the stump-jump plough is invariably used.

If, on the other hand, a paddock is not immediately required for cultivation, and sufficient labour is available to clear it thoroughly, that is, to take out the stumps to a depth of 6 to 9 inches, this method has much to commend it, as it leaves the paddock clear of all stumps for all time, and any kind of plough can be employed in future operations. The methods by which land is cleared for cultivation are more fully dealt with in another portion of this Handbook under the section heading "The Farm Holding." The farmer may safely make it his motto to clear as thoroughly as possible. Well cleared land saves many a breakage.

Providing the timber is well dead and the ground dry, stumps that are fired will burn themselves out to a depth of several inches, in fact, in pine and buddah country Yankee-grubbing may then prove as thorough as grubbing out, for the fire does its work well and does not go out until it is done. The stump-jump plough will then pull out most of the running roots, which can be carted off and burned inexpensively.

CULTIVATION METHODS.

The determining factor in the cultivation of wheat in New South Wales is the rainfall; not so much the annual rainfall as the amount which falls during the growing period of the crop.

To produce a crop of 15 bushels per acre, $4\frac{1}{2}$ inches of water are required to pass through the crop*; for every additional 5 bushels, $1\frac{1}{2}$ inches are required, so that 6 inches of rain must actually pass through a crop in order to produce 20 bushels. This by no means signifies that only 6 inches of rain must fall during the growing period, because out of an actual fall of 6 inches during six months, 3 inches or more may be lost through evaporation or other causes.

The exact amount of rain that is actually needed during the growing period of the crop in order to allow 6 inches to pass through the tissues of the plant is hard to estimate, for much depends upon whether the rain has been distributed over few or many days, the condition of the soil, the temperature, the amount and velocity of prevailing winds, and many other factors; it is sufficient to say that the rainfall during the growing season in most of our wheat districts is not sufficiently large to allow 6 inches, or even $4\frac{1}{2}$ inches, of moisture to pass through the crop during the growing period.

The first impression produced by such a statement is, perhaps, surprise that wheat-growing should have become such an extensive industry as it has. In consequence, however, of the low cost of production in Australia, and of the undoubted fertility of the soil in large areas of the wheat belt, it is possible to raise crops averaging 10 to 12 bushels per acre that certainly do still leave a margin of profit. Economical methods, such as those referred to, are necessarily adopted by new settlers, and are usually profitable on

* The late Prof. King, Wisconsin.

new land for the first three or four years; they may even be adopted—and certainly are over large areas—on much older wheat-land than that, and the persistence of the system is evidence that the growers are able to show satisfactory profits. In such case the land is ploughed as early in the autumn as the conditions will allow, and harrowed or cultivated once or twice before sowing. Crops grown under such conditions are dependent entirely on the rain that falls immediately before sowing and during growth, and are consequently readily affected by an unfavourable season. The fact that there has existed, side by side with this system, another and better one has probably influenced the extension of the past few years, even though ordinary farm methods have not been affected to the extent that might have been expected.

The system advocated by the Department and adopted now to a certain extent throughout the drier districts of the State is known as “Dry Farming.” The term is somewhat of a misnomer, but it is intended to imply the use of good farming methods in dry districts for the production of crops without irrigation.

Dry Farming in Australia.

So much has been written and said about “dry farming” in America, that many are apt to conclude that only in that country has dry farming been practised. They are apt to overlook the fact that dry farming (as the term was understood until quite recently) has long been carried out in Australia.

For years past dry-farming methods have been practised in South Australia, Victoria, and New South Wales. South Australia is famous in the Commonwealth for the amount of grain produced in districts of scanty rainfall. The successful settlers in the Mallee districts of Victoria, with an annual rainfall of 12 to 16 inches, give striking examples of dry farming in that State; and in New South Wales the appearances of the farms in numerous localities and the flourishing condition of many inland towns furnish undoubted evidence of the success which has attended dry farming in those districts.

Wheat-growing is uncertain in some districts, because no attempt is made to conserve the rain that falls prior to planting. Modern methods require, and enable this to be done, and when they become general, failures in our present wheat districts will be almost unknown. The industry will then be less speculative; it will be placed on a sounder and more prosperous basis than ever; the average yield will be largely increased; the wheat belt will be widened, and a large proportion of that immense area between the limits of the 14 and 16-inch rainfall will be brought under cultivation.

“Fallowing” and its Results.

It might be said that the name under which “dry farming” more commonly goes to-day is “fallowing.” The term describes a system of cultivation that consists of ploughing the land during the year previous to sowing the crop and allowing it to rest in the interval. Its effect is to conserve in the soil and subsoil an increased amount of moisture, and to afford favourable conditions for the activities of the bacteria who prepare the stores of plant-food upon which the crop will be grown.

For twenty years the Department of Agriculture has urged the system upon the wheat farmers of New South Wales. The response has often seemed disappointingly small, but there have always been those who—good season and bad season—have been able to point to the practical results of the system and to declare that the bank-book furnished the most convincing evidence. To-day there are hundreds of farmers who each year take time by the forelock, beginning the preparation of their wheat paddocks months in advance of seeding, while hundreds of others, prevented by circumstances from putting the system into practice, freely admit that it offers them more certain and better profits if they could but take advantage of them. Slowly, no doubt, but surely, the Department's propaganda has borne fruit, and to-day not only is it possible to point to an altered attitude of farmers towards the idea of fallow, but it is reasonable also to claim that better cultivation methods have been a factor in the improvement of the yield of wheat, which, notwithstanding the extension of wheat-growing into districts once regarded as quite unsuitable, has been apparent in recent years.

The change of feeling quite evident among farmers to-day can only have taken place under the influence of hard facts—the hard facts of crops that have weathered through dry spells more healthfully and more attractively than others nearby, and that have filled more bags and returned more money. The experiment plots conducted in conjunction with the Department by many private farmers in all parts of the wheat belt during the past ten or twelve years have been a material factor in the change.

Other issues such as varieties, fertilisers, and so forth are tested on these plots from time to time, but the logic in favour of the outstanding feature of the plots—fallow—is indisputable. In the plots the Department is able to point to a mass of valuable information, and to advocate modern methods with more confidence than ever.

Behind the results obtained on these plots, too, there has also been (as already indicated) a solid and increasing body of men who have adopted fallowing as a regular feature of their farm practice, and who have done so for that best of good reasons—that it pays. Where one of this class has kept records of his returns for a number of years, and has carefully distinguished between fallow and non-fallow, the evidence can only be esteemed most valuable.

Such a record of results has been carefully kept for twenty years by Mr. W. W. Watson, of "Woodbine," Tielborne, near Parkes, who has generously made his results available for the benefit of his fellow wheat-growers.

The farm, be it related, which was acquired in 1902 (a bad year to start), consisted of 1,200 acres of conditional purchase and special lease, of which 50 acres had been cleared. Fallowing was attempted at once, 30 acres out of the 85 acres planted receiving the lengthy preparation for the 1903 planting. Those were days of small things at "Woodbine," for plant and other things were not too plentiful, and with the exception of 70 acres in 1906 no more fallowing was done for four years. As things improved, however, and resources increased, a regular application of the system became possible, and since the year 1908 Mr. Watson has always had a proportion of his wheat under fallow, and year by year the proportion has increased, until latterly the larger part of the area, and in some years the whole, have had that thorough preparation.

The accompanying table, prepared from Mr. Watson's own records, shows the cropping on the farm year by year, the rainfall, and the returns from the fallow and non-fallow areas:—

AREA cropped at "Woodbine," 1903 to 1920, showing wheat sown on fallow and stubble separately.

Year.	Wheat.						Oats.		Rainfall.	
	Grown on Fallow.		Grown on Stubble.		Hay.		Area.	Average Yield.	On crop 1 April to 8 Nov.	Total for year.
	Area.	Average Yield.	Area.	Average Yield	Area.	Average Yield.				
	acres.	ush.	acres.	bush.	acres.	tons.	acres.	bush.		
1903	31	26	55	23	15	2	20	40	12.50	19.50
1904	...	...	125	8	30	$\frac{1}{2}$	25	24	10.90	16.45
1905	...	...	150	13	20	1	...	...	12.30	20.30
1906	70	22	180	12	32	$11\frac{1}{2}$	18	32	17.35	25.75
1907	...	...	200	5	70	$3\frac{3}{4}$	30	20	7.70	18.60
1908	50	12	140	5	130	$1\frac{1}{2}$	...	...	6.20	14.16
1909	110	23	130	20	20	$11\frac{1}{2}$	60	36	10.20	15.31
1910	120	21	160	$10\frac{1}{2}$	55	1	10	16	8.42	19.18
1911	85	17	90	10	55	1	20	25	6.60	21.00
1912	210	28	85	23	65	$2\frac{1}{4}$	50	41	13.35	15.78
1913	245	15	80	$6\frac{1}{2}$	30	1	45	12	8.28	14.58
1914	210	$3\frac{1}{2}$	190	2	65	$\frac{3}{4}$	25	19	5.63	14.68
1915	400	$16\frac{1}{2}$	...	...	10	$1\frac{1}{2}$	25	26	10.07	14.12
1916	370*	10	80	12	35	$1\frac{1}{2}$	45	40	19.30	28.29
1917	250	21	80	$10\frac{1}{2}$	35	$1\frac{1}{2}$	35	47	13.42	23.29
1918	200	19	...	...	20	$1\frac{1}{2}$	30	10	9.00	14.22
1919	45	10	125^+	3	80	$3\frac{1}{2}$	30	3	6.75	15.60
1920	120	36	300	21	20	2	50	36	12.00	19.02

* 50 acres destroyed owing to excessive rains.

† 40 acres failed owing to drought.

‡ 80 acres failed owing to drought.

In compiling these figures the areas that failed have been included in the averages. In favourable seasons the hay was chiefly cut from the boundaries of crops, but in dry years it was taken off the fallow. Oats were mostly grown on stubble.

It will be interesting to present another comparison:—

Average yield per acre on fallow	...	...	...	17 bushels 51 lb.
" " " " stubble	...	...	...	11 " 44 "
Increase of fallow land over stubble	...	...	...	52.1 per cent.

The consistent excess of the "fallow" yield over the "stubble" yield is most interesting. The year 1906, for instance, must have been a most instructive one to the farmer himself. The 70 acres of fallow averaged 22 bushels, while the 180 acres on stubble land only gave 12 bushels. Again, in the bad years of 1914 and 1919, the fallow land amply paid the cost of production with $8\frac{1}{2}$ bushels and 10 bushels respectively, whereas the stubble land only gave 2 bushels and 3 bushels respectively. In 1919 practically every non-fallow crop in the district failed. Even in a wet season like 1920, when the stubble land had a rainfall of 12 inches during the growth of the crop, the fallow land still yielded over 70 per cent. more, although in the

stubble land are included areas that failed in 1919 and that, being sown again in 1920, had the advantage of a sort of accidental fallow. Only in one year (1916) did the fallow show to disadvantage, and then the growth was so heavy that when 13 inches of rain fell in the four months, September to December, the crop lodged and only portion could be harvested, whereas on the unfallowed land the crop was lighter and could all be saved. It was an experience shared by a good many farmers that year.

Can it be wondered that the Department should quote such a case with approval? The separate record of the returns from fallow and non-fallow on a private farm is perhaps unique, and combined with the present prosperous condition of the farm itself it affords most practical and valuable evidence of the soundness of the methods which for years all officers have urged upon the farmers of this State, and which we must continue to insist upon as essential to ultimate success.

Having said so much by way of commending fallowing to farmers, we may turn to the discussion of some of the practical issues that arise in connection with it.

. When to Commence Fallowing.

As the essence of fallowing is the storage in the soil of moisture precipitated before the seed is sown, so that it may supplement that which falls during the growth of the plant, the time of the year at which the plough should be put in must be governed largely by the incidence of the rainfall.

In southern portions of the wheat belt the greater part of the year's rain falls in the winter, and operations must be directed at carrying the rainfall of one winter through the following summer in order that it may be available in the soil in the autumn.

In the western districts the summer rainfall is greater than in the southern districts, and therefore fallowing might be done a little later; but though the average summer rainfall is higher, it cannot be relied upon in any particular year, and the safe practice for the farmer in that portion of the State, therefore, is to commence fallowing as soon as possible after sowing. The farmer who follows that practice will almost always be able to complete the full area he has planned to fallow, while the farmer who delays commencement of operations frequently finds that the setting in of dry conditions in the spring renders it impossible for him to fallow a considerable portion of his area.

A modification of fallowing is allowable in northern districts where the rainfall is much more definitely a summer one, and where ploughing immediately after harvest will usually conserve much of the rain that falls in January, February, and March, and that otherwise evaporates before seeding time arrives. Farmers in the north-west can therefore meet their conditions by ploughing half the following year's wheat area in the spring, and the other half immediately after harvest. This system would enable a man with, say, 300 acres of wheat land to sow 200 acres every year, half of which would receive a full fallow as preparation, and the other half a short, or summer fallow.

Ploughing should take place when the soil is neither too wet nor too dry—a condition that generally obtains in the winter months, sufficient moisture being then usually present to make the soil crumbly, so that it will not turn over in heavy dry clods. If the soil is too wet ploughing will destroy its physical condition, and it will dry out in hard lumps, from which it will be very difficult to get it back into good free condition.

Depth to Plough.

In years past the practice was to plough as deep as possible, even to 7 inches, but with more experience to guide us, it is found that very seldom more than 5 inches is necessary, and the best results are usually obtained from a depth ranging from 4 to 5 inches. Farmers should be careful not to plough too many years at the same depth, however, as such a procedure is very liable to result in the formation of a hard pan. An occasional variation of, say, half an inch in depth will prevent this.

If the ploughing in one season is from north to south, it is advisable that the following year it should be from east to west, in order that the formation of deep furrows may be prevented. Many farmers, for convenience, plough the paddock round and round, but it is certainly a better method to plough in "lands."

The Implement to Use.

Much controversy exists among farmers as to whether the mouldboard or the disc plough is the better implement for the purpose. No hard-and-fast rule can be laid down, and the farmer must be guided to a large extent by the class of soil he has to handle and the condition it is in when making a choice between the two implements.

The mouldboard plough may be said to do better work in land that is likely to break up too fine, and is certainly superior to the disc on land covered heavily with weeds or other rubbish.

On the other hand, the disc plough on fairly clean land has many advantages, chief of which is that from 400 to 500 acres can be ploughed with the one set of discs without renewing them. However, a great deal less depends upon whether the land has been ploughed with a disc or mouldboard plough than upon the choice of the right time and the thoroughness with which the work is done.

Treatment of Ploughed Land

The ploughed land should lie in the comb for six or seven weeks after ploughing, and then be broken down with heavy harrows. This method is usually preferable to breaking the comb down immediately after ploughing, because the winter rains in the former case are more likely to be absorbed, air, wind and sunshine are better able to penetrate and sweeten the soil, and the particles of the soil are not likely to run together and form a hard crust as easily as they would if the land were harrowed immediately after ploughing.

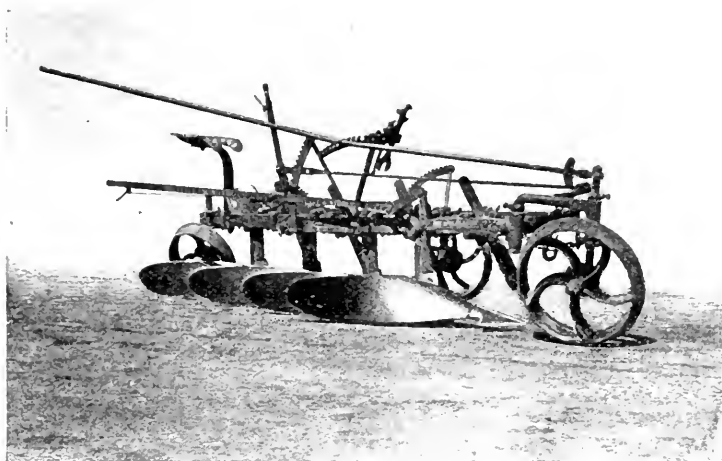
As the principal object of fallowing is the storage of moisture, to the end that two years' rainfall may be used to produce one crop, it will be easily recognised that the subsequent working of the fallow has a very important place in this method of cultivation.

Working the Fallow.

It may be said that only a small percentage of the fallowed land in the State is worked as it should be. It is true that the wise practice of ploughing in the winter or spring preceding sowing is becoming more general, but it is seldom that the soil is given the attention during the fallow period that it should have, and the wonder is that a lot of fallowed land yields as well as it does. Weeds are allowed to spring up and are not checked; the surface is allowed to become crusted and is not disturbed; and in this way the value of much of the work that has been done is seriously

discounted. Surface cultivation to prevent evaporation has the closest possible association with the earlier working—the prevention of crusty and weedy surfaces is absolutely essential if fallowing is to be truly and thoroughly effective.

It is well enough known that, while the top 12 or 18 inches of the soil are the most important to plant life, beneath that is stored water which is conducted by capillary attraction to the surface, where it is lost by



A Modern Mouldboard Plough.

evaporation. This capillary movement of the soil moisture if permitted to continue, will carry off the moisture as long as there is any below, and the only way to prevent that taking place is to disturb the surface and interrupt the action, thus locking the moisture in.

Neglected Surfaces and Their Losses.

A few figures will prove that this is the case. The late Professor King, of Wisconsin (U.S.A.), said that he reduced the mean daily loss from .071 of an inch to .034 of an inch, by freshening the mulch, taking off 1 inch and placing it back loosely and lightly—a saving of 50 per cent. of the average daily evaporation.

In California, Hilgard and Loughridge made instructive comparisons. They found that while in uncultivated land there was 4.3 per cent. of moisture in the first foot of soil, in cultivated land there was 6.4 per cent., and continuing their experiments at every foot to 6 feet below the surface, they showed that the advantage was the same almost the whole way down. In other words, while the uncultivated land had equal to 86 tons of moisture per acre at the first foot, 88 tons at the second, 100 tons at the fourth, and 90 tons at the sixth, in the cultivated area there was equal to 128 tons at the first foot, 116 tons at the second, 130 tons at the fourth, and 120 tons at the sixth—an advantage, where cultivation was carried out, of 30 to 40 per cent. more moisture the whole way down to 6 feet.

American and English experiments are not the only ones which we have to rely on in urging this work upon our wheat-growers. Experiments at Geelong, Victoria, showed that just before sowing time a worked fallow contained equal to 492 tons of moisture per acre in the top 18 inches of soil, while a neglected fallow could only show 281 tons.

The work was continued on a more extensive scale the following summer at Longerenong Experiment Farm, the moisture-content of a worked and a neglected fallow being carefully ascertained at different depths every month. Certain land was ploughed and cultivated in September, one portion receiving no further cultivation, and the other being worked in the same way and time as other fallow land in the vicinity. On the 1st November there was already a difference in the moisture-content, and by April the difference was marked, the neglected fallow having in the first 4 feet 27·16 per cent. of moisture, while the cultivated fallow had 32·71 per cent. As February and March were months of good rainfall, the difference in the top 4 feet was not as great as it would have been in a dry summer, but further tests showed that the rains referred to had gone a good deal deeper than 4 feet on the cultivated portion, and remained there to nurture the succeeding crop.

The effect of neglecting the fallow, as the above results clearly show, is to allow the moisture which has been caught to escape again into the air. The only way to prevent that is to maintain a loose surface, and thus put a lid on the reservoir.

There is another reason. A neglected fallow means a dirty fallow, in which weeds add their part to the loss of moisture and plant-food, and spread their seeds to the detriment of the next crop.

When to Work the Fallow.

As the object of working the fallow is to produce a loose mulch on the surface in order to prevent the evaporation of the soil-moisture, it can be easily understood that the fallow should be worked in such a way as not only to produce, but to preserve this loose mulch.

Provided the soil has been ploughed when in good condition, it can with advantage be left in the rough state as broken by the plough, there being no necessity for immediate further treatment. But if the ground has been ploughed when wet enough for the furrow to show a polished surface, it will be desirable, in most cases, to harrow it as soon as it is dry enough to crumble perfectly; otherwise it is likely to become so hard and lumpy that the labour necessary to make a good seed-bed will be largely increased.

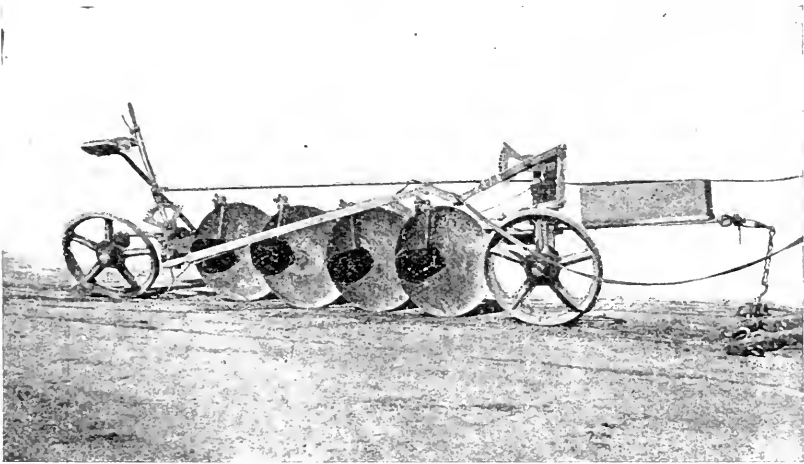
The object of working the fallow early in the season is to keep a mulch on the surface, so as to conserve the moisture in the soil beneath. As already explained, mulches break the connection between the surface soil and that beneath it. The more thoroughly this connection between the two sections is broken the more effective will the mulch be.

The plough, by cutting off a layer of surface soil and returning it loosely and more or less inverted, completely breaks the connection between the two sections, and in consequence makes a more effective mulch than any other implement. Recently-ploughed land is, therefore, covered with the most effective mulch possible. This is especially the case if a sod or the residue of a green crop has been turned under. Until this mulch has been destroyed by rain and other natural causes, nothing will be gained by working the land and breaking down the rough surface. Indeed, to do this will be rather a disadvantage; for it will have a tendency to re-establish the connection

between the surface soil and that beneath, thus strengthening the capillarity and increasing the flow of water upward to the surface, where it can be lost by evaporation.

Even if the ploughed surface has become somewhat settled, and therefore less effective as a mulch, little will be gained by working it in the winter. At that season, when the days are cool and often cloudy and the amount of evaporation, even from damp soil, is not great, it would require almost continual stirring of the soil to maintain an effective mulch; for, owing to the conditions prevailing, the connection between the surface soil and that beneath would be re-established almost as fast as broken.

Later, after dry weather sets in, the amount of working the fallowed land will require will depend upon the climate and the condition of the soil. Professor King found, as a result of experiment, that in seven weeks the loss of moisture from unmulched ground was equivalent to 170 points of



A Modern Disc Plough.

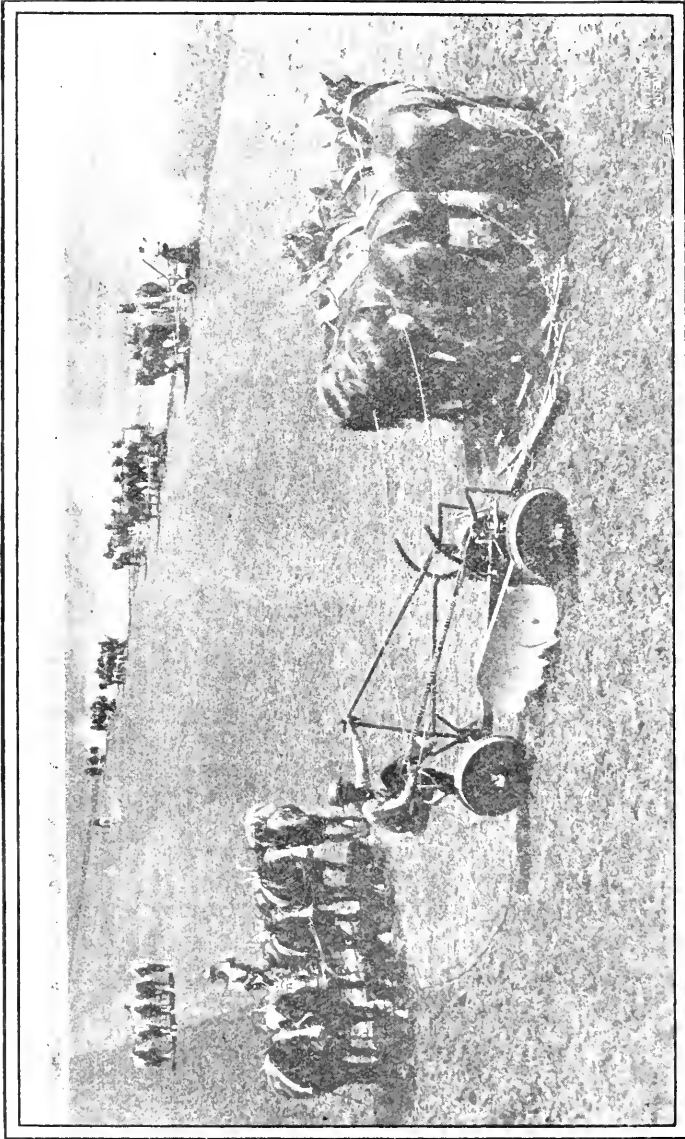
rain more than from mulched land. But if this moisture is to be conserved, the soil must be stirred as soon as the effectiveness of the mulch is destroyed by rain; mulches are only effective when loose and dry.

Even a light shower is sufficient, under some conditions, to render a mulch non-effective; and when this is the case the soil is often drier twenty-four hours after the shower than if no rain had fallen. This is due to the increased capillarity of the particles, caused by the wetting and consequent compacting of the soil, resulting in loss of subsoil moisture by evaporation. This is illustrated by the results of another experiment conducted by Professor King, who found that 25 points of rain in twenty-four hours was sufficient to cause an increased flow of water (equal to 70 points of rain) from the subsoil to the surface, where it could be lost by evaporation.

The cultivation of the fallow must necessarily fit in with other operations on the farm. A December cultivation, for instance, may be extremely desirable but is seldom practicable, the men and horses being busily engaged with the harvest. It may be considered desirable (subject to the conditions already outlined as to the state of the soil) to give a cultivation before hay cutting begins, and a second one after the harvest is over and rain has fallen.

Implements for Working the Fallow.

No hard-and-fast rule can be laid down as to the implement to use for working the fallowed land. The farmer will be guided by the condition of the soil, and will use the implement likely to achieve the result in the cheapest



The Disc Plough on a large area at Narramine.

way, mindful that the object of working in the early stages of fallowing is to conserve the moisture rather than to prepare a seed-bed. No effort should at this time be made to reduce the surface to a fine tilth, for coarse muleses remain effective longer than fine ones.

Before the ground gets very firm, and if free from weeds, the tine harrow can be used cheaply and with advantage. If the ground is "set" a cultivator should be used, and if weedy the disc cultivator or skim plough. The one-way disc cultivator has proved itself well adapted for economically working fallowed land. The skim plough is also a suitable and effective implement for the purpose. Some farmers favour the one-way disc cultivator, others the spring-tooth cultivator or the ordinary tine harrow, but much depends on the class and condition of the land.

If the fallow is dirty with weeds, it is useless to try to get them out with the spring-tooth cultivator or the tine harrow. In this case the farmer must resort to the one-way disc cultivator, which literally chops the weeds out of the ground, at the same time leaving the surface in a fine tilth. The skim plough is the better instrument to use in soils that are likely to break up too fine; for the farmer must ever remember that the finer the surface, the easier it sets again after the first shower of rain, a further early working being thus necessitated to prevent the rise of moisture to the surface.

The spring-tooth cultivator allows the finer particles to sift through, leaving the surface in a fairly cloddy or lumpy condition, but it should only be used on a clean fallow where there are no weeds.

Tine harrows may be used in the loose soils which are frequently found in districts where the soil is of volcanic origin. The physical condition of such soils will often permit even light harrowing to produce the essential mulch.

It will be seen that no hard-and-fast rule can be laid down as to which implement should be used in working the fallow. The farmer must follow his own judgment, being guided by the physical condition of the soil.

While clean surfaces are a valuable factor in conserving moisture, it is not forgotten that where sheep are combined with wheat-growing the weeds that spring up on fallow land afford good feed, and often quite an abundance of it.

Depth of the Mulch.

Experiments carried out for a series of years at Wagga, Nyngan, and Cowra experiment farms, have conclusively proved that nothing is gained by mulching too deep, and while it is not practicable to set the cultivator so as to cultivate exactly $2\frac{1}{2}$ or 3 inches deep, it may be laid down that any cultivation that is deep enough to destroy weed growth is the most suitable.

Though a mulch should be reformed as soon as possible after its effectiveness has been destroyed by rain, nothing will be gained by working the soil before the surface has a crust on it. If worked before this stage is reached, the implement teeth instead of stirring the soil cut through it like a knife, and leave it in such a fine condition as to assist rather than retard evaporation.

The Seed-bed.

As the result of the working which the land has received whilst being fallowed, its condition at the time for the reception of the seed should be ideal, especially if the final cultivation, just before seed-time, has been with the skim plough to ensure that any young weed growth likely to interfere with the welfare of the wheat has been effectually destroyed. As the result of such treatment the seed-bed will be clean, in good tilth, with the soil immediately below the surface in that compact condition which induces constant capillarity and admits of the free upward flow of the soil-water from the subsoil, thus providing conditions favourable for ready germination and vigorous growth.

For the same reason deep reploughing just before seeding is not recommended; it is likely to make the seed-bed too open and dry for the wheat plant, and also by bringing deep-lying and dormant weed seeds to the surface where they will have the same opportunities as the wheat to grow and compete with it for existence.

The compaction of the seed-bed—that is, the soil just below the surface—is of greater importance than is generally realised. To sow seed in a loose seed-bed often means failure. Many a farmer has realised it when he has ploughed a stubble paddock 5 inches deep and sowed the seed shortly after the ploughing. No time has been allowed for the worked soil and the sub-soil to become again compacted into a homogeneous mass, and the roots of the young plants have dried out in the large air spaces left by unskilful cultivation.

Compacting the Seed-bed.

Under a system which provides for the working of fallowed land, the use of the roller to break clods or compact the soil will be unnecessary and in many cases distinctly harmful. During the period of fallowing, any clods that may have originally been present after ploughing will have become weathered down into good tilth; should this not have occurred and the clods still be there, a spiked roller may be used.

Nor will there be any need for the use of a special implement like the sub-surface packer to compact the sub-surface soil and so bring the subsoil moisture to just below the mulch, where it will be available for the germination of seeds. This will have been accomplished incidentally, as the result of working the fallowed land, the sub-surface soil of which will have become compact as the result of natural settlement, aided by the tramping of the grazing stock and by the teams and implements passing over the land. During the period between early ploughing and seed-time the soil is more thoroughly compacted by the forces of nature than could possibly be done by any implement devised by man.

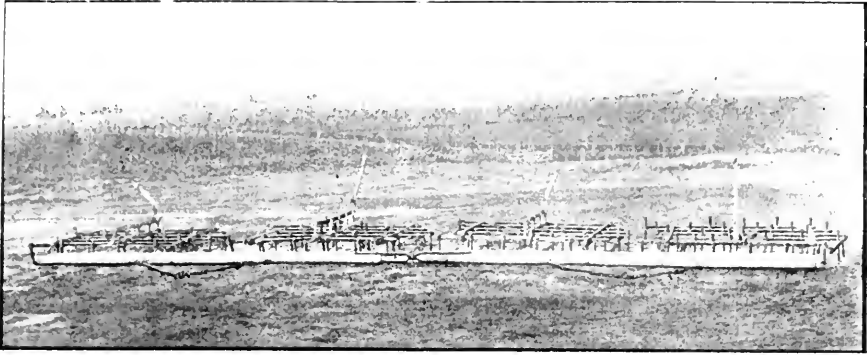
Does Fallowing Pay?

The all-important issue respecting fallowing is raised in this question, and a comparison of the cost of working fallowed with non-fallowed land, together with the average returns in each case, is distinctly interesting. For the purpose we may take the average yield of the State, which is about 12 bushels per acre, as representing the non-fallowed land (a distinctly favourable basis), and the average yield on the Farmers' Experiment Plots (which according to a large number of plots in all parts of the State spread over several seasons, may be fixed at 20 bushels), as representing fallowed land.

Cost per acre of Wheat-growing on Non-fallowed Land: estimated yield, 12 bushels.

	£	s.	d.
Ploughing once	0	8	6
Harrowing once	0	1	0
Drilling	0	2	6
Seed, 45 lb. at 7s. 6d. per bushel	0	5	8
Superphosphate, $\frac{1}{2}$ cwt. at 7s.	0	3	6
Pickling seed	0	0	4
Harvesting with header	0	9	0
Rent, at 8s. per acre	0	8	0
Bags, four at 10d.	0	3	4
Cartage, at 4d. per bushel	0	4	0

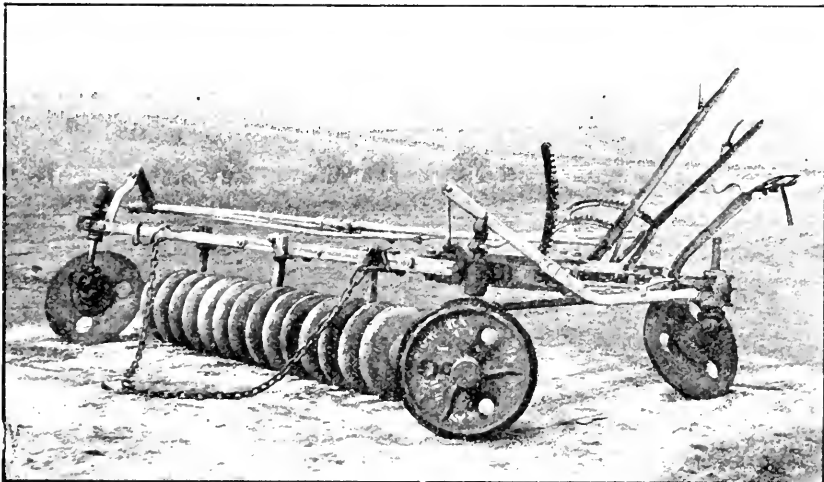
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A set of harrows for stirring the surface of fallowed land.



Spring-tooth cultivator.



The one-way disc-cultivator used for cultivating the fallow in recent years.

Allowing an average yield of 12 bushels per acre for non-fallowed land (an estimate really in excess of the actual) the gross proceeds at 5s. per bushel would be £3 per acre. If the cost of production, with rent, averages £2 5s. 10d. per acre, as shown above, the actual profit is 14s. 2d. per acre.

On the other hand, if the land be fallowed, the cost will work out thus:—

Cost per acre of Wheat-growing on Fallowed Land; estimated yield, 20 bushels.

	£	s.	d.
Ploughing once	0	8	6
Harrowing three times	0	3	0
Disc-cultivating once	0	4	0
Spring-tooth cultivating once	0	2	9
Drilling	0	2	6
Seed, 45 lb. at 7s. 6d. per bushel	0	5	8
Superphosphate, $\frac{1}{2}$ cwt. at 7s.	0	3	6
Pickling seed	0	0	4
Harvesting with header	0	9	0
Rent, two years at 8s. per acre	0	16	0
Bags, seven at 10d. each	0	5	10
Cartage, at 4d. per bushel	0	6	8
	<hr/>		
	£3	7	9

The return in this case, on the average of the Farmers' Experiment Plots, would be 20 bushels, which, at 5s. per bushel, represents £5, showing a profit at the rate of £1 12s. 3d. per acre over the two years, or at the rate of 16s. 1d. per acre per annum, compared with the 14s. 2d. per acre per annum derived from the non-fallow crop.

The advantage attaching to fallowing as a farm method is obvious.

In addition, in the non-fallow case there is always a possibility of almost total failure to be reckoned with, while in the case of the fallowed crop there is always a reasonable certainty of success.

It is evident that, apart from any other advantages gained by fallowing, such as the maintenance of fertility, the cheeking of wild oats, &c., a rigid system of fallowing should commend itself on a simple commercial basis to every wheat-farmer in the southern or western portion of the State.

Manuring the Wheat Crop.

Like all other plants, wheat requires the presence in the soil of a number of elements which it assimilates as plant-food, and without any one of which the crop must be a failure in a greater or less degree. Most of these elements are present in the soil in sufficient quantities, but the supply of the three most essential—phosphoric acid, nitrogen, and potash—is often too small for the plant's needs; more often still one or all is present in abundance, but not in a form in which the plant can make use of it. Hence it is that in many countries in which wheat is extensively grown it is necessary to use fertilisers that will supply all three.

Fortunately, in Australia, the supply of nitrogen and potash in the soil appears to be equal to requirements, and it is only necessary to add phosphoric acid, which, luckily for the farmer, is the cheapest of the three. The addition is made in the form of superphosphate, because it dissolves readily in the soil moisture, and the phosphoric acid becomes available for the plant in a very short space of time.

Farmers in the southern portions of our wheat belt have already learned the value of the superphosphate, and its use there may be said to be almost universal. Little surprise need be entertained that this is so, for the advantages are conspicuous.

In the western portion of the State the use of superphosphate is not yet so general as in southern parts, but experiment and demonstration plots have done much in late years to make the practice more general. The all-important question is, does it pay, and to that the results of the Farmers' Experiment Plots during the past few years in southern and western districts furnish an answer that leaves no room for doubt.

The need for phosphatic manure in the western and southern portions of the State is more apparent than in the northern and north-western portions. In fact, it appears from the results of continuous experiments, that the further south the greater the need for phosphoric acid for wheat-growing. This may be accounted for in two ways—firstly, soils in the northern and north-western districts are naturally better supplied with phosphoric acid than those in the southern wheat-growing area; and, secondly, the southern districts have been cropped for wheat for many years past, whereas the western and north-western districts have only been opened up for wheat-growing during comparatively recent years.

This being so, it is to be expected that the application of phosphatic manures should meet with a more generous response in southern and western than in north-western and northern soils. In this respect the results of manurial trials bear out this contention. In the north-west it appears that superphosphate is not so much needed as in the south, where the average difference between manured and unmanured plots is not less than 5 bushels per acre. It is these extra 5 bushels per acre which mean to the wheat-farmer the difference between success and failure.

Quantity of Superphosphate per acre.

Generally speaking, it may be said that 56 lb. per acre is about the correct quantity of manure to use; on new land 40 lb. will be found to be sufficient, and on land that has been cropped for a number of years the quantity can with advantage be increased to 70 or 75 lb. per acre. In dry districts the applications of superphosphate should be light. At Nyngan Experiment Farm 30 lb. has been found sufficient.

Useful as superphosphate is, it must be borne in mind that in order to obtain the maximum benefits from it, the employment of good cultivation methods is essential. Manuring and good cultivation go hand in hand—one is useless without the other—and the farmer will find that it is better in many cases to till the fertility into the soil than to buy it in bagfuls. In other words, the plough, harrow, and cultivator play quite as important parts in the fertility of the soil as artificial manure.

Liming Wheat Land.

Little has been done in New South Wales in the way of liming wheat land, but a few isolated experiments have been conducted without anything very definite being disclosed, except, perhaps, that farmers should conduct experiments for themselves if the condition of their land suggests a shortage in the soil of this necessary substance.

Rotation on the Wheat Farm.

Many of the problems that confront the wheat-grower may be solved by rotation of crops.

All farm crops require very much the same plant foods, but different crops require them in different proportions. Hence, the production of the same crop from the same land year after year tends to use up the supply of one or, perhaps, two kinds of plant food faster than they are made available by the ordinary processes that are going on in the soil, with the result that in a few years the yields become consistently disappointing. The introduction, from time to time, of a crop that uses different elements of plant food, or uses them in different proportions, allows the renewal of the supply of that particular element upon which the previous crop has made the heaviest demand, and enables the farmer to return to his main crop with the assurance of greater profit.

The Value of Rotation.

A change of crops, indeed, may sometimes actually result in an increase in the supply of plant food in the soil. An illustration is afforded by the practice in parts of the tablelands of the State, where oats for hay and potatoes are rotated. The cultivation required by the potatoes is quite different from that required by the oats, and the effect of the different treatments is certainly to hasten the break-up of the chemical compounds in the soil, and thus to render certain elements available that, though present previously, could not be used by the plants. Another illustration may be quoted—that of lucerne and wheat. Farmers know that no wheat-land yields grain like that on which lucerne has been grown, and the reason is that the deep-rooting habit of the lucerne has led to plant food being brought from the subsoil and made available for the surface-feeding wheat when the lucerne has been broken up and the roots have decayed.

Rotation has an important relation, also, to some of the active enemies of crops—notably weeds, insects, and fungi. It is now widely recognised by farmers that the occurrence of wild oats is closely associated with continuous cropping for wheat, and that some change is imperative if a dirty paddock is to be cleaned up. Better illustration of this can hardly be furnished than by the result of the "continuous wheat experiment" at Cowra Experiment Farm. Certain land on that farm was cleared in 1906 and divided into three main parts—one of these being devoted to wheat every year, another to wheat alternated with fallow, and the third to wheat alternated with a fodder crop. That experiment was initiated to prove that wheat cannot be grown continuously without a serious loss in the eventual yields. And that was exactly what happened. Seed of the cleanest and best quality was used; cultivation methods were adopted that should have tended to check and destroy any oats that might have been on the land (an old common); but it was to no purpose. Wild oats and Saucy Jack were to be seen by 1910, and by 1912 they had so taken possession that the manager reported that "but little wheat is now taken from the area, and the weeds have become a menace to the cleared adjoining areas." It is a most significant fact that on the sections where wheat was grown alternately with fallow and with fodder crops, the oats were a negligible factor. A valuable experiment had thus to be interrupted and started on a new area, simply because the "wheat-every-year" portion had become infested with wild oats. The Department set out to prove that continuous wheat is not profitable compared with some rotation,

however limited, and the wild oats furnished the evidence in quick time. We know of no better proof of the value of the change of crops than that abandoned experiment at Cowra.

The influence of rotation on insect pests is, perhaps, less conspicuous in the case of wheat than of almost any other crop, though even there it has its value. As to fungus diseases, especially "take-all," there is no room for doubt; indeed, it will be found that a change to oats is quite essential where a paddock contains badly infected patches.

Limitations of the Position.

The importance of rotation being thus indicated, the question presents itself, "What crops can be used in connection with wheat under New South Wales conditions?"

It has to be confessed at once that there is no crop that wholly serves the purpose. Wheat is grown on such a large scale and under such extensive cultural conditions in this State that there is no other crop that offers such a certain market at remunerative prices, or that can be grown in such large areas. Barley and oats have not the sure market awaiting them in large quantities, even if they could be relied upon to yield as well in all parts of the State where wheat is profitable; and the same objection applies with even greater force to potatoes, turnips, and the other root crops which in nearly all other agricultural countries are considered most desirable as changes from grain.

Rape in combination with either barley or oats, or by itself, is a valuable soil renovator and fodder crop, but to recommend it as a rotation crop on a large scale under our conditions would be to presuppose that the farmer would have at certain times of the year a far larger number of sheep than can be carried on any average wheat farm.

It is essential, as we have said, that any change recommended in rotation with wheat should be a profitable one; in other words, it should be such as will not only improve the condition of the soil, but also improve the condition of the banking account.

Fallow as a Rotation.

The rotation this Department would advise in respect of large portions of the wheat belt is simply wheat, alternated with fallow, with such occasional variations as the circumstances require or permit. The period of fallow not only enables the farmer to increase the store of moisture, but it also allows the soil to recuperate, and additional plant food to be made available, and it gives an opportunity for cultivating the surface for the destruction of weeds and certain fungus and insect pests. The value of fallow in connection with wheat has been discussed again and again in the *Agricultural Gazette* and in other publications of the Department, but in this recommendation of fallow as an alternative to wheat in a rotation, it is not out of place to refer again to the experiment at Cowra. In the six years of that experiment the "wheat-every-year" section averaged 16·8 bushels per acre, the "wheat-after-bare-fallow" section averaged 24·8 bushels, and the "wheat-and-fodder-crop" section, 26·4 bushels.

Various Suitable Crops.

Variations should certainly be made from time to time, however, for a simple rotation of wheat and fallow indefinitely is likely eventually to exhaust the humus content of the soil. The store of this important soil constituent may be maintained in two ways, both associated with the

depasturing of live stock on the farm, viz.: (1) the growth of fodder crops like oats or barley, and (2) the leaving of the paddocks "out" at intervals. The value of these crops as soil renovators and for fodder purposes is already well known to farmers, and on every farm of 600 acres we should find annually at least 40 to 50 acres under one of them. Farmers have long since proved, too, the excellent feeding value of the natural herbage, especially of the trefoils, that springs up on large areas of our cultivated lands when "left out." Such herbage deserves to be esteemed almost as much for its fertilising properties when ploughed under with the excrement of the animals that have been depastured on it, as for its value as feed.

In the way of ordinary crops, the resources of a farmer who desires to change the crop on an area that is beginning to go off are greater than might be supposed. More oats could certainly be grown with profit in this State, and the same may be said of barley, and, though it must be admitted that neither of those crops quite fulfil what constitutes a rotation (inasmuch as they are "white" or grain crops), they might well be made to serve the purpose of the farmer every few years. Both have been subjected to a good deal of improvement by crossbreeding and selection in the last few years, and are commercially more comparable with wheat than they once were.

It should be taken for granted that where root crops can be grown to advantage they should be resorted to occasionally, and their value should not be overlooked. There remains one other crop that might be mentioned—lucerne. It certainly cannot be grown on an extensive scale in most wheat districts; but its value on any farm, either for the accumulation of a reserve of high-class fodder, or for the purposes of grazing, and its effect on the fertility of the soil, are so great that it should have a place on every farm.

What has been said with regard to rotation should be regarded by farmers as suggestive of their resources in the way of change. Certain it is that continuous wheat-growing is disastrous in the long run, and it is for the careful agriculturist to realise that the demands made upon his soil by wheat are to a great extent minimised by fallowing. What other rotation is suitable to his district on the lines indicated in the foregoing, he alone can decide.

Wild Oats.

Wild oats are certainly very common in our wheat areas, but their suppression is largely a matter of cultivation and is not by any means so difficult as would appear. Weeds we shall probably always have in our fields, as long as our fine wheat lands retain their fertility, and the wild oat will probably always find its place; but a consideration of its characteristics will show the proper methods of keeping it within bounds and utilising the undoubtedly good forage which it provides when it cannot be entirely suppressed. The principle is to induce the oat seeds to germinate, and then destroy the plants before they seed.

But having resolved upon the necessary steps to be taken in the campaign against the pest, we find that their practical application is not such a simple matter. It means work, and in cases where the pest is bad it may mean the sacrifice of at least one crop on land under continuous cultivation. When we recollect, however, that the lost crop would have been a dirty one, that the ground is greatly improved by the spell, and that perhaps a valuable supply of winter feed is obtained for stock, we cannot consider the price of redemption too high. Moreover, the steps recommended by the Departmental officers will be found less costly, and spread over a shorter period, than the efforts which many have put forth in their vigorous attacks upon the intruder.

If any farmer should doubt the ultimate result of his labour in following these recommendations, let him go to the nearest Experiment Farm and, growing in the midst of infested districts, he will see good clean crops upon land from which the terror of the wild oat has long since disappeared.

The Control of the Wild Oat Pest.

The loss in yield caused by the presence of black or wild oats amongst the wheat crops is yearly increasing. The pest is the more troublesome because the seed lies in the ground without germinating until the wheat is sown, when the favourable temperature and condition of the soil make it sprout and grow with the wheat. In some of the older paddocks the oats come up so thickly that is impossible to obtain a profitable crop.

The prevalence of wild oats may be attributed to two causes—the almost universal use of the combined harvester, and the constant cropping of the land. The combined harvester is almost diabolically devised as a disseminator of the seed of the wild oat, and a paddock which is comparatively clean will, in three or four years, be almost unfit to sow with wheat when this means of harvesting is employed. When to this is added constant cropping, until the land becomes too dirty to produce wheat, it can be realised how difficult it is to control the pest.

An additional source of infection is the use of "oaty" feed for working horses. The hairy coating of the seed enables it to survive the digestive operations of the horse and the ox, and the pest can thus be spread to land hitherto clean.

Attempts of various kinds have been made to eradicate the oats, but they are only partially successful. Perhaps the most general practice is to leave the land out for a year, and utilise it for grazing. Usually the land is not worked, however, and the method is practically unsuccessful, as only a few of the seeds germinate. One fair crop of wheat may be obtained in the following year, but after that the land has to be rested again.



Wild Oat (*Avena fatua*).

Another method is to leave the land out for a year in the same way, but to plough it either late in the winter or early in the spring or summer. This gives better results, but it does not completely clean the land.

Other farmers do not leave their land out, but plough early, in some cases as soon as the harvest is over, and work the land with the harrows or cultivator to induce the oats to germinate. A quick-growing, early maturing variety such as Canberra, Florence, or Clarendon is then sown. This method is perhaps the most successful, but it does not altogether remove the evil, for the simple reason that many of the wild oat seeds lie dormant and only start into life after the wheat has been sown.

How, then, is the wild oat to be controlled? If the seed which is lying in the ground can be made to germinate, then its eradication becomes a simple matter, as it is only necessary to kill the young plant. How is germination to be brought about? The wild oat seed is accused of lying dormant in the ground for years. Some men quote instances of paddocks, which have been thrown out of cultivation and so closely grazed that no oat seeds have been allowed to mature, but which have produced oats as thickly as ever, five, seven, and even ten years later, when ploughed up. Even allowing for seed which may have been produced unobserved, it is certain that the seed does, under certain conditions, retain its vitality for long periods when buried.

Close observation and study lead to the opinion that the persistence of the wild oat is not due to any peculiarity which causes some seeds to remain dormant for one or more years, but is chiefly due to the fact that the seed germinates slowly and requires favourable temperatures. It is evident from the observations of Dr. Darnell-Smith that the short velvety hairs on the seed form a protective covering, preventing moisture coming in contact with the germ, and so retarding germination. It is probable that this protective covering is effective only for a time, and that when the soil immediately surrounding the seed is kept moist long enough, germination does take place.

If young wild oat plants are examined it will be found that in nearly every case the seed has sprouted in the earth about 3 or 4 inches below the surface; and it is here the land remains moist for the longest period. The surface soon dries out, and becomes unfavourable to germination.

Experiments have proved that when the soil is kept moist only 24 per cent. of the seed germinates after three weeks in February, when the temperature of the soil is comparatively high. Observation in the field indicates that comparatively low temperatures encourage germination, and that the oats come up most thickly in May, June, and July. This has led practical farmers to sow wheat early so that it will start ahead of the oats.

Experience shows that few of the seeds will germinate if the land is not worked. It may be left out for a year, but when it is broken up the wild oats will come almost if not quite as thickly as ever. This, of course, shows that the cultivated soil provides the conditions which are favourable to germination.

If the seed be examined it will be noticed that the hairs are arranged in such a way that it always moves forward when touched. The tough awn or tail attached to the seed assists in the progressive movement, as with changes in amount of moisture, &c., it alternately twists and straightens, and each time forces the seed in a forward direction. The seed, therefore, works through the soil, and is further distributed by cultivators, harrows, ploughs, &c., until it is ultimately mixed with the soil to at least the depth to which cultivation is carried.

The clods on the surface harbour many a wild oat seed. It is probable that in a dirty paddock there is more than sufficient in these to re-seed it. Strenuous efforts may be made with the ploughs, harrows, and cultivators to encourage germination; but all the time the clods are harbouring the seed. The smallest of them is big enough to hold a grain. They never become moist, and thus the seed is well protected.

We can now see from this reasoning that to free a paddock from wild oats—

- (1) The right time must be selected;
- (2) The land must be well worked;
- (3) The clods must be all broken;
- (4) The soil must be kept moist from the surface downwards as long as possible.

To bring about germination, in fact, a little more care, rather than less, must be used than is the case with other seed; the contrary is usually the case—hence many failures.

The time to commence the work of cleaning a paddock coincides with that of preparation for wheat. It should be so arranged that the land will be in good order about May, when the actual work of fitting the land for the germination of the seed should commence. Since, however, the preparation for wheat generally monopolises attention at this time the working of land to destroy oats is delayed. If it be taken in hand as soon as the sowing is over, it can, provided the season is propitious, be accomplished before the season is too far advanced.

Immediately sowing is finished, the dirty land should be well ploughed and thoroughly harrowed—the harrowing is most important, as it helps to make the soil fine, and leaves it in such a condition that it retains the moisture. Ploughing alone is not sufficient; the land is left loose and soon dries out. The farmer must remember that he is dealing with seed, although he has done no sowing, and the same attention must be given as when wheat is sown. No one ever dreams of merely ploughing his wheat in and leaving it at that, and there is no earthly reason why it should be sufficient to do so when it is required to make oats grow. The harrow *must* be used to make the ground *fine and firm* about the seed. If the ground is dry when it is ploughed, it is practically useless to harrow; the work should be done when the soil is moist. The paddock ought to be ploughed in readiness, and harrowed immediately after rain.

When wild oats are being dealt with, harrowing, however, is not sufficient; the roller must be used also. It was pointed out above that the soil must be kept moist from the surface downwards to promote germination. This is one of the essential conditions, and its maintenance depends chiefly upon the use of the roller. If the land is harrowed and left rough, a loose, dry layer of earth soon forms at the surface. The layer may be 2 or 3 inches deep. The large number of seeds lying in it do not germinate, as moisture is not in contact with them long enough. Observations will always show that the young oat plants found amongst the wheat crops have come from seed buried deeply—the soil there is firm and moist.

Further, seed of any kind will always germinate best in a fine soil. Wild oats are never found to be as troublesome in the fine sandy loams as they are in the clay soils, which are often cloddy. The fine particles of such soils wrap around the seeds and hold the moisture to them closely.

Another most important point, and one which in the past has been overlooked, is the power the clods have of protecting the seed of wild oats against germination. Neither moisture nor air penetrates them readily, and in the absence of either, germination will not take place.

The roller breaks the clods, makes the soil fine, and leaves it firm at the surface. Moisture rises freely to replace any lost by evaporation, and all the seed in the ground is under favourable conditions. None of the loose open spaces, which do so much towards preventing germination, are left in the ground after the roller has been over it. Briefly, the conditions are made as nearly ideal as possible.

Summarised, then, the land should be well ploughed, thoroughly harrowed, and rolled at the right time. The right time is in May, June, or July. After the roller is used the land should not be touched with any implement. Provided the season is at all favourable, it will be found that this working will sprout the seed.

The plants then have to be destroyed. This can be accomplished either by feeding-off with sheep or by ploughing. When either method is followed, care must be taken that the plants do not get an opportunity to seed.

The oats make excellent feed for sheep, and their value in this respect repays the cost of cultivation. It is perfectly safe to feed them off while the cool weather lasts. Immediately warm weather begins to assert itself, however, no time should be lost in ploughing the oats under. They produce seed in a remarkably short space of time, and any hesitation may result in a fresh supply being formed.

If the oats are kept closely eaten, it is a simple matter to destroy them with the plough. Long, rank growth is somewhat difficult to cover, but unless it is done the plants will go on growing and will ripen seed. This is especially likely to be the case should the land be wet when it is ploughed. Under such conditions mouldboard ploughs do the most satisfactory work, as the sod is well turned. The best time to destroy the oats is when the land is dry. The cutting up of the plant, when soil moisture is scarce, kills it at once.

As it is still doubtful how deep wild oat seeds lie in the ground, care should be taken, when cropping in the subsequent year, not to till deeper than was done when ploughing to prepare for the germination of the oats. If a deeper ploughing is given it is possible that fresh seed will be brought to the surface and germinated there by the favourable conditions that have been carefully devised to help the wheat seed.

VARIETIES RECOMMENDED.

A few pages back we made the statement that the production of improved varieties has been one of the important factors in the development of the wheat-growing industry in New South Wales, and that is no exaggeration of the facts. A number of excellent varieties of wheat have been the result of the cross-breeding and selection carried out by officers of the Department, some of them (notably Federation and Canberra) adding in a very substantial degree to the average yield of grain, others to that of hay, and yet others (like Thew) to the quantity of green feed that coastal dairy-farmers can grow for the early spring.

Beyond even those conspicuous contributions to potential and real wealth, there are others (several of them, like Marshall's No. 3 and Yaudilla King, not the products of the Department, though recommended by it) that for

special seasons, special climatic conditions or special purposes have so far proved their worth as to be well and favourably known among wheat-growers.

Some varieties fulfil a dual purpose, and can be cut for hay or harvested for grain. On the other hand, farmers growing wheat for the chaff market must exercise particular care in choosing special hay varieties. Further, in growing for grain the difference between the yields of a suitable and unsuitable variety may be as much as a third of the crop. In general, the best yielders are those that are able to make use of the full growing period in their respective districts—that is, those that can be sown early and mid-season.

Several factors have to be taken into account in selecting the variety or varieties that are to be sown on a farm. They may be briefly presented thus:—

1. *The climatic and other conditions of the district.*—In a cool district the varieties grown may be slow-growing or long-season ones, so that the plant may have every opportunity of making the maximum growth and producing the maximum crop.

2. *The convenience of the farmer at sowing and harvesting times.*—Both operations must be distributed as much as possible in order to avoid too great a pressure of work at one time, and this can be effected by sowing a proportion of slow-growing varieties before the main sowing season, and a proportion of quick-growing ones after the main crop is in. The result of such a method will also be that harvesting work will be extended over some weeks.

3. *The aspect and other conditions of the farm.*—One farmer may find that a certain variety does particularly well with him, though not so well generally throughout the district.

4. *The particular market which the grower wishes to cater for.*—The variety for the early chaff market must be quite different from that intended for grain even in the same district.

5. *Soil conditions.*—It is becoming quite clear that certain varieties do better on certain soils than others. Little information has so far been collected on this point, but recent experiences have indicated that the soil must be studied in relation to the variety.

6. *The moisture requirements of a variety.*—A variety that is economical of soil moisture is valuable, especially in a dry district. In California Briggs and Shantz compared Early Bart (the principal local variety) with Hard Federation, and found the latter to require far less moisture to produce a profitable crop than the former. In dry districts like the western portion of the wheat belt this is an important consideration.

“Early” and “Late” Wheats.

Sow early-maturing varieties late in the season, and late-maturing varieties early in the season, is a rule which usually can be followed in its entirety.

Heavy losses are occasioned yearly through farmers sowing their wheats at the wrong time. This is due either to the fact that farmers do not know which varieties are early and which are late, or, as is more frequently the case, it is due to a misapprehension of the terms “early” and “late” as applied to varieties of wheat and other plants. To the vegetable-grower, as well as to the stud wheat-farmer, the term “early” has always meant a variety that grows quickly, and produces its crop early, and similarly the term “late” has always meant a variety that matures slowly, and produces

its crop late. Hence, to sow an "early" wheat at the beginning of the sowing season is literally to make an attempt to produce wheat in the middle of winter, and to sow a "late" wheat at the end of the sowing season is to look for a grain crop in the height of summer. The quick-growing habit of the first kind will bring it into head at a time when, even if other conditions are favourable, frost is almost sure to prevent the maturing of grain, and the slow-growing habit of the second kind will produce the ear at a time when extreme heat will be just as disastrous.

If it is remembered that "early wheats" are early in maturing, and "late wheats" are late in maturing, the whole problem is solved, and there is no possibility of mistakes being made in the future.

Sow "early" wheats last, and "late" wheats first.

VARIETIES FOR VARIOUS DISTRICTS AND PURPOSES.*

As the foregoing pages have amply indicated, the purposes for which wheat may be grown differ considerably, just as do the districts and conditions. No variety is suitable for all purposes or all districts, and the farmer must therefore select the variety he is going to sow with careful regard for his object as well as his conditions. The production of grain in the Riverina, for instance, is a very different matter from wheaten hay in hot western districts or green fodder on the coast.

In the following arrangement of districts the varieties are named that are most suitable for each purpose, and also the time when they should be sown. The farmer will do well to follow these recommendations with care.

Varieties According to Maturity and Sowing.

For the guidance of growers it will be convenient first to classify the best wheats in respect of maturity, though slight differences in various districts may be expected:—

Very Early.—Sunset.

Early.—Clarendon, Florence, Firbank, Canberra, Thew, Improved Steinwedel.

(These should usually be sown late.)

Mid-season.—Hard Federation, Genoa, Warren, Bomen, Federation, Gresley.

(These should usually be sown in mid-season.)

Late.—Marshall's No. 3, Yandilla King, Warden, Zealand, Cleveland, Huguenot.

(These should be sown early.)

The Department's Recommendations.

The wheats recommended by the Department for various purposes may be grouped in districts as follow:—

Coastal Districts.

[Embracing those districts bordering on the coast, and which are specially subject to rust.]

For Hay—

Clarendon, Florence, Firbank, Thew (early maturing varieties);
Warren (mid-season maturing);
Cleveland (late maturing).

* Detailed descriptions of the varieties recommended in this classification will be found beginning on page 311.

For Green Fodder—

Clarendon, Florence, Firbank, Thew (early maturing varieties);
 Warren, Huguenot (mid-season maturing);
 Cleveland (late maturing).

Sowing for hay should be made later than for green fodder.

Northern Tableland.

[Of which Glen Innes is representative.]

For Grain or Hay—

Genoa (early sowing);
 Warren (mid-season sowing);
 Florence (mid-season and late sowing).

For Green Fodder—

Florence (early, mid-season, and late sowing).

Central Tableland.

[Of which Bathurst is representative.]

For Grain or Hay—

Cleveland (early and mid-season sowing);
 Marshall's No. 3 (early and mid-season sowing);
 Yandilla King (early and mid-season sowing);
 Florence (mid-season and late sowing).

For Hay only—

Zealand (early sowing);
 Warden (early sowing).

South-western Slopes and Riverina.

[Of which Wagga and Temora are representative.]

For Grain or Hay—

Yandilla King (early sowing);
 Marshall's No. 3 (early sowing);
 Bomen (mid-season sowing);
 Improved Steinwedel (mid-season sowing) in drier portions only;
 Florence (mid-season and late sowing);
 Gresley (mid-season and late sowing);

For Grain only—

Federation (early and mid-season sowing);
 Hard Federation (mid-season);
 Canberra (late sowing).

For Hay only—

Zealand (early sowing);
 Warden (early sowing);
 Firbank (mid-season and late sowing).

Central-western Slopes.

[Of which Dubbo, Gilgandra, Wellington, Cowra, Grenfell, Forbes, and Parkes are representative.]

For Grain or Hay—

Cleveland (early sowing), especially suitable for the cooler portions of this district, such as Mudgee ;
 Bomen (mid-season sowing) ;
 Marshall's No. 3 (early and mid-season sowing) ;
 Yandilla King (early and mid-season sowing) ;
 Warren (mid-season sowing) ;
 Improved Steinwedel (mid-season sowing) ;
 Gresley (mid-season and late sowing).

For Grain only—

Federation (early and mid-season sowing) ;
 Clarendon (mid-season and late sowing) ;
 Hard Federation (mid-season and late sowing) ;
 Canberra (late sowing).

For Hay only—

Warden (early sowing) ;
 Firlbank (mid-season sowing).

North-western Slopes.

[Of which Tamworth and Gunnedah are representative.]

For Grain or Hay—

Cleveland (early and mid-season sowing), especially suitable for the cooler portions of this district, such as Inverell and Delungra.
 Yandilla King (early and mid-season sowing) ;
 Marshall's No. 3 (early and mid-season sowing) ;
 Bomen (mid-season sowing) ;
 Warren (mid-season sowing) ;
 Improved Steinwedel (mid-season sowing) ;
 Florence (late sowing).

For Grain only—

Hard Federation (mid-season and late sowing) ;
 Clarendon (mid-season and late sowing) ;
 Canberra (late sowing).

Black Soil Plains.

[Of which Coonamble is representative.]

For Grain or Hay—

Warren (early sowing) ;
 Improved Steinwedel (mid-season sowing) ;
 Canberra (mid-season sowing) ;
 Florence (mid-season and late sowing).

Western Plains.

[Of which Nyngan and Condobolin are representative.]

For Grain or Hay—

Improved Steinwedel (mid-season sowing) ;
 Clarendon (mid-season sowing) ;
 Canberra (mid-season and late sowing) ;
 Florence (mid-season and late sowing) ;
 Firlbank (mid-season and late sowing) ;
 Sunset (mid-season and late sowing).

Varieties Recommended.

A.—DUAL PURPOSE WHEATS.

Recommended for both Grain and Hay.

Variety.	Period of Sowing.	Districts.
Bomen	Mid-season	Central-western Slopes; South-western Slopes and Riverina; North-western Slopes.
Canberra	Mid-season	Black Soil Plains
	Mid-season and late	Western Plains.
Clarendon	Mid-season	Western Plains.
Cleveland	Early	Cooler portions of Central-western Slopes.
	Early and mid-season	Central Tableland; cooler portions of North-western Slopes.
Firbank	Mid-season and late	Western Plain †
Florence	Mid-season and late	South-western Slopes and Riverina; Central Tableland; Northern Tableland; Black Soil Plains; Western Plains.
	Late	North-western Slopes.
Genoa	Early	Northern Tableland.
Gresley	Mid-season and late	Central-western Slopes.
Haynes' Blue-stem.	Very early	Northern Tableland.
Improved Steinweidel.	Mid-season	Drier portions of South-western Slopes and Riverina; Central-western Slopes; North-western Slopes; Black Soil Plains; Western Plains.
Marshall's No. 3	Early	South-western Slopes and Riverina.
	Early and mid-season	Central Tableland; Central-western Slopes; North-western Slopes.
Sunset	Mid-season and late	Western Plains.
Warren	Early	Black Soil Plains.
	Mid-season	Northern Tableland; Central-western Slopes; North-western Slopes.
Yandilla King	Early	South-western Slopes and Riverina.
	Early and mid-season	Central Tableland; North-western Slopes; Central-western Slopes

B.—WHEATS FOR GRAIN ONLY.

Not recommended for Hay.

Variety.	Period of Sowing.	Districts.
Canberra	Late	South-western Slopes and Riverina; Central-western Slopes; North-western Slopes.
Clarendon	Mid-season and late	Central-western Slopes; North-western Slopes.
Federation	Early and mid-season	South-western Slopes and Riverina; Central-western Slopes.
	Mid-season	Central Tableland; North-western Slopes.
Hard Federation	Mid-season	South-western Slopes and Riverina.
	Mid-season and late	Central-western Slopes; North-western Slopes.

C.—WHEATS FOR HAY ONLY.
Not recommended for Grain.

Variety.	Period of Sowing.	Districts.
Clarendon	Early, mid-season and late ...	Coastal.
Cleveland	Early and mid-season ...	Coastal.
Firbank	Early, mid-season and late ...	Coastal.
	Mid-season	Central-western Slopes.
	Mid-season and late	South-western Slopes and Riverina.
Florence	Early, mid-season and late ...	Coastal.
Gresley	Mid-season and late	South-western Slopes and Riverina.
Huguenot	Early and mid-season	Coastal.
Thew	Mid-season	Coastal.
Warden	Early	Central Tableland; South-western Slopes and Riverina; Central-western Slopes.
Warren	Early and mid-season	Coastal.
Zealand	Early	Central Tableland; South-western Slopes and Riverina.

D.—WHEATS SUITABLE FOR GREEN FEED AND SOILING.

Variety.	Period of Sowing.	Districts.
Clarendon	Early, mid-season and late ...	Coastal.
Cleveland	Early and mid-season	Coastal.
Firbank	Early, mid-season and late ...	Coastal.
Florence	Early, mid-season and late ...	Coastal; Northern Tableland.
Huguenot	Early and mid-season	Coastal.
Thew	Early, mid-season and late ...	Coastal.
Warren	Early and mid-season	Coastal.

Change of Seed.

The complaint is frequently made by farmers that the seed of a variety that they have been using for years has "run out." Similarly, the statement is often heard that Federation or some other variety is not yielding as well as it did, say, ten years ago.

In most cases the statement is perfectly correct—that is, as to the strain that the farmer is using. Inquiry into the facts will usually disclose that the seed has not been changed for years—that year after year a portion of the grain harvested on the farm is kept for next year's sowing, and as probably very little care is taken in the selection of the bags to be kept, there has been a steady decline in vigour and quality. And can any surprise be entertained that this should be so? Can we expect if a variety is grown for years without any attempt to maintain the quality and purity of the variety and the vigour and productivity of the strain that there will be anything else than decline? What would be the result of allowing a hundred stud ewes and a couple of rams to breed indiscriminately for years without the guiding hand of man? No farmer would contemplate such a method. Instead he culls and selects year by year, and actually improves and increases the product of the flock. The same applies, though in a rather different way, to the crops of the farm. As a result of continuous selection and care, the Federation that is now being distributed from the experiment farms of the Department is appreciably better than it was twenty years ago. An illustration of this was afforded some years ago on an occasion when three samples of Federation came to be compared in the laboratory. A sample was

brought to the Department from Temora district to show how Federation had deteriorated, and it was subjected to comparison with a Departmental sample of the same variety several years old that was available, and with a sample of Federation of that season's growth on one of the experiment farms. It was found that the old sample was distinctly better than the farmer's sample, and that the modern sample was best of all. Here, then, were three Federations—one showing the quality sold to farmers by the Department years before for seed purposes, a second showing how the variety had deteriorated in farmers' hands, and a third showing the improvement effected by selection in the hands of the Department.

Good as they may be to-day, neglect would allow even such varieties as Hard Federation and Canberra gradually to lose favour.

The system of plant improvement that has been in operation at the experiment farms in the wheat belt consists of the selection for its outstanding qualities of a single plant of the different varieties grown. The seed from this plant is then sown in a single row, which can be inspected and undesirable plants discarded; the grain from that row is again sown by itself until sufficient seed has been produced from the single plant to enable a larger area to be sown on the farm, whence it is distributed to farmers for use in their paddocks and very often in farmers' experiment plots.

Not only is seed of greater purity obtained in this way, but also a strain of greater stamina and productiveness. The farmer garners the good seed with the bad, and does it year after year, but the above system (which is really not beyond the capacity of any farmer himself) ensures improvement rather than decline.

It is not necessary for the farmer to undertake the selection of a single plant every year and from it to raise seed for future use. He has neither the time nor the necessary knowledge for such work. What is suggested is that when a farmer finds his favourite variety is not yielding up to his expectations, he should obtain a few bushels of stud seed from the experiment farm nearest him, and from it propagate seed that can be sown on the farm area the following year. Such seed will retain its stamina for several seasons, when it may be time for another recourse to the experiment farm.

The Value of Graded Seed.

It is very important that only graded seed be used. Grading not only removes wild oats and other foreign seeds, but also ensures uniformity. If the size of the seed is uneven the sowing will be uneven, inasmuch as the grain will not run evenly through the cups of the drill.

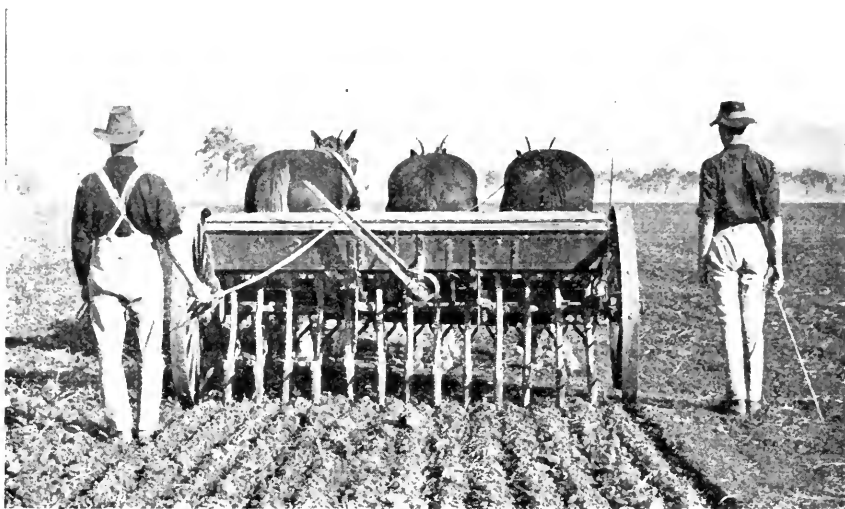
It must not be imagined that because small grains are sown, weak or poor plants will necessarily result. As a matter of fact, if the smallness of the grain is due to adverse weather conditions during growth, no harm is done—indeed, the crop may be a vigorous one. But if the smallness of the grain is due to the parent plant having been weak or diseased, it is obvious that a good strain cannot result.

In order to be on the safe side, therefore, the Department would urge upon farmers thoroughly to grade their seed before sowing.

Various types of graders are on the market, but it will generally be found that the type equipped with the cylinder and perforated screens is the most efficient, and for all practical purposes the single-cylinder machine is the most convenient. For small quantities of up to, say, 250 or 300 bushels, a hand machine will admirably answer the purpose, but for larger quantities of wheat it is advisable to drive the grader with a small power engine.

SOWING THE WHEAT.

One of the essentials of a well-sown paddock of wheat is that the seed should be thoroughly covered. Whether the land has been fallowed or has been under stubble, a final cultivation or harrowing has to be given, and, unimportant as it may appear at first sight, a great deal really depends upon the direction in which it is done. Cultivators leave shallow furrows and ridges in the soil, and if the hoes of the drill get into these furrows and run laterally along them, especially on land that is not quite even, the seed will



The Drill at Work.

not be covered to a uniform depth. If, on the other hand, the final cultivation has been carried out at right angles to the direction in which the seed is to be sown, the hoes of the drill will cut through the furrows and ridges, and the seed will be properly covered. In actual practice it may sometimes be difficult to do this, but if the last cultivation has to be in the same direction as the drilling it is a good idea to level the soil by trailing a harrow behind the cultivator. A surface is then obtained in which the seed can be well covered.

Setting the Drill.

An important operation connected with sowing is the proper setting of the drill according to the variety and condition of the seed. A drill set to sow, say, 45 lb. of Federation per acre will often sow as much as 55 lb. of small "shotty" seed such as Comeback. Liming after bluestone makes a great difference. Atmosphere also influences flow of seed through the drill. Many farmers have made mistakes in this way, having taken it for granted that the drill will sow large grains and small grains at the same rate. In reality the larger grains run through the drill distinctly slower than shotty seed, with the result that a farmer who thinks he has put out enough to sow a certain paddock finds he is several bags short. It is safe to reduce the drill to sow about 35 lb. of "shotty" grain as compared with 45 lb. of an average sample of Federation.

Again, a variety will differ with the season. The Federation harvested in 1921 before the rain, for instance, was appreciably heavier and more "shotty" than the same variety harvested after the rain, and the drill should next season have been set according to the sample.

The farmer will find it advisable in starting to sow, to weigh the seed used over a known distance, and then it is possible to calculate almost exactly what will be required to sow the paddock, and to set the drill accordingly.

Cleaning out the Drill.

The cleaning out of the wheat-cups in the drill is another operation that frequently exercises the farmer. If he rightly wishes to keep his paddocks absolutely clean by avoiding the mixing of varieties, he is reduced to the alternatives of running out the seed that remains in the drill on to the headlands, or of jacking the drill up by setting a log, end on, under the axle and standing the horses "up." But the former is obviously not a good method, and the latter is most unsatisfactory in the extreme probability that the axle will be bent.

If the drill be examined, an opening will be found in the iron plates at the ends of the seed-box, and working just inside the hole is the end of the square iron bar that agitates the feeders in the cups. A key is supplied with most makes of drills to fit through the hole in the plate on to the square end of that iron bar. A few turns of the key will soon empty the cups of any wheat they may contain, and the mixing of varieties is avoided without waste, and with a minimum of trouble.

Quantity of Seed to sow per acre.

The quantity of seed to be sown per acre depends largely upon the variety that is sown, and also upon the time when it is sown. A safe rule to follow is that good stooling varieties, such as Marshall's No. 3 and Yandilla King, should be sown at a lesser rate per acre than such a comparatively poor stooling variety as Firbank. If the wheat is sown early, a smaller quantity can be used than if the seed is sown later on in the season.

Again, the rainfall in the district largely influences the quantity of seed that should be sown per acre. For instance, in a district where the rainfall, is say, 22 inches, a larger amount of seed can be sown per acre than in a district where the rainfall is only from 17 to 18 inches per annum.

The size of the seed and the fertility and condition of the soil are other factors that have to be taken into account. A small seed will require a slightly lighter seeding, and the same will apply in the case of a fertile or well conditioned soil.

As a general practice in the true wheat belt, the quantity of seed for early sowings should average 40 to 45 lb.; for mid-season sowings 45 or 50 lb.; and for late sowings 55 to 60 lb., the largest figure being chiefly for hay crops that are being sown quite late. In the tableland districts sowings should on the whole be heavier, and on the Black Soil and Western Plains they should be lighter.

Depth of Sowing.

The depth at which wheat should be sown is often a subject of discussion among farmers, there being those who advocate a comparatively shallow sowing and others that favour a deep one. In general, nothing is gained by sowing too deeply. The contention of many farmers that deep sowing

ensures deep rooting, and therefore greater drought resistance, is based on a misconception. The roots of a grain sown 2 inches deep will penetrate just as far into the soil as those of one sown 4 inches deep. The principal advantage of sowing fairly deep is to make sure that the grain is well covered and thus protected from the attacks of birds. Any greater depth than 3 inches can only be justified if the soil is in such a condition as will ensure immediate germination and enable the young plants to get above the surface before the top soil has had time to set hard. Certainly to put seed more than 3 inches below the surface is, in most instances, to court failure.

If the conditions are favourable, from 2 to 2½ inches is deep enough. In the case of a late sowing—towards the end of June—when a quick germination is desired, it will be found that 1½ inches is ample, provided the drill is in good working order and the soil in such a condition that most of the grains will be uniformly covered.

The condition of the soil, indeed, is perhaps the most important reason for farmers sowing too deep—the soil is lumpy and not in a good state of tilth, and in order to cover the seed in places the drill has to be set to a considerable depth. On a well-cultivated and well-prepared paddock the drill can be set to sow ever so much shallower than on a rough, ill-prepared one. With a well-prepared seed-bed the seed can be placed just where the farmer desires.

COST AS A FACTOR IN WHEAT PRODUCTION.

The question of the cost of producing a crop of wheat has always been of supreme importance to the wheat grower, but perhaps never in the history of New South Wales has it been of greater interest than now. Discussion has been frequent and prolonged, the result being the disclosure of greater diversity of opinion than about almost any subject touching farm practice. Individual variations in methods of farm management and work are so great that, while hundreds of farmers can agree about the quantity of seed or manure that should be used per acre, or about the preparation of the land, few can agree as to the actual cost of production. The estimates presented in this article have been prepared from figures furnished by the managers of various experiment farms in the State, and by the inspectors stationed in the wheat belt, who in their turn obtained much valuable information from the leading growers in their respective districts. Even in figures so carefully collected as these, some variations have been disclosed, but they are not sufficiently large to seriously affect the issue, and it is possible to present the estimates in this article as approximating the average costs for the wheat belt of the State.

Wheat for Grain.

Estimates of the cost of producing wheat for grain (fallow and non-fallow compared) appeared on page 242, but it may be convenient to repeat the figures for fallowed land here. These estimates, be it further remarked, are in respect of operations in the commonly recognised wheat belt of this State. Production on the tablelands, especially in New England, is another matter, and is specially dealt with on page 272.

The item "rent" will vary with the value of the land, but for convenience the capital value is assumed to be £6 per acre, but as the wheat will be grown on the best portion of the farm, the rental is charged at 8s. per acre. It should not be understood, however, that the farmer can make nothing out of the land while it is under stubble or after it has been ploughed for the fallow. As pointed out a few pages further on, profitable pickings are avail-

able for sheep on such cultivation land at different times in the year, but, as the present concern is the cost of producing a crop of wheat for grain, that aspect of the subject may be set aside, and the rent for the whole of the two years must be charged against the grain crop. In the case of unfallowed land, of course, only one year's rent would be so charged.

Cartage to the railway is another item that is hard to estimate, as very much depends on the distance and the nature of the country, but for an average distance of 6 or 7 miles it works out at very close to 4d. per bushel.

Cost of producing an acre of wheat for grain. Estimated yield, 20 bushels.

	£	s.	d.
Ploughing once	0	8	6
Harrowing three times	0	3	0
Disc-cultivating once	0	4	0
Spring-tooth cultivating once	0	2	9
Drilling	0	2	6
Seed, 45 lb. at 7s. 6d. per bushel	0	5	8
Superphosphate, $\frac{1}{2}$ cwt. at 7s. per cwt.	0	3	6
Pickling seed	0	0	4
Harvesting with harvester	0	9	0
Bags, seven at 10s. per doz.	0	5	10
Rent, two years at 8s. per annum	0	16	0
Cartage to rail, at 4d. per bushel	0	6	8
Total	£	7	9

Wheat for Hay and Chaff.

Whether it is more profitable in an average season to harvest for grain or for hay is ever an interesting subject for discussion. In the main, of course, everything depends on the market prices of the two lines, but the respective costs of growing, harvesting, and carting are also important, and it may therefore be of interest to consider the average outlay per acre of cutting with the reaper and binder and subsequently chaffing.

As the preceding estimate is on the basis of a yield of 20 bushels of grain, it is convenient to assume that the equivalent yield in hay will be 2 tons.

The estimate is again formed on the assumption that the land is fallowed, and the rent for two years is added as before.

Taking 1s. 6d. per ton per mile as the basis of the item "cartage to rail," the cost for a distance of, say, 6 miles can be set down at 9s per ton.

Cost of producing an acre of wheat for chaff. Estimated yield, 2 tons.

	£	s.	d.
Ploughing once	0	8	6
Harrowing three times	0	3	0
Disc-cultivating once	0	4	0
Spring-tooth cultivating once	0	2	9
Drilling	0	2	6
Seed, 50 lb. at 7s. 6d. per bushel	0	6	3
Superphosphate, $\frac{1}{2}$ cwt. at 7s. per cwt.	0	3	6
Pickling seed	0	0	4
Cutting with binder	0	5	6
Twine	0	3	6
Stooking	0	2	6
Carting, stacking, and thatching	0	15	0
Cutting for chaff, 2 tons at 15s. per ton	1	10	0
Bags, say 24 per ton, at 8s. per dozen	1	12	0
Rent, two years at 8s. per annum	0	16	0
Cartage to rail, at 9s. per ton	0	18	0
Total	£	13	9

SHEEP ON THE WHEAT FARM.*

Sheep must be regarded as an indispensable factor on the wheat farm. They are valuable as part of the working plant of the farm for the control of weeds, &c., and as an important and reliable source of income.

While, as a general practice, the use of agricultural land for sheep-raising is unprofitable, if due consideration is given to questions of interest and other items of a like nature, it cannot be taken as a hard and fast rule, as the indirect value of the sheep is frequently of greater importance than the cash return. It is essential to the success of the crop that the farmer have on his holding as many sheep as possible, compatible with the most economical use of the land for wheat production.

Sheep are useful and valuable on the following grounds:—

1. They consume and turn to profit the straw left after the harvest.
2. They turn weeds to profit and prevent them from seeding at times when the farmer is unable to deal with them, owing to pressure of other work.
3. Their manure improves the fertility of the land.
4. When the season is so bad that the crops fail to produce grain, sheep turn them to profitable account.
5. The income from the farm is rendered more certain, as the farmer does not then depend entirely upon a crop that may be destroyed by fire or hail.
6. Sheep necessitate the adoption of a rotation, which tends to improve the fertility of the land, and to increase the yields of the crops.
7. They can be used to feed off crops that need such a check.
8. A supply of cheap mutton is made available for the farmer's own household.

To these advantages might be added the pride and pleasure derived by a farmer from the possession of a good flock.

The Number to Carry.

The number of sheep that can be carried on a wheat-farm varies according to the class of soil, climate, and the farming system adopted. If the sheep are regarded purely as an adjunct to wheat-growing, and are kept principally for scavenging, then the number must be strictly limited. If, on the other hand, a farmer regards lamb-raising as an important part of his enterprise, and makes provision for the growing of crops solely for sheep-feed, then the number may be very considerably increased. Some who adopt the latter practice carry as many as one and a half sheep to the acre, and still grow a considerable quantity of wheat.

In districts with a distinctly summer rainfall, particularly the north-western portion of the State, it is doubtful whether it is a sound policy for farmers to endeavour to grow wheat as the main source of their income. Some have already realised that their income is more assured when sheep take an important place in the farm operations. A very great deal of the land in the north-western districts suitable for wheat is not good land for the carrying of sheep in its natural state, but it is immensely improved by cultivation, and after being used for wheat for a few seasons it makes splendid

* A. H. E. McDonald, Chief Inspector of Agriculture.

grazing land. Further, Sudan grass and lucerne both thrive well there. The value of the latter is well known, and it needs no recommendation. A number of practical farmers are now extensively growing Sudan grass solely for the fattening of lambs, and are getting excellent returns.

In the north-west, and in other districts to a lesser extent, rain very frequently falls during the summer months, but fails during the wheat-growing season. Where wheat alone is relied upon the year's income is partly or wholly lost in a dry season, but where sheep have a prominent place on the farm a failing crop can be profitably utilised by turning the flock in. The summer rains, on the other hand, produce an abundance of feed, particularly if Sudan grass or a similar crop has been sown.

In the past it has usually been taken for granted - as a result of habits formed during our long pastoral history - that sheep should be turned out into the grass paddocks for their living. Such traditions are, however, now dying, and many practical farmers are producing crops to increase the carrying capacity of their land.

Such crops are valuable in several respects. Sown crops invariably make quicker and greater growth than natural herbage, even under the most favourable conditions. This indicates that some crop should be grown to produce succulent green feed for lambs about April or May. Such feed promotes the rapid development of the lamb by increasing the milk flow of the mother, and results in the early maturity of a first-class lamb.

The growing of fodder crops is of great value, inasmuch as a large quantity of feed is produced on a small acreage. On a good crop of oats, barley, or wheat, from ten to twenty sheep can be carried per acre for a lengthy period in the spring. It is just at this period that the summer herbage is sprouting. If heavily stocked at that stage, the young grass is eaten off as quickly as it sprouts, and is prevented from making a strong growth. Where a crop is available on which the sheep can be kept at this period, the grass can be protected until it has made a good growth, and a heavy body of feed is thus provided that will carry sheep through the summer. Even on purely grazing properties it is found that the carrying capacity can be largely increased if the sheep can be kept off the grass at this period.

Sheep are particularly valuable in controlling weeds, especially wild oats. It frequently happens during spring that the oats cannot be entirely destroyed. Even on the best-worked farms wet weather may prevent their complete destruction. The farmer finds the haymaking at hand, and his only possible means of preventing the oats on his fallow land from seeding is to graze them off with sheep. When the returns from the sheep are being taken into account due credit should be given for these indirect benefits.

Fallowing in Relation to Sheep.

The value of fallowing is now recognised by all capable farmers. Fallowing, however, can only give the best returns when combined with sheep, and it actually provides the opportunities for keeping sheep. Where fallowing is not practised the straw is burnt off and the land is ploughed for the succeeding crop, but under a fallowing system it is not necessary to burn the straw, for the stubble can be grazed with sheep six or seven months after harvest. A great deal of the straw is eaten, and the balance is broken and trampled into the ground, and is generally put into such a state that it can be ploughed under easily without the texture of the land being interfered with.

In the Old World great value is attached to farmyard manure, the basis of which is straw. It is not yet possible, in this country of high labour costs, to adopt reaping and threshing and the production of farmyard manure for the maintenance of soil fertility. The grazing of sheep on the straw and the ploughing under of the residues, however, is a very fair substitute, and has the advantage, which appeals to all of us, of being applicable at no outlay for labour.

A very undesirable feature of farming in our wheat districts is its one-crop nature. Such a system tends to deplete the fertility of the land, and to encourage weeds and diseases. Some of these—namely, wild oats among the weeds, and take-all among the diseases—levy very heavy toll upon our crops, and the only practicable method of dealing with them is by rotation. In practically all the wheat districts, wheat is the only saleable crop which can be raised; but oats, barley, Sudan grass, and others can be grown as fodder crops and can be turned to account by means of sheep. By the use, therefore, of sheep, we can apply one of the great principles of good farming—rotation of crops.

Perhaps the chief reason that more sheep are not kept by many farmers is that the area under crop must then be restricted. Under our conditions any year may be a winning year—that is, the weather conditions may be so favourable that very heavy yields may be obtained from even the worst prepared land. This reason operated to a very great extent in the early development of wheat-growing, and still prevails in many newly-opened districts, but in the settled districts very many capable farmers have realised the value of adopting sound systems of mixed farming, which give sure and satisfactory returns.

It is very rarely that a crop fails entirely, but it does happen in our worst years, such as 1914 and 1919, that the crop fails for grain. In such years a growth is produced which, by the use of sheep, can be converted into wool and mutton, and made to give a very fair return.

The number and class of sheep which can be carried upon the farm depend upon the soil, climate, &c. In reaching a decision, other points should be taken into consideration—first, the cash return from the sheep, and second, the indirect return in the shape of heavier crop yields resulting from the greater fertility of the soil that results from grazing with sheep.

In the Riverina and central west, where the conditions are favourable for the production of wheat, the number of sheep carried on a farm would be the number required to keep the fallows in clean condition, and to enable the stubble to be turned to good account. A fair amount of feed is available from December to June, but natural herbage is generally short during the balance of the year, owing to most of the land being under fallow or in crop. A few acres of oats or barley should be grown to provide feed at this time. Such crops are particularly valuable for topping off the lambs.

In the northern portion of the western district, and to a greater extent in the northern districts, the climatic conditions are not so favourable for the production of wheat. The rainfall largely falls during the summer months, and the wheat-growing season is frequently so dry that the growth of the crop is affected. On the other hand, it happens not infrequently that the winter and spring are abnormally wet, and the yield suffers by lodging or by the attacks of rust.

While in this part of the State a large part of the annual rainfall occurs during the summer, it is not, excepting in one or two districts, sufficient for the production of summer crops for sale off the farm, such as maize, but it is sufficient for Sudan grass and for grazing lucerne. As the wheat crop is risky, it is evident that to stabilise the returns greater attention should be given to sheep, particularly the raising of fat lambs. Where the rainfall is so heavy as in the north-west—about 25 inches per annum—the carrying capacity of the farm is fairly heavy when fodder crops are grown. These latter are essential, for, as indicated previously, much of the land is not of good grazing quality in its natural condition, although when allowed to run to grass after cropping it improves very considerably.

Fodder Crops Essential to Best Results.

Farmers who have not had experience in raising fat lambs on crops look askance at suggestions of growing fodder crops, but those who have had experience and who have a good class of ewe, joining them with good rams, find the returns compare very favourably with those from wheat. It must be remembered that risks are avoided, and that the expenses of sacks and of harvesting are not incurred.

In the first districts mentioned, namely, those in the Riverina and the southern portion of the west, about 150 to 200 ewes can be kept on farms of about 600 acres. These could be carried principally on the stubble and fallows, with a little grass land. It would be necessary to provide some fodder to supplement the small amount of herbage on the fallows in the spring and early summer. For this purpose, a few acres, say, 20 or 30, of early-sown oats, would be sufficient. In some places in these districts summer crops cannot be successfully grown; but in some, Sudan grass grows reasonably well, and a small acreage should be sown.

In the northern districts the farmer should, on account of the somewhat risky nature of wheat-growing, definitely make lamb-raising an important part of his operations. On a 600-acre farm about 300 or 400 good ewes should be kept and fat lambs raised. This may appear a large number, and it would only be possible to keep so many by growing fairly large areas of fodder crops: but the climate is suitable for the production of these, and in the winter months oats and barley can be provided, while during the summer Sudan grass gives good feed and lucerne will also provide valuable grazing.

On every farm where sheep are kept a good reserve of pit silage should be held. Silage can be made easily and cheaply in the pit, and keeps indefinitely. It should be regarded as a reserve for dry years only, and therefore need not be made every year. Indeed, it would probably be found that the silage would remain in the pit for years, but the possession of it enables a farmer to keep up his carrying capacity, as he is not confronted with the danger of shortage of feed.

The Class of Sheep to Keep.

The lines along which the farmer shall work in the handling of his flock require a little consideration. Mr. F. B. Hinton, Sheep and Wool Expert, has pointed out that three avenues of direct profit from sheep are open to the farmer:—(1) He may confine himself to wool production, or (2) he may produce both wool and mutton, or (3) he may devote special attention to the production of lambs.

With regard to the first of these three the mixed farmer is at a disadvantage compared with the larger grazier. The latter has cleaner pastures and is able to produce a class of wool that commands more attention in the wool sale-room, for on the farm the dust from the cultivation paddocks and fallows penetrates the wool and opens it on the back, depreciating the value of the fleece. The farmer is, therefore, rather pressed into the second and third ways of earning profits from his sheep. The type of sheep that under most circumstances has proved profitable to the mixed farmer is the crossbred, which principally means the progeny of some longwool English ram with a Merino ewe.

A lot of attention has been devoted by the Department to this phase of the industry, and extensive experiments have been conducted to determine the best breed of ram and the best type of ewe for the purpose. Many English breeds have been tried, but certain ones have gradually been eliminated, until it has narrowed itself down to a contest between the Lincoln and the Border Leicester. Of the two, the latter shows slightly to advantage, although for certain districts the Lincoln is undoubtedly the better. Some of the Down breeds were also tried in this connection, but they failed to "mick" well with the Merino in the first cross. The class of ewe most suitable for mating with these British rams has been found to be a large-framed, plain-bodied, robust and roomy type of Merino ewe. The crossbred thus obtained gives a heavy weight of fleece and is always in ready demand as a mutton animal, whether for local consumption or for export as frozen mutton.

The third line of profit open to the mixed farmer is that of raising fat lambs. This is an industry that commends itself to farmers owing to the quick returns it furnishes, for it involves the marketing of the lambs straight off the mothers at the age of 16 to 20 weeks. The requirements of the trade are an animal that, as a dressed carcase, will run from 35 to 40 lb. and at the same time have the sappy, luscious flesh that belongs to lambs.

For fat lamb production certain things are essential, viz., the farm must be within easy distance of the railway, a supply of feed must be ensured for the ewes, and a combination of breeds must be used in order to ensure that the lambs grow quickly. Extensive experiments have been carried out by the Department in this direction, with the object of finding the best combination of breeds to produce early lambs, and it is here that the Down breeds showed their usefulness. Representatives of practically every Down breed (Southdown, Shropshire, Hampshire, Oxford, &c., and the Dorset Horn) were tried, being mated with first-cross ewes from the longwool crosses already referred to. At the conclusion of the experiments, the three breeds which showed out ahead of the others were the Dorset Horn, Southdown, and Shropshire, in the order named. The Dorset Horn proved itself pre-eminently suited for the production of early lambs. Working on these lines, the farmer gets approximately 25s. per head for the lambs, and in the vicinity of 10s. each for the ewes' fleeces.

The class of farming thus outlined commends itself to the wheat farmer—firstly, by reason of the quick returns; and secondly, because the sheep can be utilised for cleaning up the fallows and cultivation, and for feeding down crops when necessary. The farmer must ensure a supply of green feed for the ewes during and after lambing, in order that there may be a constant flow of milk for the lambs, which must not suffer any check or set-back from birth to marketing.

Handling the Flock.

Reverting to the subject of the ram most suitable for farmers' purposes, it must be remarked that unfortunately many farmers are content to use almost any breed of ram, and in many cases the crossbred has become a nondescript animal. It should always be remembered that a poor type of lamb costs as much to keep and as much to market as a high-class one, while the difference in price will amount to many shillings. Similarly, a poor type of ewe costs as much to keep as a good one, but will breed only a poor lamb and give half the weight of poor quality fleece.

It may cost a little more to buy a good line of ewes or a few good rams, but the extra outlay is amply justified by the return in wool and progeny.

The ewes should not be kept after their mouths begin to break. Old ewes certainly make good mothers, but they give a poor fleece of low weight, and furthermore, do not thrive in dry times, and they generally die early in drought periods. When they are becoming aged the first opportunity should be taken to fatten and sell them.

Success in lamb-raising depends very largely upon successful mating. In some cases this may be difficult to secure, but as a rule it should be arranged to commence towards the middle of April, about which time good green feed should be available. At an earlier period the pastures would probably not be in the autumn flush. The ewes should be in good condition at the mating time, but not too fat. It assists if the ewes can be put on some good green feed about a fortnight before mating.

The rams should be in good, strong, vigorous condition, and to obtain good results two rams should be used to every 100 ewes. If they show a disinclination to work, the ewes and rams should be yarded together at night.

Sheep are very fastidious in regard to water, and should always be provided with good fresh water. If dirty, they will only drink with reluctance, and as ample water, particularly when they are on dry feed, is essential, they should drink abundantly. It is, therefore, an advantage to pump water from dams or tanks, and to keep the drinking troughs scrupulously clean.

Feeding-off Growing Wheat.

The feeding-off of growing crops of wheat is frequently practised throughout the wheat belt of New South Wales. It is an operation that is entirely dependent upon the season, and with good rains and mild temperatures in April and May it may become an absolute necessity; but there are many cases where it is not carried out to best advantage as regards the ultimate yield.

Many farmers who combine sheep-raising with wheat-growing sow their crops very early with the specific object of making use of them during the winter months, when the natural pastures are often insufficient for sheep and particularly unsuitable for maintaining the supply of milk in ewes with lambs at foot. Such men are content to regard any loss in the ultimate yield of grain or hay as amply set off by the feed derived by the sheep.

Crops Sown for the Purpose.

Where a crop is being sown with the intention of feeding-off, the sowing should be early in order that the wheat may have a long enough growing season to recover from the effects of the feeding-off, and still yield a satisfactory crop. The slow-maturing varieties are, therefore, the most suitable, and have the added recommendation that they produce the largest quantity of leaf. Hence varieties such as Yandilla King and Marshall's No. 3

are eminently suitable for crops that are intended to provide some green fodder in the winter and a grain crop later in the year. Large areas of Federation are sown a little on the early side with the object of ensuring some feed in midwinter, though Federation hardly produces as much feed as one of the long-season varieties sown, perhaps, two or three weeks earlier. Neither late-sown crops nor quick-growing varieties can be expected to produce anything appreciable in the way of green feed, most of the varieties suitable for June sowings being comparatively poor stoolers and of scanty vegetative habit.

Strongly Rooted Crops.

A crop may usually be said to be ready to be fed off when it is about 6 inches high. It is a common error for farmers to turn sheep on to wheat that is not sufficiently well rooted to stand the pulling about that the sheep will certainly give it. How frequently this happens will be realised if a careful examination is made of a few paddocks after the sheep have been removed, dead plants being everywhere observable if the wheat was not strongly rooted when the stock were turned in. A good firm root-hold is an essential to grazing the crop down.

Feed-off Rapidly.

The length of time the sheep should remain on growing wheat is also of importance. For the sake of the crop it should be as short as possible. It is much better to turn on, say, thirty sheep per acre for one week than, say, ten sheep per acre for three weeks, because in the latter case the soil will be tramped too hard, and tracks are likely to be formed that will remain until the grain is harvested. Tracks are most likely to appear when there is a tank or dam in the paddock, but they are apt to become almost as distinct even in the absence of a dam, if the sheep are allowed to remain too long on the crop.

Heavy stocking for a few days has also the advantage that it ensures more uniform treatment by the sheep. In a crop that is very rank in patches, and that is in danger of developing rust or powdery mildew, there is every likelihood that the sheep will tackle last those patches that the farmer wishes to see eaten back first, and that tendency can only be combated by turning in a large flock for a short time.

Objection will naturally be offered by the farmer who has sown a large area early for the express purpose of ensuring green feed in the winter, and with the definite object of getting a return from his sheep. To him a week or two is quite insufficient to fatten off the lines of stores that he has probably purchased for the purpose, and the only advice that can be offered to such a man is that he must in some measure choose between the wheat crop and the fat sheep—relying on his experience as to which is likely to yield him the greater profit.

When not to Feed-off.

On some soils, particularly those of a heavy clayey nature, feeding-off has the effect of tramping the ground so hard that the harrows seem to do little good, even when heavily weighted. Obviously feeding-off should be avoided as far as possible in all such cases. Nor can the operation be advocated in respect of paddocks where the seed-bed was not as clean as it might have been. In such cases it often happens that the wheat keeps ahead of the grass and weeds until it is fed-off, and would probably have done so till harvest, but it fails to do so after it has been checked by the sheep. The enemies of the crop seem then to get such a hold as to interfere with its growth and materially to reduce the ultimate yield.

Sheep should never be turned on to the crop when it is too wet, or when the land is in a boggy state, otherwise the soil will be trodden right out of condition. Similarly, if rain falls while the sheep are on the crop, they should be removed as soon as possible.

When to Remove the Sheep.

Considerable differences of opinion exist amongst practical men as to the latest date at which wheat should be fed-off, some holding that the operation should be limited to the early part of the winter, and others contending that it may safely be extended into early spring. The controlling factor is the weather. In a favourable spring, a crop will recover and yield well notwithstanding that feeding-off has been prolonged, but on the other hand it is obvious that if a dry spell ensues upon feeding-down close in July or early August there is practically no hope of a recovery. The question is therefore, what is likely to be the nature of the spring, wet or dry? Were it possible to forecast the weather with any degree of certainty, this and many other problems would be solved. Even the average incidence of the rainfall for particular districts is of little value, but this can be said—in New South Wales dry springs are certainly more common than wet ones, and the farmer who would err on the side of safety will limit feeding-off to early and midwinter, and will make an absolute end of it by the 30th June. The only extensive exception to this rule is the north-west, where the time may with safety be extended to the middle of July. Speaking generally, the earlier the sheep are off the better for the crop.

Effect of Feeding-off.

Does feeding-off affect the yield, and to what extent? There are farmers who turn sheep into their wheat simply because they believe they will get an increased yield, but there is ample evidence of the most reliable kind that a distinct decline in yield is caused, particularly in the case of hay crops. The idea that feeding-off promotes stooling, and thereby a strong rooting habit, is probably well grounded, but that the crop suffers in bulk in the great majority of cases is practically certain. Admittedly there are occasions when wheat crops must be fed-off. It is quite possible for a crop to become so forward that, if the growth is not checked, it will come into ear at a time when weather conditions will be unfavourable for hay-making, and when it will probably be badly frosted if left for grain. Very often this untimely "heading out" of a crop is the result of ignorance of the true nature of the variety, an early or quick-maturing kind of wheat having been sown early in the season instead of late. Such rapid development of a field of wheat under normal conditions is rare, however, and given right varieties, feeding-off under the impression that it will greatly increase the yield cannot be advocated.

Harrowing.

After feeding-off it is advisable to put a heavy set of harrows over the field to loosen the surface. Some farmers think that heavy harrows pull too many wheat plants out of the ground, and while it must be admitted that a few will suffer in this way, no wheat farmer should be concerned about that, for the advantages far outweigh the disadvantages. "The man that harrows should never look behind" runs an old adage, and there is truth in it. The harrows should always be run across the direction in which the seed has been drilled.

WHEAT-GROWING IN NEW ENGLAND.*

The conditions governing the production of wheat on the Northern Table-land differ considerably from those in the rest of the State. The climate is cooler and the rainfall heavier and more reliable than elsewhere, while the soil is of a heavier nature and chiefly basaltic, though volcanic ironstone also occurs. The cooler temperatures necessitate the use of hay on a larger scale for the feeding of stock than in the warmer districts, and wheat is so suitable for this purpose that quite half the area sown to that cereal each year is cut for hay. Under the influence of changing conditions, however, there are indications that wheat for grain may in the future prove a larger factor in farming in this part of the State than formerly.

The New England farmer requires to select his soil with some care for the different crops. Good hay crops are obtainable on almost any class of soil, though the darker and richer soils are perhaps the best, but for grain such land should generally be avoided, and preference be given to the lighter and red coloured soils. It has been observed that the head does not always fill well on the heavy soils; very heavy yields of straw are obtainable, but even in the shorter crops the heads do not always fill well.

In one respect the New England farmer enjoys a distinct advantage over his western compeer—he can adopt a rotation of crops that is profitable at each course, and yet practically complete. The western grower is distinctly limited in the matter of profitable crops that can be alternated with wheat, but the New England farmer can adopt a rotation that in four years provides three grain crops, a fodder crop, and a fallow. The course consists of:—

Maize or Potatoes—sown in October or November; harvested in June.

Wheat or Oats (quick-growing variety)—sown in July or August; harvested in December.

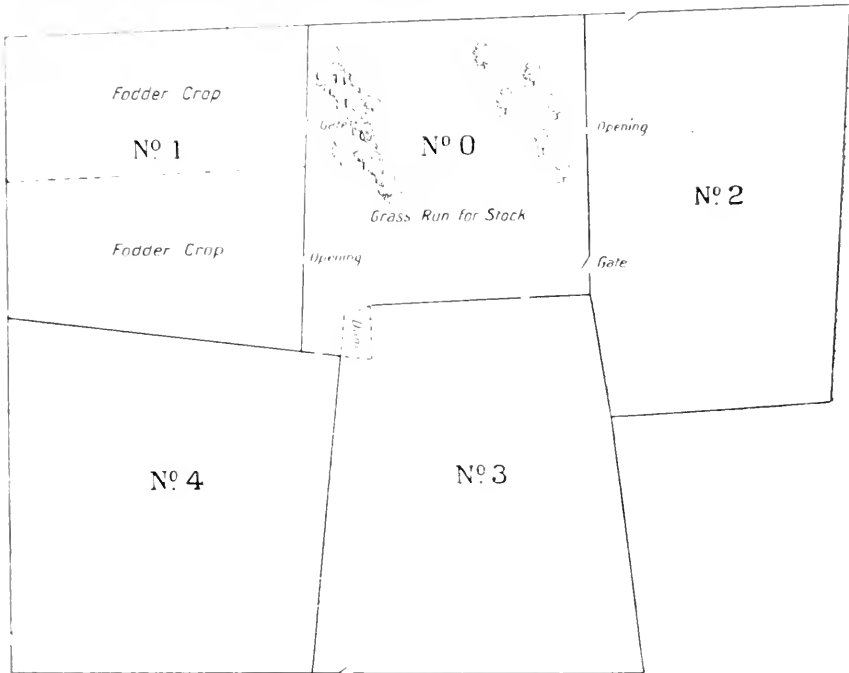
Fodder crop (rape or turnips in combination with a cereal, sown in February; or clover with an annual or biennial grass, sown in March or April); fed off with sheep, residue ploughed under in early summer.

Wheat or Oats (slow-growing variety)—sown in April; or medium slow-growing variety—sown in May or June; harvested in December; land fallowed in January or February in view of sowing maize or potatoes in the following spring.

Such a rotation carries its own recommendations, there being a sufficient variety of crops to maintain fertility, as well as provision for a flock of sheep on the farm. It should not be necessary in these days to commend to a wheat-grower the value of a flock of sheep. In every part of the State it is found that the combination is an invaluable one, and New England is no exception. Some of the best crops obtained on Glen Innes Experiment Farm have followed the fodder crop, but sheep also turn weeds, self-sown wheat and stubble to account, and enable the farmer to make money out of

* R. H. Gennys, Manager, Glen Innes Experiment Farm.

what would otherwise be a source of trouble and expense. The accompanying diagram gives some idea of how, taking advantage of natural conditions, the paddocks are arranged for the rotation at Glen Innes Experiment Farm. It will be seen that the paddock No. 0 contains a dam to which access can be had from all the paddocks in the rotation area. Several acres of red gum scrub near the water afford protection for the stock from wind and rain in winter, and from the heat of the sun in summer. Suitable licks are always available in the timber, and generally a straw stack for the stock to pull at; in lean seasons these stacks are invaluable, and even when succulent fodder is available they help to balance the ration.



Plan showing the arrangement of Rotation Paddocks at Glen Innes Experiment Farm.

[The dotted line across No. 1 Paddock indicates a temporary fence.]

The practice on this farm is to clear the maize stalks off, and plough the land at once, so as to get it into condition and enable the seed to be sown as soon as possible. It goes without saying that to sow wheat immediately maize stalks are removed would be impracticable in other districts, as the ground would be quickly dried out. The moisture conditions of New England enable it to be done, however, and done profitably.

The depth of ploughing for this sowing is usually 4 inches, and a method of preparing the seed-bed must necessarily be adopted that will conserve to the maximum the moisture left in the soil by the maize. Necessarily it is July or August before the wheat can be sown, but it is not too late for the district. As a matter of fact, visitors from other parts of the State are often surprised to see crops being sown on these tablelands as late as the beginning of September—a time when the coastal crops are ready for cutting, and when western crops are regarded as approaching maturity.

An early maturing variety of wheat must be used. Thew has been tried, but with only a fair amount of success on the Experiment Farm, and with farmers who are sowing late wheat crops in this district, Florence is becoming a great favourite. Any grower who is disposed to try some other variety should avoid rust-labile wheats, and all seed should be treated with bluestone solution as a preventive of bunt. Sometimes oats are sown instead, and then such a short-season variety as Sunrise or Guyra is used. Occasionally White Tartarian is sown, for though slower in maturing it is more adapted to late harvesting, and is cut in January or even in February.

This late-sown cereal crop is used very much as the season directs. It is not so certain as the early sown crop, and it has more often to be cut for hay than for grain, but in some seasons excellent grain crops have been harvested.

This cereal crop is followed, as indicated above, by a fodder crop sown in the early part of the fall. Rape or turnips, sown alone or in alternate drills with a good stooling variety of wheat or oats, or perhaps with Cape barley may be planted in February; another useful combination according to our experience on this farm, and of other farmers in the district, is red clover, in combination with Italian rye grass or some other annual or biennial grass; the seed is sown in March or April. The fodder crops are fed off through the winter, the sheep being turned in once, twice or more often as the growth permits, and if possible, some growth is left to be turned under with the residues in the early summer.

This gives a short period of fallow before the sowing of the long-season cereal crop of the rotation. Any weeds or other growth that appear are fed off prior to a second ploughing, about the early part of April.

The first ploughing, when the fodder crop residues are turned under, is usually a deep one—about 5 inches—while the second ploughing is a little shallower—not exceeding 4 inches. The sowing of the wheat immediately follows this second ploughing, a long-season or slow-growing variety being used. Haynes' Blue Stem is sown on the earliest paddocks, but Genoa has also done well on the farm if sown a little later. For New England conditions, in fact, Genoa may be considered a mid-season to late wheat, whereas Haynes' Blue Stem is a very late variety.

The last-named variety has been a useful one locally, but it may shortly be superseded by one of several varieties of long-season wheats that are now attracting attention in the experimental area. Though producing a very bulky crop for hay, Haynes' Blue Stem has the fault that the chaff is so light as to necessitate the use of too many bags to the ton: moreover, the grain shells too freely.

While some of the Manitoba and other Fife wheats, such as Power's Fife and Marquis, have yielded well at times, here it has been found that, notwithstanding that they may be very strong when imported, the grain quickly deteriorates under local conditions, and in a few years their flour strength is no better—and sometimes worse—than the local varieties. Some imported varieties are uncertain yielders, for in some years they fill well and yield heavily, while in other seasons, without any discovered cause, large patches of the crops fail to set grain. Marquis has given good yields of hay and grain in wet seasons. Rust-labile varieties, of course, will always have to be avoided.

The early-sown cereal crops are more certain than the late-sown crops that follow maize. In a dry season they have the advantage of a certain amount of moisture conserved in the soil by the short fallow, while in a wet season they are apt to make such heavy growth as to go down. The best grain

returns are obtained from these early-sown crops, but good hay crops are also obtained from them. It will be seen that the farmer is practically assured of a profitable crop whatever the season may be.

The seed, which should be "bluestoned," is generally planted about 2 inches deep with the disc drill; on the whole, in this somewhat moist district, it can be a bit shallower than in very warm districts. The quantity of seed used varies with the time of sowing, and may be best indicated in the following table:—

	April.	May.	June	July.	August
	lb.	lb.	lb.	lb.	lb.
Haynes' Blue Stem ...	50-60	60-70	...	...	...
Genoa ...	...	70-75	70-75	...	...
Marquis ...	...	70-75	70-75	...	...
Florence ...	...	...	70 75	80	90

In all cases, if the crops are expressly intended for hay, the sowing should be a little heavier. As a rule it is not advisable under New England conditions to feed off wheat, unless very prolific growth occurs early in the season.

Methods of Harvesting.

The methods of harvesting grain in New England are very different from those of the drier western districts. The straw is too tough to strip as the wheat of the west is stripped, and moreover, it is invaluable as feed for stock during the winter, and the dry spells that occur from time to time. Even dry stock have to be fed during such times, and the straw must be saved or losses are likely to be heavy. Thousands of livestock were lost in the last drought which could have been saved had the supply of straw been larger, and those farmers fared best who had kept stacks of straw and hay beyond all seemingly probable requirements.

The soil, too, is not even enough in quality for the stripper or combined harvester, and some patches ripen earlier than others, while heavy dews would often prevent operations until late in the day.

Hence it comes about that it is the older machinery—the reaper and binder and the threshing machine—that are used to deal with the grain crop, and though it must be admitted that the operation is a more costly one than highly specialised machinery has made it in the west, the larger yields and the greater value of the straw, make it worth while.

Taking the average season, wheat grown in New England will never have the milling quality of that raised in the drier districts, but there are not lacking indications that a larger area will be devoted to the crop in the future, and probably (as varieties and methods improve) with a wider margin in favour of the grower, and certainly with higher yields than the average of the State.

The stage at which wheat is cut is of considerable importance. The quicker grain ripens the better the flour strength; slow ripening produces a soft wheat of reduced value for milling purposes. Under New England conditions, cutting with reaper and binder, and allowing the grain to mature in the stook before threshing, actually aids the production of a better quality grain. It is preferred on this farm to cut the wheat in the dough stage, and allow it to "make" or mature in the stook, or the result is a far better milling wheat and an attractive translucent grain. Cutting with the reaper and binder actually favours some varieties of wheat. In other districts, for instance, Florence

shells readily, because it has to be kept until it is dry enough to strip. At Glen Innes, on the other hand, it can be cut at a stage when it still holds its grain well, and allowed to mature in the stook, with the result that it yields very well. Others also of the varieties successfully grown in New England are liable to shell if left until dry enough to strip.

Bleaching is largely prevented by cutting with the reaper and binder, for wheat that is left until ready or the stripper is much more likely to be damaged in this respect.

The straw also is of much better quality when cut with the reaper and binder, for when ready for stripping it has become little more than fibre, whereas cut at an earlier stage it still has a good deal of nutriment in it, and is accordingly better feed for stock.

Four essentials to successful wheat-farming in New England may be mentioned:—1. Suitable soils; 2. Suitable varieties; 3. Sowing at proper times; 4. Cutting the crop at the right stage.

The Cost of Production.

In presenting the following estimate of the cost of producing an acre of wheat under New England conditions, it may be pointed out that it is based on the experience of Glen Innes Experiment Farm and of farmers generally in the district.

Costs have not advanced in recent years in this district so much as in some other parts of the State. One or two factors of a specific kind have been responsible for this. Ploughing, once done in New England with heavy single-furrow or double-furrow implements, is now being done with four-furrow implements on many farms. In part, this is due to the implements used being of lighter construction than formerly. Time was when a two-furrow plough was a very heavy thing indeed, and farmers hesitated to try a four-furrow one, but to-day better and lighter models of four-furrow implements hardly involve any more horse power, and farmers are more disposed to use them. Stump-jump ploughs are preferred in stony paddocks.

The depth considered essential to best results is also less than it used to be. It is now found that nothing is gained by ploughing too deep on the heavy clay soils of the tablelands. In other words, the use of better implements and methods has almost kept pace with the increase in the cost of labour in ploughing.

ESTIMATED cost of producing an acre of wheat for grain in New England—
Estimated yield, 20 bushels.

	£	s.	d.
Ploughing, once (land previously under cultivation) ...	0	7	6
Harrowing, twice at 1s. 4d. per acre	0	2	8
Drilling	0	2	0
Seed, 75 lb. at 7s. 6d. bushel	0	9	4
Superphosphate, $\frac{1}{2}$ cwt. at 7s. cwt....	0	3	6
Pickling seed at 4d. per bushel; $1\frac{1}{4}$ bushels per acre ...	0	0	5
Cutting with binder	0	3	2
Twine, 5 lb. per acre at 8 $\frac{1}{4}$ d. lb.	0	3	6
Stooking for grain	0	4	3
Carting and stacking	0	11	8
Bags, seven at 8s. per doz.	0	4	8
Threshing at 2s. per bag	0	14	0
Rent, one year	0	10	0
Cartage to rail, 5 miles distant, at 5s. per ton ...	0	2	10
General depreciation, and interest charges on horses and plant	0	4	10
Total cost of 20-bushel crop... ..	£4	4	4

The above is based on an 8-hour day. For the crop that follows maize one ploughing is sufficient; but for the long-season crop following the fodder crop two ploughings are usual, and the additional ploughing would cost an extra 6s. 6d., being more easily and quickly accomplished than the first ploughing.

For hay, we like to cut the wheat in the flowering or early grain stage. No grain, or only shrivelled grain, is preferred to fully matured grain in a sample of hay chaff. As the object is to get stock to eat the whole plant, it is well to cut the crop when the nutriment is best distributed throughout the plant and when palatability is also greatest, and these things are both secured by cutting at the stage indicated.

In harvesting hay for chaffing purposes in the New England district special care is necessary in stooking the sheaves. The method adopted on the farm is to set up four sheaves in each stook (two and two in a diamond) and then tie them together with a band of hay. A good spread is given to the sheaves at the bottom to enable them to dry quickly and to prevent them from being blown over. The cost of stooking for hay and chaff is a little greater than for grain.

Throughout the district, the stacks built are all round ones, and if well made they require no thatching, and will throw any water off.

ESTIMATED cost of producing an acre of wheat for chaff in New England—
Estimated yield, 2 tons.

	£	s.	d.
Ploughing, once (land previously under cultivation) ...	0	7	6
Harrowing, twice, at 1s. 4d. per acre	0	2	8
Drilling... ..	0	2	0
Seed, 90 lb. at 7s. 6d. per bushel	0	11	3
Superphosphate, $\frac{1}{2}$ cwt. at 7s. per cwt.	0	3	6
Pickling seed at 4d. per bushel, $1\frac{1}{2}$ bushels per acre ...	0	0	6
Cutting with binder	0	3	2
Twine, 5 lb. per acre at 8 $\frac{1}{2}$ d. lb.	0	3	6
Stooking for hay	0	5	8
Carting and stacking... ..	0	11	8
Cutting for chaff, 2 tons at 12s. per ton	1	4	0
Bags, 2 doz. per ton, at 8s. per doz.	1	12	0
Rent, one year	0	10	0
Cartage to rail, 5 miles distant, at 5s. per ton	0	10	0
General depreciation, and interest charges on horses and plant	0	4	10
Total cost of 2-ton crop	£6	12	3

SHARE-FARMING.

SHARE-FARMING was first introduced into New South Wales about the year 1896, on the Iandra Estate, near Grenfell, and the favourable results which at once attended it there and that have followed it wherever it has been tried, have led to its general adoption. It is not confined to wheat-growing, but has been extended to dairying and pig-raising, and other branches of farming. It is easy to become a share-farmer, but it is harder to remain one, for the reason that share-farming opens the way to the farmer to procure land of his own—to farm on his own account. This step has been quickly and surely taken by many men in New South Wales, who began with little or no capital.

The practice is not confined to any particular district, but extends all through the best wheat-growing areas of the State. Indeed, in several centres it is the ordinary method of leasing land, and is a most popular one, the demand for "areas on the shares" continually pressing on the supply. Wherever wheat is grown in the State, the principle has been adopted.

The intending share-farmer, therefore, need never bother himself about his ability to get started on shares. If he knows his work, and has his stock and farming implements, he is certain of easily finding good openings between the months of January and March or April. Ploughing finishes in June.

No hard-and-fast rules or conditions are observed, each landowner making his own terms with his tenants, but, broadly speaking, the terms as between the landlord and the share-farmers are uniform in regard to the under-mentioned headings, though, of course, the conditions vary in different cases. The landlord, as a rule, provides—

- (a) The land cleared, fenced and ready for the plough.
- (b) The seed-wheat and bluestone for pickling the seed.
- (c) Bags and twine for his own share of the crop.

The tenant, as a rule, is called upon to provide—

- (a) Machinery and horses necessary to work the land.
- (b) The necessary labour.
- (c) His dwelling.
- (d) Bags and twine for his own share of the crop.
- (e) He must keep gates and fences in good repair.

Specimen Memorandum of Agreement.

MEMORANDUM OF AGREEMENT made theday of..... in the year one thousand nine hundred and..... between..... of..... in the State of New South Wales..... (hereinafter called "the landlord") of the one part and..... of..... in the said State (hereinafter called "the tenant") of the other part WHEREBY the landlord agrees to let and the tenant agrees to take on lease ALL THAT piece or parcel of land being..... and containing approximately acres, being part of..... upon the terms and conditions following :—

1. The term of the lease shall be from..... to
2. The tenant shall cultivate and put under crop each year in proper season the whole of the said land for the purpose of growing wheat.
3. Except as herein otherwise provided, the tenant shall provide all horses, plant, implements, labour, and all material and requisites of every kind required for ploughing the said land and for the successful cultivation, harvesting, gathering in and making marketable the crop so grown as aforesaid.
4. The tenant shall commence ploughing with his full plant as soon as the ground is workable, and ploughing shall be done to a depth of not less than..... inches. In the case of new ground, ploughing shall be commenced at such time and be carried out to such depth as may be agreed upon with the landlord.
5. The tenant shall remove from the ground all roots and other foreign matter which the plough may unearth.
6. The tenant shall thoroughly harrow the land and drill in the seed and keep the ground in proper order and condition by afterwards harrowing or rolling as directed by the landlord, and all headlands shall be properly ploughed, harrowed, and sown.
7. No crop shall be sown after the.....day of..... except with the written approval of the landlord.
8. The landlord shall supply free of cost all necessary seed sufficient to sow the land at the rate of..... pounds to the acre, and shall provide free of cost a quantity of bluestone sufficient to treat the seed wheat to be sown, and no unpickled seed wheat shall be sown without the sanction in writing of the landlord.

9. Manure shall be applied to the land at the rate of... pounds per acre, half of which shall be provided by the landlord and the remaining half by the tenant.
10. The tenant shall commence to harvest immediately the crop is ready (of which time the landlord shall be the judge), and the term "harvest" shall mean the proper reaping and threshing or stripping, cleaning, stacking, and placing the produce in the best marketable condition.
11. The tenant shall cut a track half a chain wide round the paddock, and any tracks which shall be necessary for the proper working of the stripper or harvester. Upon the satisfactory carting and stacking of the whole of the hay so cut, the tenant shall be entitled to receive two-thirds and the landlord one-third, or the tenant may take the landlord's share of such hay at the same value per acre as the remainder of the farm shall average under wheat.
12. Before any portion of the crop is cut for hay other than tracks referred to in the preceding paragraph, the tenant shall obtain the written consent of the landlord, and all hay shall be properly gathered in and securely stacked.
13. As soon as any wheat has been threshed or stripped, the tenant shall immediately winnow, clean, and if necessary bag the grain so as to avoid exposure of the grain to the weather.
14. The tenant shall for the convenience of loading and branding make the stacks of wheat in the field as large as possible (and not less thanbags) and such stacks shall be protected against fire by being separated a distance of 15 feet at least from the chaff and by having a strip of at least 12 feet wide cleared of stubble round the said stacks. All bags of grain harvested are to be kept protected from the weather by the tenant until completion of the harvest and shall be stacked by the tenant on timber, the cost of such timber to be borne equally by the landlord and the tenant.
15. The landlord shall supply bags and twine for his share of the crop.
16. Provided that the conditions herein are observed and performed by the tenant in so far as they apply to him, he shall be entitled to and shall receive..... of the crop, and the landlord shall be entitled to and shall receive the remainingof the crop, provided that the tenant shall receive as a bonus the surplus over.....bushels, up to.....bushels, after which the division shall be equal.
17. In the event of it being decided by mutual agreement between the landlord and the tenant to cut the crop or any portion thereof for hay the tenant shall harvest the crop or such portion thereof, and shall stack and thatch the hay in a proper and workmanlike manner. The hay shall be divided equally between the landlord and the tenant, but the landlord shall pay to the tenant the sum of.....shillings per ton for the landlord's share of the hay as remuneration for the extra cost of harvesting the same.
18. The pecuniary benefit to which the tenant is entitled hereunder shall be subject to deduction in respect of any amount becoming due to the landlord under the terms of this agreement or for goods or produce supplied by him to the tenant.
19. The tenant shall pay the landlord for or make good any damage done by or loss sustained in consequence of damage done by himself, his employees or stock to gates, fencing or other property of the landlord, and the tenant shall keep all fencing on the area in good repair.
20. In case the landlord shall make any bona fide advances of money or goods to the tenant or any moneys become due by the tenant to the landlord for the agistment of stock or otherwise, the tenant shall immediately on request of the landlord give a lien on the crop for such moneys or the estimated value of such goods, and until the same shall be given the landlord shall have all the rights and privileges given to a licensee over the crop or crops of the said tenant as if a lien on the crops had been duly made and registered under the Liens on Crops and Wool and Stock Mortgages Act, 1898, with reference to entering into possession, cutting, carrying away and selling the crops and applying the proceeds as in the said Act is mentioned, and the tenant shall not give a lien to anyone other than the landlord unless previously authorised in writing by the landlord so to do.
21. If the full area is not sown no allowance shall be made to the tenant for any expenditure incurred by him in preparation of the unsown area.
22. The landlord shall at all times have access to the said land, and on default by the tenant in properly cultivating, keeping it clean or harvesting any crop or if the tenant shall not use due care, diligence and despatch in any of these matters, the landlord may if deemed necessary and at the expense of the tenant, do all such things as he may think fit for the proper cultivation, keeping

clean and harvesting the crop, and upon the crop being harvested may sell the same, and out of the proceeds first repay or reimburse himself all expenses incurred in respect thereof.

- 23. The landlord may insure the growing, standing, or harvested crop against fire and the cost of such insurance shall be borne equally by the parties hereto.
- 24. The landlord (if the crop is sold otherwise than on the said farm) may cause the same to be insured during transit, and in that case shall be entitled to deduct half the costs or expenses incurred on that or any other account in respect of the transit or sale of the produce from the gross proceeds of the tenant's share thereof.
- 25. No smoking shall be permitted in the field during harvest unless under authorised conditions and at specified times, and the law relating to careless use fire shall be strictly observed.
- 26. No dirty or otherwise objectionable horse-feed shall be used by the tenant on the land occupied by him or elsewhere on the estate of the landlord.
- 27. The tenant shall keep all stray and strange cattle, horses, and other stock off the said land, and shall prevent any stock having access to the crop.
- 28. The tenant shall not be entitled to graze or run any stock on any part of the said land, or elsewhere on the estate of the landlord, except such horses as may in the opinion of the landlord be necessary for putting in and taking off the crop, and then only on such parts of the estate as the landlord may direct. The landlord shall give the tenant access to such grass and water as may in the opinion of the landlord be necessary and available for such horses. The landlord shall be entitled to depasture his stock on the said land at all times during which it is not under actual cultivation.
- 29. No stubble or chaff heaps shall be fired except with the written consent of the landlord.
- 30. The tenant shall not assign, sublet, or part with the possession of any part of the said land without the consent in writing of the landlord.
- 31. The tenant shall not be entitled to erect any residence or other structure on or in connection with the said land without first obtaining permission in writing from the landlord.
- 32. In case at any time during this agreement the tenant shall be adjudicated bankrupt or commit or suffer any act of bankruptcy, or bring or attempt to bring his estate within the operation of any law relating to bankrupts, or if the tenant shall make default in performing, observing or keeping all or any of the conditions or stipulations herein contained and on his part to be performed observed or kept; then and in every such case the landlord may (without prejudice to any other rights or remedies which he may have at law or in equity in respect of the matters aforesaid or any of them) determine this agreement forthwith by notice in writing, and may take possession relet or otherwise deal with the said land as if this agreement had not been entered into.
- 33. In case any question or difficulty shall arise touching this agreement or anything to be done or performed herein then the same shall be referred to two arbitrators in accordance with the Arbitration Act, 1902.
- 34. Nothing herein contained shall be deemed to constitute a partnership between the parties hereto
- 35. Nothing herein contained shall be construed to give to the tenant the legal possession of the said land or any part thereof or any right of possession or occupation other than herein expressly mentioned for the purposes of this agreement nor shall anything herein contained be construed to abridge or qualify the absolute right of the landlord his servants agents and workmen with or without horses and other animals carts carriages and other vehicles at all times to enter and remain upon the said land or any part thereof provided that the farmer be not thereby unreasonably hindered in his work upon the said land.

IN WITNESS whereof the said parties have hereunto set their hands the day and year first before written.

SIGNED by the said..... }
 in the presence }
 of }

SIGNED by the said }
 in the presence }
 of }

The Cost of Equipment.

The labour-saving implements which have been designed to suit local conditions place the farmer in Australia at the advantage of being able to cultivate his land and harvest his crops at a cost which leaves a fair margin of profit. Though the initial outlay may appear great, the profits of a single normal season go far to reduce the farmer's indebtedness for his machinery, and many of the firms dealing in these articles dispose of them on easy terms, extending in the case of some of the more expensive machines over three seasons. Owing to the wide diversity of farming conditions in the State, the machinery used differs in style and size, and it is difficult to name exactly the articles of equipment which the share-farmer may require. The list given below, however, indicates what would constitute a good equipment and the approximate cost. From this the farmer may form a fairly accurate idea of the initial expenses. The prices quoted are the average price in Sydney, and to them will have to be added rail freights:—

	£	s.	d.
Three or four-furrow plough	45	0	0
Harrows	12	0	0
Spring-tooth cultivator	35	0	0
Drill	60	0	0
Five horses, at £32 10s. each	162	10	0
Harness	20	0	0
Reaper and binder	100	0	0
Reaper Thresher	250	0	0
Waggon	80	0	0
Dray	30	0	0
	<hr/>		
	£794	10	0*

In many cases it will be found there is so little work for the reaper and binder that one may be borrowed for a day to cut the necessary tracks and headlands. The waggon also may be dispensed with, as most likely the owner will have teams and waggons of his own to cart his own wheat, and will also cart the share-farmer's wheat to the nearest railway station. The cost of equipment can thus be substantially reduced.

Nor is it necessary that the whole of the purchase money for the plant shall be paid at once, implement and machinery firms being willing (as already stated) to allow the price of the more expensive items to be spread over two or three years.

The above figures provide for a new equipment, but in many cases suitable implements can be purchased second-hand at considerably reduced figures.

HARVESTING WHEAT FOR HAY AND CHAFF.

Many factors enter into the production of wheat for hay and chaff, and the farmer who would earn the reputation for the well-grown and well-made article that commands the highest price in the Sydney market must exercise judgment in the selection of the most suitable variety for his conditions, good husbandry in the growth of the crop, skill in the handling of it in the field, and care and close attention to detail in cutting it.

* The figures quoted represent 100 per cent. increases on pre-war rates. Prices are likely to suffer marked fluctuations with a downward tendency.

All who contemplate the production of chaff for the Sydney market should make it their business to ascertain exactly what are the requirements of buyers and to act accordingly. It is quite true that many do this, and that in certain districts, particularly in the Riverina, the production of high-class hay and chaff is well understood and practised, but there are other districts where little care is bestowed on this product, and it is regarded only as a convenient method of getting something for that which is worth very little. When it is stated, however, that the proper preparation of chaff may increase its value in the market by almost as much as 20s. per ton—more than sufficient to pay the cost of cutting—it will be seen that the requirements of the market have an important relation to profits, and are therefore worth catering for.

The preference of Sydney for green chaff is due to the inclination of dry chaff to cause constipation and to necessitate the supply of some other green feed as a laxative. The city carter therefore prefers to purchase a green chaff which will save him the expense of another class of feed, and producers will find it quite worth while to study this feature of the business.

Suitable Varieties.

Chaff-production is rather different to other classes of rural enterprise, for chaff is not always the result of a crop grown intentionally for the purpose. For convenience, producers may be divided into two classes: (1) Those who grow for chaff, and (2) those who grow for grain, but who, owing to frosting, dry weather or other causes, have to cut the crop for hay and subsequently convert it into chaff.



Crop of Firbank Wheat at Ganmain. Yield 3 tons 2 owt. of Hay per acre.

The man who is intentionally growing for hay should select varieties which yield straw and flag of good colour and body. Varieties that produce light coloured hay, or that are inclined to be "flaggy," should be avoided, and it is just as well to respect the prejudices against certain varieties (such as Federation), even if they be a trifle unreasonable. Varieties that have a brown head do not make the most attractive chaff, for the brown husk shows up and buyers do not like it.

Varieties that carry heavy straw should also have a preference. Some wheats have a very thin, "shelly" straw which gives a light bodied chaff that makes no weight in the bag. Heavier straw cuts better, and produces more weight, and the chaff has more body.

This question of varieties does not receive anything like the amount of attention it should, especially in districts where wheat is not largely grown for hay. There are districts where the value of particular varieties is fully appreciated, but there are others where it has yet to be learned, and where farmers will find it well worth while to consider the subject more than they have done. Farmers in the Riverina, for instance, are prepared to pay high prices for seed of Warden, Zealand, and Firbank, having proved their suitability for hay, but in the West and North-west it will pay to study the Department's recommendations and, where hay is desired, to grow Firbank (which is one of the best), or one or other of the varieties that are recommended by the Department for that purpose.

When to Cut.

The crop is at the best stage for hay a few days after it is in flower. This condition is best, because at this stage the plant contains its maximum amount of nutritive qualities, and at the same time the nutriment is evenly distributed throughout the whole plant. This is as it should be



Cutting and Stooking.

for hay-making purposes, for when preserved as hay the whole of the plant is to be eaten, and not only the ears. It is, therefore, better that the whole of the nutriment should be evenly distributed throughout the plant, rather than that one portion should be excessively nutritious whilst the remainder is of little or no value as a food. Though the crop at the flowering stage contains the maximum amount of nutritive qualities, it has not reached the stage when it will produce the greatest weight of hay. The dry matter in the plant increases until it is mature, and because of this some farmers refrain from cutting the crop until it has passed the flowering stage, in order to get a greater quantity of hay. They gain the extra weight at the expense of the feeding-value and colour.

The position of the farmer who has to cut for hay a crop that he intended for grain, is a different one. He cannot expect to get the quality that the grower will who has grown for hay and cut at the right time. In matters both of variety and of time of cutting the grain grower is at a disadvantage—more especially when he delays cutting as long as possible in the hope that he will get a crop of grain, the straw meantime losing all the colour that would recommend it for hay. In such circumstances the only advice that can be offered is that the farmer should endeavour to cut at the earliest possible moment after he is satisfied that he is not going to get a profitable grain yield.

Cutting the Crop.

Throw the machine in gear as the horses reach the crop, and drive down and round the edges. Cut at least two rounds before attempting to cut the back swath or the piece knocked down by the horses.

By means of the lever, move the knotter to or from the butter-board as required, so that the sheaf will be tied in a position that it will be evenly balanced. When the crop is very tall, and with machines that will allow it to be done, the mechanism operating the packers and supporting the butter-board should be adjusted so as to give as much room as possible on the length of the table.

Raise or lower the reel as the height of the crop requires. If the crop is leaning away from the knife, put the reel forward, so that the beaters will be lifting the crop backwards when the knife reaches it.

In a short, thin crop the beaters should be low and well back over the table, so as to prevent the stuff lodging on the knife or falling in front.

In a very light, thin crop it is advisable to have the beaters right down on the fingers, so as to sweep the greenstuff on to the canvas. It is not possible to do this with the beaters as fitted to the machine, for these are made of wood, and therefore stiff and rigid, and in consequence they cannot be set closer than 3 inches to the fingers, because of the ridge at the back of the knife, which would break the beaters if struck by them when revolving.

The efficiency of the beaters for dealing with light crops can be very greatly increased by tacking or screwing leather on to them, so that the edge of the leather projects about 3 inches beyond the edge of the beater. As the leather is flexible, the reel can be lowered until the edge of the leather touches the fingers; when the reel revolves, the leather, as it strikes the ridge at the back of the knife, will bend and pass over it without injury, and at the same time will sweep the short straws on to the canvas.

For a very light crop the binder may be further improved by inserting a piece of tin, or galvanized iron, under the first roller-holder, and allowing it to project until it meets the clip on top of the fingers.

A light, thin crop can be cut better if rather on the dry side.

It may be thought that the mower will deal with a lighter crop than the binder, but it may be taken for granted that when a crop is too light for a binder to deal with, though in good working order, it is also too light for a mower to deal with profitably.

When the crop is too short for the mechanism to tie it in sheaves (and it is then so thin that if cut with a mower the rake would miss a great deal), it may be gathered in loose bundles by loosely covering the sheaf-carrier with hessian.

This will carry the loose straws until enough are collected, when the trip can be released and the bundle deposited on the ground.

Laid crops can only be dealt with by cutting them in the opposite direction to which they are lying. This entails working the binder only one way. When the crop is tangled as well as laid, considerable patience and judgment are required to make the most of it. All that can be done is to drive the binder with care, seizing every opportunity to drive it against the direction of the majority of the laid plants.

Curing the Hay Crop.

After cutting at the right time, to secure the maximum food-value the plant is capable of producing, it is essential that it be dried, and so preserved with as little loss as possible of this food-value. Loss takes place as the result of rain washing out the sugar and other soluble food ingredients, and as the result of the heat and sun drying off the essential oils and other volatile compounds. To minimise these losses by protecting the sheaves from the action of the sun and rain, a considerable number are placed together in a stook.

The sheaves should be stooked without delay after they have been cut with the binder. The machine may be allowed to cut a couple of swaths, and then sufficient men should be employed stooking to keep up with the machine.

In a light crop, one man can stook the sheaves as fast as the binder can cut them, but in a 2-ton crop two men are not sufficient to keep pace with it.

The sheaves in long, open stooks dry more rapidly than in round ones, but in the former, more of the crop is exposed to the bleaching action of the sun. Long, open stooks are therefore suitable for moist districts, whilst the practice of making large, round stooks is adapted for the dry ones.

Stooking and Stacking.

Sheaves are allowed to remain in stooks until the hay is so dry that when placed in the stack it will not heat or mould. This stage is determined by drawing a handful of straws from the middle of the stook and examining the knots or joints in the straws. If these are dry the material can be stacked without danger.

In hot, dry districts like the west, the hay dries out sufficiently in fourteen to twenty days in October. Later in the season it will be ready sooner. It requires to be watched by the farmer, however, as the stage at which it is carted in will influence the quality of the produce a good deal. If an examination of the upper joints of the stem shows that these joints have shrunk, it may be taken that the hay is dry enough to stack. Until that shrinkage is apparent the hay will be apt to sweat if stacked, but once the contraction of the upper joints can be seen, the crop should be got in as quickly as possible, as otherwise it gets hard and is then more difficult to make up into good chaff.

Admittedly very fair chaff can be made from poor hay, much then depending on the manner in which the chaffing is done, but the farmer who aspires to "topping the market," or who wishes to get full value for his crop, will regard all the foregoing points as important, and will take care that every one of them receives due attention.

Chaffing Hay.

The man who is pitching off the stack to the cutter should be instructed to throw out all sheaves that have been damaged. A shower at stacking time may cause several sheaves to turn mouldy, or a little rain may have found its way in if the stack has not been well built, and although it is true that a damaged sheaf or two will do little harm to a large sample, there is too much danger that the buyer will hit upon it when he comes to inspect the consignment. If he does the farmer loses a substantial sum by his neglect to throw out in the beginning that which was of little consequence any way.

The Use of the Steamer.

Every farmer who has hay chaffed by contract should insist on the use of the steamer, especially in dry districts. In cooler districts it is perhaps less essential, though frequently the quality of the chaff would be improved were it used. The object being to toughen the hay so that it will cut without breaking, it is particularly necessary in hot districts, but it is also desirable in cool districts where the conditions have been very dry during the curing of the hay, and still are at the time of chaffing.

A certain amount of care and judgment are required in the operation. As the steam is only used to toughen the hay, it will be found that a larger amount of steam is needed for the top of the stack than lower down, the hay at the top having dried much more than in the body of the stack. The best guide is to examine the chaff as it comes to the bags, and to increase or decrease the flow of steam according to the condition of the chaff.

The steam must be high-pressure, dry steam, for there is then no danger of causing mustiness. If wet steam is used, the occurrence of mustiness is probable, especially if the hay is itself somewhat damp. The best results are obtained when a pressure of 90 lb. is maintained. The steam pipe should be placed on the engine in such a position that dry steam is obtained, and to that end the off-take should be from the steam chest. On a Marshall engine at Coonamble the connection was made by inserting a T piece into the pipe leading to the whistle. On no account should steam be taken from the smoke-box end of the boiler.

The hay naturally becomes heated in passing through the steamer, and in the bag the chaff has a hot, damp, or slightly damp feeling, but provided the hay was quite dry before steaming there is no danger of any fermentation in the bag.

Just as in the case of the man who is pitching off the stack, the man who is sewing the bags should be instructed to watch the chaff as it comes through, and if any of the bags are not up to the standard they should be put aside for home use, in order that they may not reduce the value of the whole line.

Cutting.

The first point in connection with the actual cutting is that the "runs" should not be too long. Much depends on the size of the machine, but if the periods are long, the knives get blunt, and towards the end the chaff is broken up badly (instead of being cut), and the sample is rendered uneven. Short runs pay because of the higher quality of chaff.

The knives should be kept sharp, should have a good long bevel on them with a fairly straight set, and they should set close up to the face plate, which must be kept with a good angle. The angle, it will be found, requires renewal after every 300 to 400 tons are cut, for otherwise it gets rounded.

and the knives cannot cut cleanly against it. It is also important that the knife wheel should be set firmly, so that when cutting the blades remain close against the face plate.

Sometimes the wheel becomes loose, and when the knives are being set they are apparently right, but when the machine is put in operation the wheel springs away from the face plate. Whether the knife wheel is loose or not, can be ascertained by pushing against the wheel away from the face plate, and if it is found not to be tight, it can be adjusted by means of the set-screws.

One point attaches to the bagging—second-class bags at once makes second-class chaff. Good chaff should be presented in a manner that will commend itself to the buyer, and an inferior or dirty bag does not produce a favourable preliminary impression.

Attention to all the above points in cutting will enable a farmer to produce a very fair sample of chaff even from an inferior, "flaggy" hay. The object in dealing with hay of this kind must be to prevent the flag being broken into dust, and to give the chaff a good appearance—and that can only be achieved by care and attention to every detail in the machining.

Feeding Value.

Apart altogether from appearance, however, there is one feature in chaff production that has yet to be appreciated by both grower and buyer—that is, it may vary much in feeding value. It is a quality that cannot be detected in the final product, but it is nevertheless a fact. The feeding value of chaff depends largely on the class of soil on which it is grown, a rich soil generally producing a chaff of high feeding value. At Coonamble Experiment Farm it was observed that chaff from hay grown on the rich, black soil required to have very little grain added to make it a sufficient ration for horses. Chaff produced on good soils has not always such an attractive appearance as that which comes from the lighter soils, but if the feeding qualities were better understood the former would be appreciated more highly. To convince the Sydney market that this is so will take time, no doubt, but meantime the farmer who has a strong soil can console himself that he can feed his horses well with less grain than if he were located on lighter land.

HARVESTING WHEAT FOR GRAIN.

For harvesting grain crops the reaper and binder, the stripper, the combined harvester, and the reaper thresher have been used successively.

In moist districts the reaper and binder is used exclusively, for in such districts the grain in the standing crop is rarely hard and dry enough to be taken off with a stripper.

Over the greater portion of our wheat area the conditions are, however, favourable for harvesting with the combined harvester or some of its later developments.

Considerable controversy has waged about the advantages and disadvantages of harvesting with the respective implements. As cheap and rapid means of garnering the grain, the harvester and reaper-thresher are unexcelled; but advocates of the reaper and binder point to the fact that the straw, or at least portion of it, is wasted, and that what is saved is of lessened value. This is unquestionably true, but the fact must not be lost sight of that, after all, straw is a very inferior feeding material. The cost of saving it is in most cases greater than its actual value in normal seasons, and

it is only by storing it until a very dry time, when inferior materials have an abnormal value, that the farmer is able to recoup himself for the outlay connected with the saving of it. It is claimed that the expenditure necessary for saving the straw, if spent in other directions, would have made more and better provision for times of scarcity.

Nor must it be forgotten that it is not necessary to waste all the straw if the crop has been stripped. If stock be turned on to the stubble it will be put to good account without expense.

The question as to which is the more desirable implement will never be settled by argument. It is a question entirely of profit and loss, and the farmer who finds the harvester more profitable, under his conditions, than the reaper and binder will use the former. This much is certain, that inexpensive methods of harvesting grain have played no mean part in the development of our wheat areas, and that but for them many acres now being profitably cultivated could never have been brought under the plough.

The modern harvester is a wonderfully efficient implement, and Australians may be proud that such an implement was produced and developed in their country. It is particularly adapted for peculiar conditions which necessitate that the individual cultivate a large area to be profitable.

Precautions against Loss by Fire.

Fire-breaks.—Hay-making affords a splendid opportunity to protect the crops, when ripe, from advancing bush fires, by surrounding them with a bare strip, which will act as a fire-break.

It is a fairly general practice in the grain-raising districts to cut for hay a strip about half a chain wide round the standing crops. Such a practice might be followed by all. In large paddocks the practice might, with advantage, be extended to provide for the cutting of openings, half a chain wide, so as to divide the crop into blocks of approximately 200 acres each.

This is a ready and economical way of safeguarding the dry, ripe crop against destruction by fire. The piece of short stubble land provides a suitable place for checking the advance of a fire, which may have broken out in the grass paddocks or other portions of the crop. This is especially the case when, as at landra, a portion of or the whole strip of stubble is ploughed.

Fire-cart.—To assist in controlling or extinguishing a fire, should one break out, a fire-cart, filled with water and equipped with buckets, beaters, and axe, should be stationed, during harvest time, in a convenient place, with harnessed horses for drawing it, close by. On small farms where the number of horses is limited, the most suitable place for such a cart is considered to be at the winnower, or if the harvester is being used, at the place where the bags are sewn up.

It can be brought daily to such a place by some of the horses used in the stripper, and when required for a fire the animals necessary to draw it can be taken from the stripper or harvester working close by. There is an additional advantage in having it stationed at such a place, in that a small portion of the water in the tank can be used for giving the stripper horses a drink during the heat of the day. But care must be taken when such a plan is followed, that every favourable opportunity is seized to fill the tank, and that the quantity in it never becomes unduly low.



The advantages of the Sheaf-carrier.



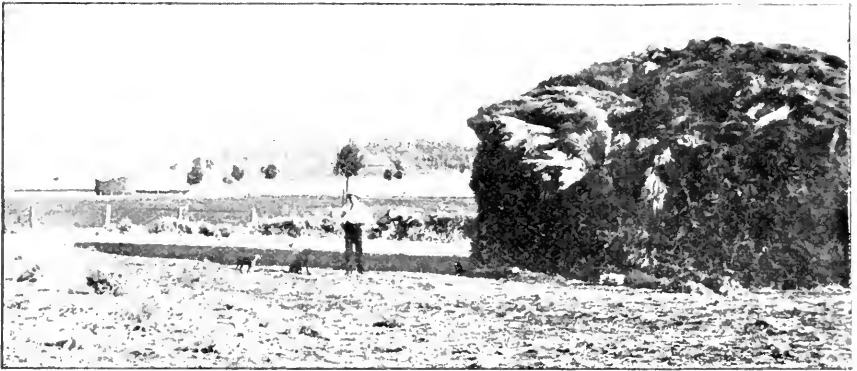
A Large Field of Stocked Wheat.
An unusual sight under New South Wales conditions.



Harvesting with the Reaper and Binder at Bathurst Experiment Farm.



Carting to Stack.



Effect of a gale of wind on bad stacking—note hay sheaves blown against fence.

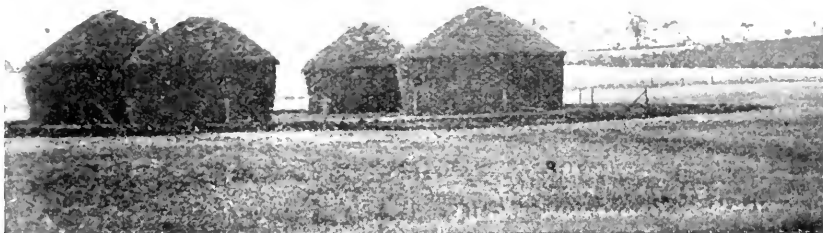


Building stacks at Wagga Experiment Farm.

A.—Harvesting with Reaper and Binder for Grain.

The crop is ready for the reaper and binder when the straw under the ear has turned yellow. At this stage the grain is doughy, and the crop may be cut without fear of loss. It is advisable to use the reaper and binder on the heaviest portions of the crop, and also on any portions that may have become laid, for it is impossible to deal satisfactorily with such portions with the stripper. Even with the reaper and binder, care and trouble are necessary to gather all the crop.

It is probable that, when labour and other conditions allow, the up-to-date farmer of the future will commence his grain harvest with the reaper and binder, and complete it with the harvester.



Stacks placed for economic working, the threshing machine or chaff-cutter being hauled between them.

Stooking.

The methods adopted vary with the climatic conditions. In districts where fine-weather conditions during harvest are the rule very little trouble is taken, and twelve or fifteen sheaves are put together in round stooks in such a way as to withstand the winds only.

In districts where wet harvests are common, considerable skill is required in building stooks so as to shed rain, dry quickly, and withstand winds.

Stooking, whenever practicable, should be done in the morning when the straw is tough, to prevent waste in handling. *Ripe wheat should not be handled during the heat of the day, as the grain is then more liable to shed.*



Rectangular Stacks.

In stooking, two sheaves should be handled at once. Each sheaf should be grasped about a foot from the ears and stood firmly on the ground, leaning towards each other at the top, and the short side of the sheaf towards the centre. About three pairs should stand firmly upon their own bases. Two additional pairs at each end should lean towards the central pairs, and a single sheaf should be placed at each end. This would make sixteen sheaves upon the ground. Two sheaves should be used as caps. The butts should be placed in the centre and pressed together to interlock them, and a good handful of straw upon each side of each capping sheaf should be bent down from the bands to prevent the winds from blowing the cap off.

The number of sheaves in such stooks will depend upon the length of the sheaves, as no more should be placed in the base than can be reasonably covered by the two capping sheaves. Such stooks, if properly built, will turn considerable rain and dry readily. As they are only two sheaves wide, they may be blown over. To overcome this, buttresses should be started upon either side at the centre and built as the original stook, and covered by two capping sheaves as before described. A stook in the form of a cross is thus made, which will withstand considerable wind.

Stacking.

The oblong stack is preferred to the round form, as it is easier to top up. A new hand working on a round stack will often find it bulging before he reaches the full height, and he will have some difficulty in keeping a true circle. But we do build round stacks at Wagga, following the same principles, and with excellent results. Those who prefer the round forms and have had experience of the work, will find no difficulty in adapting these notes to that form of stack.

The size of stack which is found the most convenient is 12 yards by 6 yards, built 14 feet to the eaves. The capacity is 45 to 50 tons. The stacks are often required to stand through all weathers for so long as seventeen months, and become compacted to such an extent that the eaves are

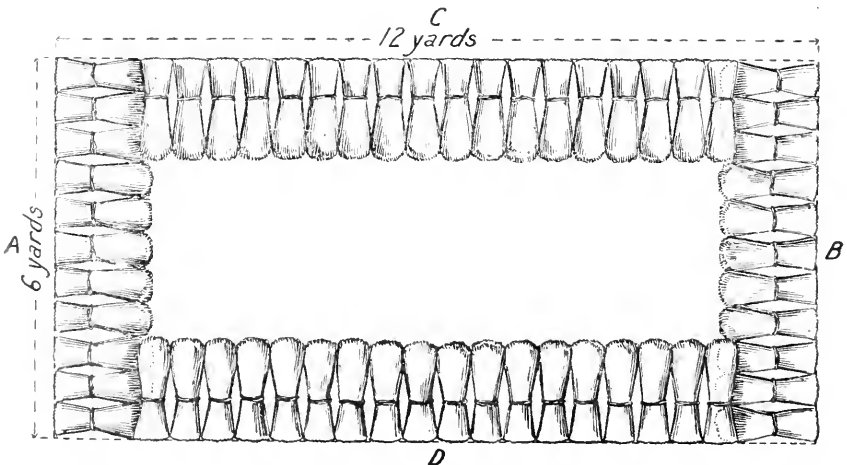


Fig. 1.—Commencing the stack.

about 10 feet from the ground; yet the stacks have remained quite perpendicular. They have suffered no damage from wind or rain, and the loss of butts on the outside is not worth mentioning.

After selecting a good site, level and dry, measure off the ground 12 yards by 6 yards, and build a good straddle of straw, sticks, or other suitable material which may be handy. You can start from the centre or from the outside, but it is simpler work to start from the outside, and this is the general practice.

Fig. 1 shows the easier method of commencing the stack. First of all, place a layer of sheaves on the ends, A and B, butts outwards, and running lengthways with the stack. Then lay sheaves along the sides, C and D, butts outwards, running across the stack and overlapping the heads of the end sheaves. These are the only sheaves which will be placed flat on the ground.

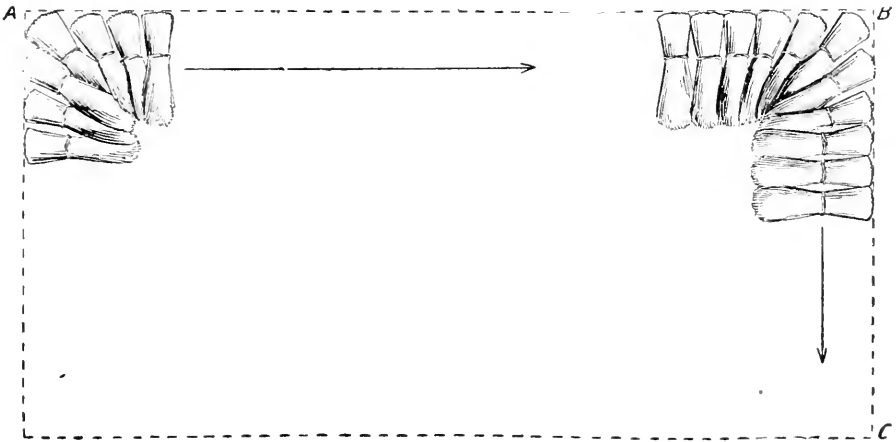


Fig. 2.—Another method of commencing the stack.

Another method of commencing, which is not quite so simple, is shown in Fig. 2, and provides for binding the corners of the first tier. The first sheaf, A, is placed at an angle, pointing towards the centre of the stack. The next sheaf overlaps the head of the first, and the third that of the second, and so on, until the sheaves are lying straight across the stack. As the corner B is approached, the butts are spread and the heads overlapped to bind the corner. Then the sheaves are straightened again along the end, B C, and so on around the stack.

In filling up the centre of the first tier, always place the butts on the ground. The dotted lines in Fig. 3 show the sheaves first laid. Fill up by placing sheaves heads outwards, overlapping the bands of the first layer. Continue around the stack, and then commence again in the centre, always placing the butts on the ground, until the centre is filled.

The second, or binding tier, is laid upon the first tier of sheaves exactly as shown in the second method of commencing the stack (Fig. 2). A start may be made at the corner, or in the centre of the end, working to the

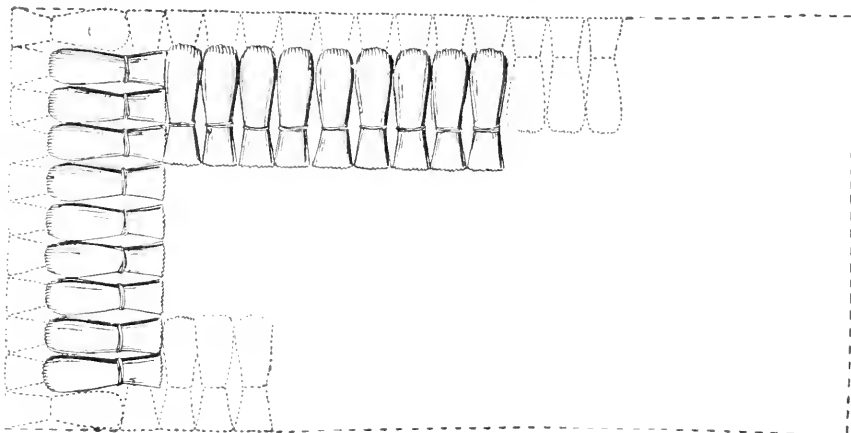


Fig. 3.—Filling up the centre of the first tier.

corner. The usual method is to start at the corner. Place butts outwards to the edge (Fig. 4), and bind the corners by laying the sheaves at an angle. Lay the sheaf flat, and close the head somewhat. In finishing, just go far enough to catch the head of the sheaf first laid.

The centre of the second tier is filled by placing sheaves butts outwards and well up to the bands (Fig. 5). In this portion of the work a good deal of judgment has to be exercised. The aim is to keep the centre of the

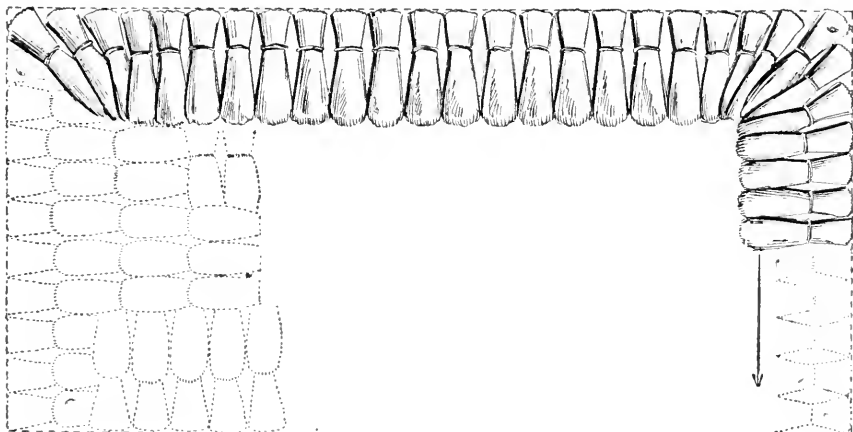


Fig. 4.—The second, or binding tier.

stack a little, but not too much, above the edges. In a stack of this size the centre should be kept about a foot higher than the edges. This is obtained by placing the centre sheaves farther out or farther in as required. To make the stack fuller in the centre the sheaves are placed farther out; to make it more level they are drawn in. As the filling proceeds, the stack

always looks as if it were going to have a hollow centre, but the next layer fills it up. It may require a little practice to see exactly how far out to place the sheaves, so as to get the centre the right height.

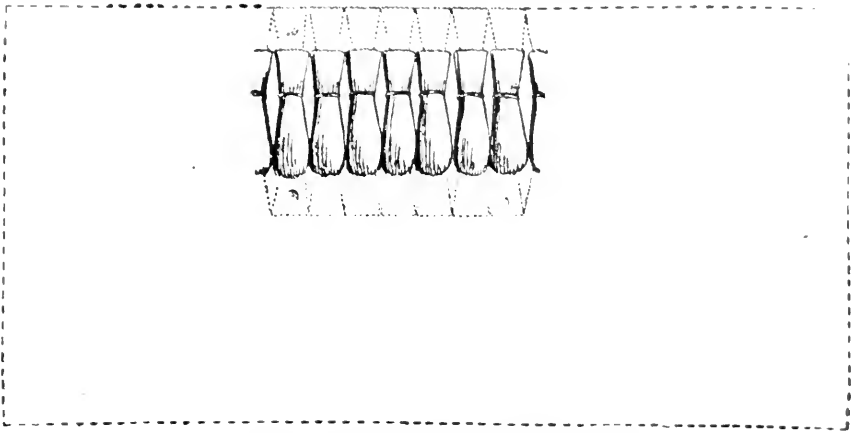


Fig. 5.—Filling up the centre of the second tier.

The following tiers are all put on the same as the second, binding with the butts outwards, and keeping the centre high. If rain beats upon the sides it would have to travel upwards to get into the stack. In the case of a wheat stack, the water would need to travel upwards the full length of the sheaf before it could injure the grain.

In commencing the third tier, place the corner sheaf at an angle with the first sheaf of the second tier. Looking at Fig. 4, it will be seen that the corner sheaf slopes towards the bottom side of the stack. When putting on the corner sheaf of the third tier, slope it towards the right end of the stack, making an angle with the lower one. This will make the corner secure.

A good stack-builder will always keep the sides of his stack perpendicular. The stack has a tendency to spread as it rises. Do not draw the sheaves in, but use a board about 15 inches x 12 inches, with a handle about 6 feet long (Fig. 6), and beat the edges in with this.

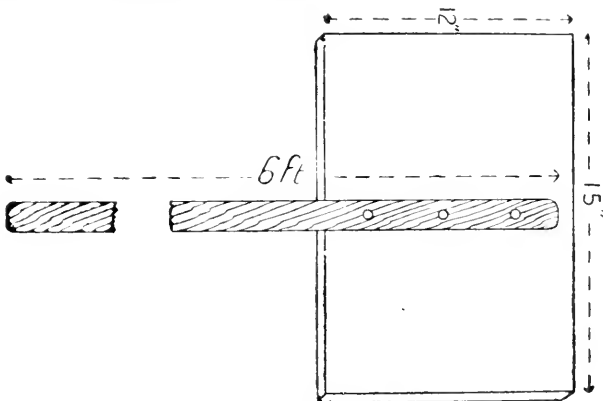


Fig. 6.—Board for squaring off edges of stack.

The stack is built 14 feet to the eaves. A light, but strongly constructed platform, which can be readily moved by two men to any required position, is sometimes used for reaching the higher levels.

The second last tier is laid so that the sheaves overhang the sides about 3 inches (Fig. 7). The ends are flush with the other end sheaves. There is no hip to the roof of our stacks—it is a straight gable. The heads of the

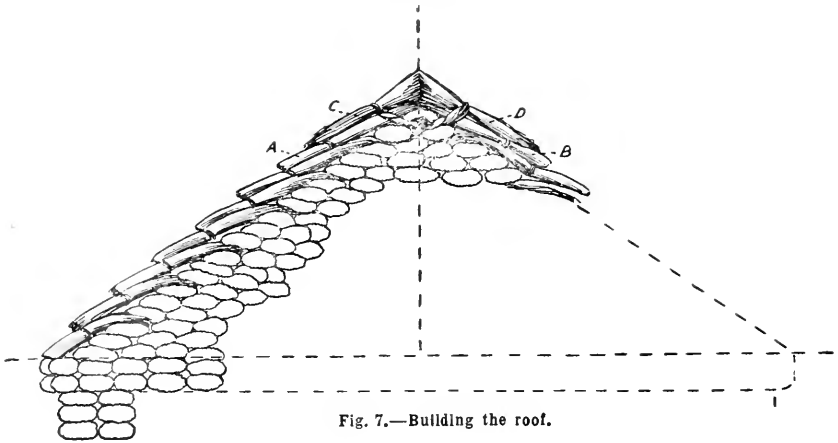


Fig. 7.—Building the roof.

corner sheaves are bound in so as to support the corner of the roof. The last tier is laid level on the edges with the second last one, binding the corners as explained above. This forms a good eave.

Now we come to the top and roof of the stack. The construction requires a little explanation, but it is hoped that the sketches will enable the reader to grasp the method. The aim is to build a gable roof in such a manner that butts only will be exposed, except at the cap, and the whole made firm and strong.

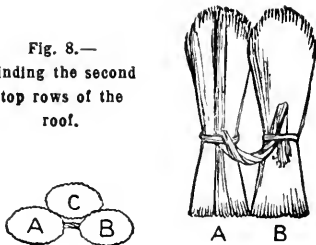
All the top sheaves are laid lengthways on the stack, butts outwards at the ends. You can bind in the centre by laying them either way. Start from the edge and work along the stack. It will take about twenty sheaves to run the length of the stack.

Commence the first row about 1 foot in from the eaves. Build all the rows of this layer right across, and then commence the second layer a little farther in. Judgment must be used to give the roof the correct pitch. When about three layers have been built in this way, place the first row of roofing or thatching sheaves in position. They are placed butts downwards on the eaves, the heads resting over the top of the portion of roof already built. If the sheaves are long, four layers of roof may be required before placing on the first thatching sheaves. Lay these thatching sheaves right along the stack on both sides.

Now build three more layers of the roof. Before placing the first row in position, press the heads of the thatching sheaves down upon the stack and bind them in. (See Fig. 7.) When these three layers have been built, put on another row of roofing or thatching sheaves, butts downwards, just covering the bands of the first layer, and resting the heads over the stack as before. Proceed in this way, working both sides together, until the ridge is reached. It will be seen that only the butts of the thatching sheaves are exposed.

Always use well-bound sheaves for covering the stack in this way, as these are the ones which have to stand the weather. It is well to ask the carter for a good load to top the stack.

Fig. 8.—
Binding the second
top rows of the
roof.



the top from spreading. Then the ridge C, the last row of sheaves, is put on, and the stack is capped.

The last two rows of roofing sheaves, coming up the roof one on each side, are placed butts downwards like the rest, so that the heads meet on the top over the ridge. These are shown as A and B in Fig. 9. On top of these place two more sheaves, C and D, butts *upwards*, to act as a cap. Take a handful of straw from each side of the band of each sheaf, roll them tightly, and twist the two together, turn the twist underneath, and push it hard into the end of the stack.

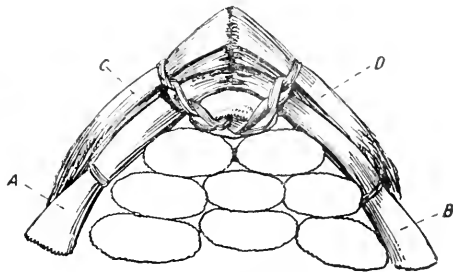


Fig. 9.—Capping the ridge.



Fig. 10.—Binding
the capping
sheaves.

The capping sheaves, butts upwards, are carried along the ridge on both sides. To bind the capping sheaves along the ridge, take a handful from sheaf B (Fig. 10), break it back at the band, and stick it into the band of sheaf A from the top. Continue this along the ridge on both sides; it pulls the sheaves together and makes the cap fast.

As a further precaution to protect the stack from the wind, stick a peg into the second capping sheaf from the end in a direction sloping in towards the stack. Draw a string from this peg over the first sheaf, and tie it to a peg stuck in the end of the stack.

Straw stacks had better be thatched. It is possible to build them without thatching by keeping the middle well up, but it is a more difficult job than with hay, and a novice is not advised to attempt it.



A fair average roofing-sheaf, taken from a stack which had been standing for seventeen months.

These are the most exposed sheaves on the stack.



The same sheaf after brushing off the rotted trash, which is seen on the ground.

This is practically the only loss in the whole of the stack.

Precautions against Mice and Fire.

Many devices have come under notice from time to time to cope with the mice pest. Building the stack upon a raised platform does not answer the purpose; the mice will climb up the blocks upon which the platform is built, run along underneath the platform-boards, and so enter the stack.

The only successful method of keeping them out is to enclose the stack with a fence of galvanized iron, either plain or corrugated, about 2 feet high.

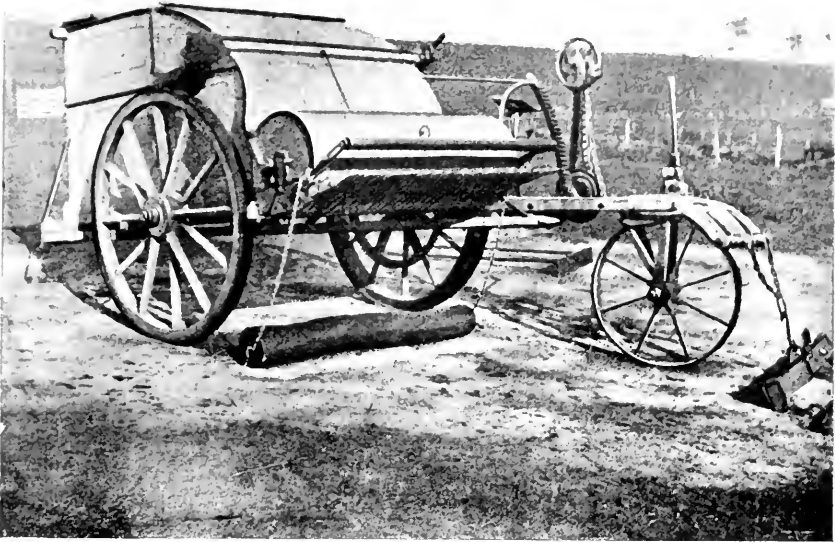
Let the iron into the ground to a depth of 4 inches, and place it in a slanting position, leaning outwards, all round the stack; take care to leave no open space at the corners. It will be found impossible for mice to enter a stack thus protected.

If it should be found that mice are troublesome in the stack, poison with arsenic dissolved in water. Place dishes of the solution all round the stack; if it will not entirely eradicate the pest, it will, at any rate, help to keep it in check.

Precautions should also be taken to protect the stacks against fire, or at any rate against heavy loss by fire by insuring at an early date.

B.—Harvesting with the Stripper.

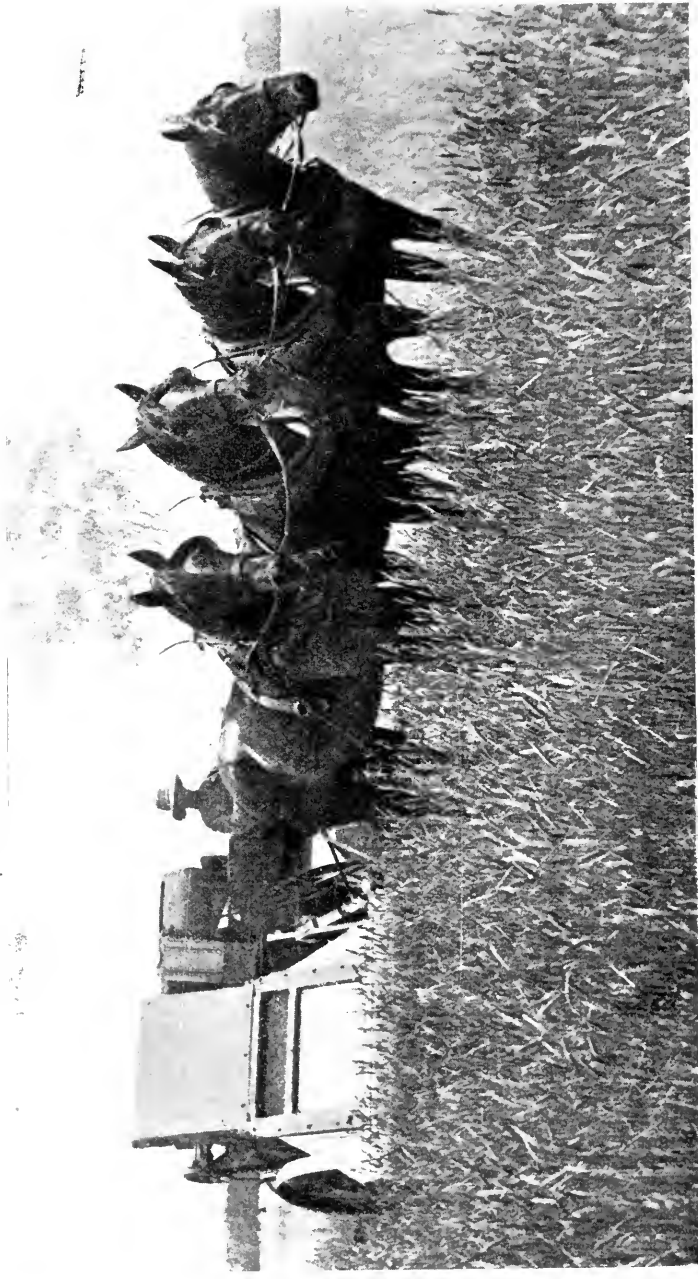
The grain, if bitten, will be found to be hard when the crop is fit to strip, and the heads of those varieties with pendant heads will hang down. In a paddock which has not had the edges cut for hay with a binder it is advisable to strip enough of the crop near the gate to admit of the winnower being set up. The winnower should be set solidly on the ground, and so placed that the wind blows from the fan and diagonally across the machine and away from the man feeding it. It should be turned at an even speed, and the tailboard set low enough to allow the chaff and cavings to blow over, but high enough to catch the white heads and grain.



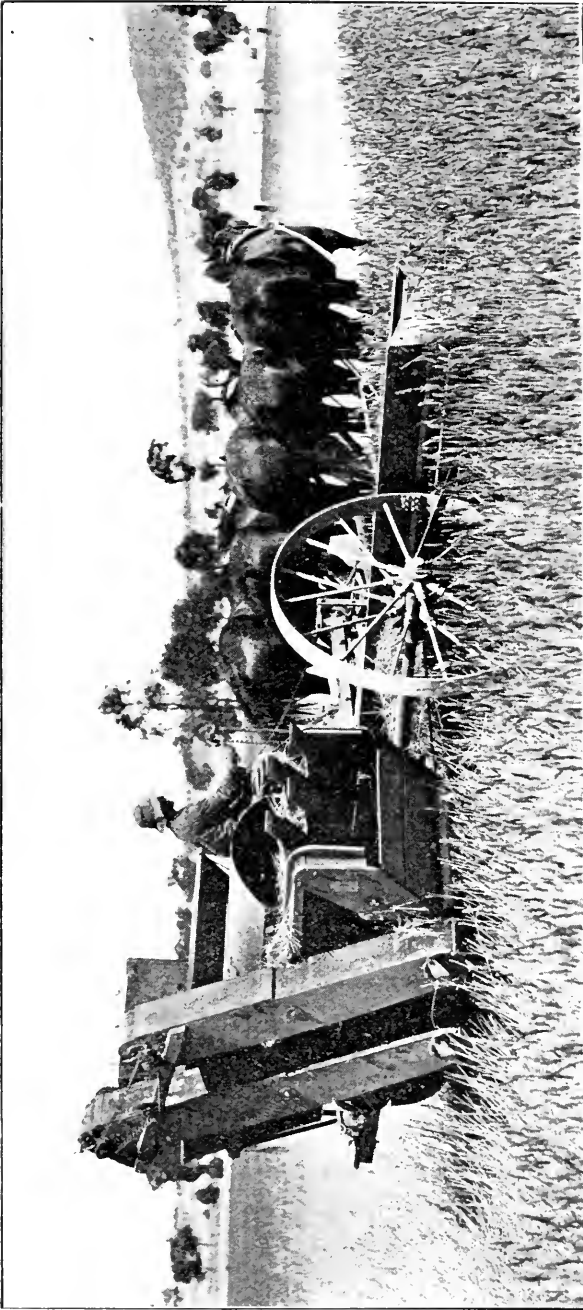
The Stripper ready for work.



Winnowing.



A Combined Harvester in a crop of Yandilla King.



One type of Reaper-Thresher.

C.—The Combined Harvester.

The advent of the combined harvester caused a revolution in the then current methods of harvesting, and the machine quickly superseded the old methods. While still entirely satisfactory for the harvesting of a good upstanding crop, its popularity has been considerably reduced by the reaper-threshers. The machine combines the operations of the stripper and the winnower, the grain being harvested, separated from the chaff and bagged, all by means of the horse-power that draws the machine through the crop. The saving in labour so effected has been one of the most important factors in the extension of our wheat areas. Indeed it is hard to see how the area devoted to wheat in this State could have reached even half its present dimensions without the combined harvester.

Manufacturers have perfected the machine with much ingenuity, and at the same time have maintained stability, so that the heaviest crops can be dealt with. During the harvest of 1915, when the work was so heavy that farmers from other lands might easily have supposed the use of some apparently simpler machine was imperative, combined harvesters were employed on probably quite 90 per cent. of our wheat fields. Crops that were as much as 7 feet high, and that yielded up to 40 bushels and more per acre, seemed to present no difficulties, provided the teams were heavy enough.

A machine so generally used requires nothing in the way of description here nor of suggestions for its most effective use.

D.—Harvesting with the Reaper-Thresher.

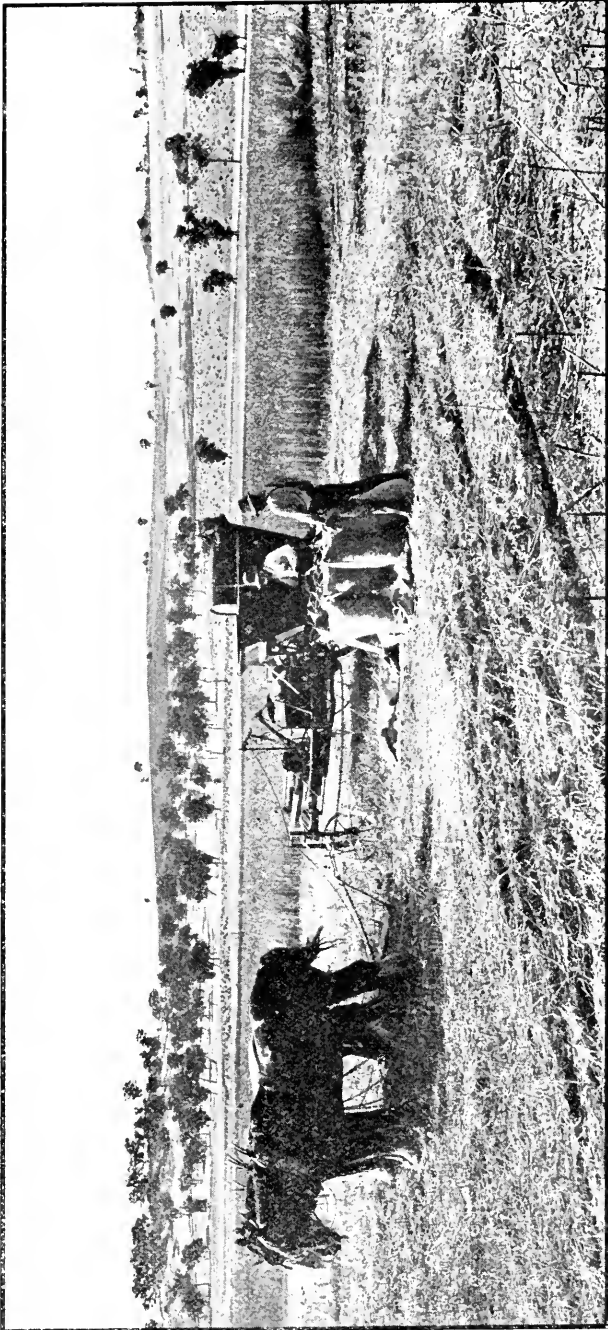
The reaper-thresher, better known perhaps as, and most commonly termed, the "header," is a comparatively new harvesting machine, which prior to the year 1910 was practically unknown in the wheat-growing districts of this State. In that year a number of the machines were distributed throughout the main wheat districts, and although farmers appeared to favour the principle on which the machine worked, the opinion seemed general that many alterations and improvements were necessary. Each year alterations have been made, and the excellent manner in which the machine handled badly-lodged crops during the 1920-21 harvest has firmly established it in farmers' favour, and it is practically superseding the combined harvester.

Perhaps the first main difference between these machines and the harvester is that the heads, instead of being stripped or combed off as with a harvester, are cut off by means of a knife, which is worked at the rear of the comb. This knife is worked on a similar principle to the knife on an ordinary reaper and binder. The straw is drawn through the comb until the heads, assisted by the reel (which revolves at about the same speed as the machine moves through the crop), comes in contact with the knife. The fact of the heads being cut off greatly lessens the draught, as the crop cannot pull heavily upon the comb. Should the ground be soft, or the straw at all weak, the wheat is not pulled up by the roots and choked in the comb. When the crop is dirty with thistles or other weeds, there is not the choking in the comb that takes place when the heads are stripped or combed off.

When the heads are cut they are thrown by means of the reel on to the conveyors at the rear of the comb. These conveyors take the heads along to a feeder, where they are evenly forced into the threshing drum. The drum on the reaper-thresher is very large, and by means of pinions can be altered



A front view of the same type of Reaper-Thresher.



Bagging Wheat from a Reaper-Thresher in the Field.

and made to travel faster or slower to meet varying conditions. A second drum, or really a cavings thresher, is placed at the rear of the machine to re-thresh any broken heads which may have escaped the first threshing.

By means of straw walkers the straw is taken from the threshing drum and thrown out at the side of the machine at the rear of the grain wheel. The grain falls on to a graded pan situated beneath the walkers, where it feeds evenly on to the riddles, and is winnowed. The grain is then carried by means of elevators up into the grain box, which has a capacity of five bags.

The machine takes an 8-feet cut, and with two average teams of, say, five horses each, in a fair crop, from 15 to 20 acres may be harvested in a day. There is very little waste of grain as compared with some other harvesters, and the lightness of draught, and its power to deal with a weedy crop, make it a most valuable addition to the wheat-grower's plant.



Another Type of Reaper-Thresher.

MILLING VALUES OF WHEATS.*

In the following table are given the average bushel-weights, flour-yield, and flour-strength of the different varieties of wheat recommended for cultivation by the Department. By the term flour-strength should be understood the amount of water, in quarts, required by the 200-lb. sack of flour to make a dough of the proper consistency for baking. The figures, therefore, give actually the water-absorbing power of the flour, which is the most ready and reliable means of determining what is understood by the baker under the term "flour-strength." The classification is that adopted in the entries competing for prizes at the Royal Agricultural Society's Show, and includes the four principal classes under which wheat are entered for competition. The "Australian Strong White" class comprise several of Mr. Farrer's crosses made with the specific object of providing a hard, strong-flour, white grain, as distinguished from the ordinary hard wheats, which are usually red in colour.

It is to the introduction of this class that the greatly improved milling quality of local wheat is due. Australian, and particularly New South Wales wheat, now enjoys a high reputation for milling excellence on

* F. B. Guthrie and G. W. Norris.

the English market, and possesses pre-eminently the valuable characteristic of being suitable for milling without previous blending with other kinds. It is always of excellent colour, and is a strong favourite with English millers on this account.

It must be understood that the figures given represent averages taken over a number of years. These figures will vary considerably in different samples and also in different seasons. For example, the bushel-weights of grain harvested in 1913-14 were all abnormally high, the f.a.q. sample being 64, as against 62½ in the previous year. Several samples of Cedar actually went over 65.

TABLE showing milling values of wheats.

Variety.	Weight per bushel.	Percentage of Flour.	Flour- strength.	Percentage of Dry Gluten.
Australian Strong White Wheats—				
	lb.			
Comeback	67	73.3	52.0	12.4
Bobs	65½	72.6	50.0	11.5
Strong Red Wheats—				
Cedar	66¼	73.3	52.7	13.8
Haynes' Blue-stem	63	71.0	50.0	12.8
Medium Strong Wheats—				
Florence	65½	73.0	49.3	13.2
Hard Federation	64½	71.4	47.6	11.5
Thew	62	69.4	46.6	11.9
Improved Steinwedel	61½	70.0	46.6	10.6
Canberra	65	71.7	46.4	11.4
Bunyip	63½	72.8	46.4	12.5
Clarendon	65	71.4	46.0	11.7
Gresley	63¼	72.6	46.0	10.8
Yandilla King	65½	72.0	45.7	11.5
Sunset	60½	69.4	45.6	14.2
Bomen	61	72.6	45.2	11.1
Warren	66½	72.5	45.2	10.6
Firbank	62½	73.1	44.2	12.1
Rymer	65½	72.5	44.2	8.1
Cleveland	65	73.4	44.2	9.5
Weak Flour Wheat—				
Currawa	64½	70.0	44.0	9.0
Federation	65½	72.5	44.0	10.0
Potatz Surprise	67½	72.1	43.4	9.1
Marshall's No. 3	62	72.0	43.0	7.5
Major	60½	72.2	43.0	7.7
Warden	64	70.0	42.3	9.8

The following table may also be of interest in showing the variations in quality of the "Strong White" and "Soft White" classes at the Royal Agricultural Society's Show for the past thirteen years.

It will be noticed that the bushel-weights, especially in the strong-white class, have regularly increased.

TABLE showing average bushel-weights, gluten content, and water-absorbing power of Wheats ("Strong White" and "Soft White") milled at the Royal Agricultural Society's Shows, from 1905-1922.

Year.	Weight per bushel.		Gluten.		Flour-strength, (Water-absorption, quarts per 200-lb. sack.)	
	Strong White	Soft White.	Strong White.	Soft White	Strong White.	Soft White.
	lb.	lb.	per cent.	per cent.		
1905	63	64	10.0	9.7	46.6	45.2
1906	63 $\frac{3}{4}$	64 $\frac{1}{2}$	11.0	9.8	48.5	45.7
1907	62 $\frac{1}{2}$	66	9.3	8.3	48.4	45.4
1908	64 $\frac{1}{2}$	65	12.2	10.2	52.5	46.4
1909	64 $\frac{3}{4}$	65 $\frac{1}{4}$	11.9	8.6	53.5	49.2
1910	64 $\frac{1}{2}$	64	13.8	12.1	50.0	47.8
1911	64 $\frac{1}{2}$	63 $\frac{1}{2}$	12.5	11.0	53.4	47.0
1912	65	64	13.4	10.6	52.7	45.2
1913	67	65 $\frac{1}{4}$	15.2	11.7	53.1	46.9
1914	67 $\frac{3}{4}$	67	12.8	10.6	52.3	45.0
1915	67 $\frac{1}{2}$	66 $\frac{1}{2}$	13.1	12.4	53.8	45.7
1916	67 $\frac{1}{4}$	67 $\frac{1}{4}$	13.0	12.3	53.3	47.5
1917	66	67 $\frac{1}{2}$	12.4	8.6	54.6	43.0
1918	67	65 $\frac{3}{4}$	*	10.2	*	44.5
1919	67 $\frac{1}{2}$	66 $\frac{1}{4}$	10.5	8.9	52.7	43.6
1920	67	65 $\frac{1}{2}$	13.6	11.5	51.3	44.7
1921	66	64 $\frac{3}{4}$	13.0	11.0	52.6	45.1
1922	66	66	12.7	10.0	54.0	44.3

* There were only two entries in the Strong White class in 1918, and these were readily differentiated by the judges without subjecting them to a milling test. The figures for gluten and flour strength are therefore not available.

For many years the northern wheats enjoyed an unenviable reputation among millers and wheat-buyers, on account of their alleged softness, their containing too much moisture, and their proneness to develop weevil. These characteristics, especially the last, are particularly objectionable from the point of view of the exporter, though it does not seem to affect their value to the same extent when used as wheats for local milling.

On this account many Sydney wheat-buyers and shippers were averse to purchasing northern wheat, and some have gone so far as to object, in previous years, to its inclusion in the f.a.q. sample.

In order to test the matter, samples were obtained through the courtesy of Messrs. Gillespie Bros. of their bulk of northern, southern, and western wheats, cleaned and graded, and ready for blending. These bulk samples

were made up of wheats from a number of different districts and from representative samples of the grain obtained from the north, south, and west respectively.

The results of the separate milling of these samples by Mr. G. W. Norris are given on the table on page 309. It will be seen that the northern mixture is in no respect inferior to the others. There is, as a matter of fact, very little to choose between them. The northern is a heavy wheat, being equal to the southern, and heavier than the western. It stands midway between the two in flour yield. In colour of flour there is little to choose between it and western wheat, the southern wheat being somewhat whiter. The same remarks apply to strength and gluten-content. In both these points the northern and western are almost identical and slightly superior to the southern.

The question of the liability of the northern wheat to contract weevil, a property which affects its keeping quality and its value as an article for export, is a separate one. It seems to be the universal opinion that the northern wheat is more liable to become weevily. The reason for this probably does not lie with the wheat itself, but with the conditions under which it is harvested. All new wheats when bagged have a tendency to heat, and this tendency would be much greater in wheats bagged in the northern wheat-fields, where comparatively humid conditions prevail, than in the drier atmosphere of the south and west.

This heating furnishes a more favourable temperature for the earlier hatching out of the eggs.

When stored for any length of time without precautions against the hatching out of weevil, all wheats will develop them in the course of time. This refers to the hardest macaroni wheats equally with the soft wheats. The fact seems to be that the weevily condition becomes sooner apparent in the northern wheats because these are bagged under surroundings favourable to a rapid development. This is a serious objection to the miller, since he prefers a wheat with keeping qualities in order to keep a stock for blending purposes, so that he can ensure a uniform flour all the year round.

To sum up, it would appear that the northern and north-western wheats are in all respects quite as good milling wheats as the southern and western wheats, but that the more humid conditions under which they are bagged render them liable to develop weevil more readily than those bagged in the drier districts, and consequently affect their keeping qualities.

Similar objection is raised to Northern River maize, because of its tendency to develop weevil. As much as 2d. or 3d. more per bushel has been paid for Tumut-grown maize than for the Northern River product on this account. The cause is the same as in the case of wheat.

Strong-flour Wheats.

The desirability of growing wheats of good flour strength cannot be too strongly insisted upon. Thanks to the work of the wheat-breeders of Australia, there are available varieties of wheat for seed purposes, suited to the different districts, which possess this quality in an eminent degree.

COMPARISON OF MILLER'S MIXTURES.

Variety of Grain.	1			2			3		
	Northern Mixture.			Southern Mixture.			Western Mixture.		
Appearance of Grain	...	...	...	Light amber, medium size, plump, soft.	Light amber, medium size, plump, soft.	Light amber, medium size, plump, soft.	...	...	...
Weight (lb. per bushel)...	...	...	...	65.9	65.9	64.2	...	...	...
Ease of Milling	...	...	...	Easy to mill	Easy to mill	Easy to mill.	...	...	...
Percentage of mill products,	{ Flour { Pollard { Bran	...	...	...	71.2	72.5	69.8	...	...
		...	...	...	14.5	14.4	17.1	...	...
		...	...	...	14.3	13.1	13.1	...	...
Nature of Flour.	{ Colour of Flour { Strength of flour (in quarts per sack of 20 lb.) { Percentage of dry gluten { Character of wet gluten	...	...	...	Excellent	Excellent, shade lighter than Western Mixture.	Excellent.	...	...
		...	...	...	46.0	45.6	46.0	...	...
Notes	...	...	...	Yellow, elastic, coherent, soft	Yellow, elastic, coherent, soft	Yellow, elastic, coherent, soft.	...	...	...
	...	...	...	Both bran and pollard clean; semolina faint yellow and soft.	Both bran and pollard clean; semolina faint yellow and soft.	Both bran and pollard clean; semolina faint yellow and soft.	...	...	...

A fairer index as to the general improvement in this respect is afforded by a comparison of the strength and gluten-content of the f.a.q. samples for the past few years. The following table gives the results obtained from the last seventeen harvests:—

NATURE of wheat and flour obtained from the f.a.q. sample in different years.

Harvest.	Weight per bushel.	Percentage of Flour.	Strength—quarts per 200 lb. sack.	Dry Gluten. (per cent.)
1905-06	62	70.5	45.5	10.2
1906-07	62 $\frac{1}{4}$	71.0	46.1	9.4
1907-08	62 $\frac{1}{2}$	68.2	48.5	10.6
1908-09	61 $\frac{1}{2}$	69.7	48.0	12.2
1909-10	62	70.1	48.0	10.4
1910-11	62 $\frac{1}{4}$	70.0	45.0	10.2
1911-12	61 $\frac{1}{2}$	72.8	45.0	11.9
1912-13	62 $\frac{1}{4}$	70.3	46.0	11.9
1913-14	64	70.0	45.0	11.5
1914-15	60 $\frac{1}{2}$	70.3	47.0	12.9
1915-16	61	72.6	45.0	11.4
1916-17	56 $\frac{3}{4}$	69.7	41.5	8.3
1917-18	58 $\frac{1}{2}$	70.7	43.8	9.1
1918-19	62 $\frac{1}{2}$	71.0	44.6	10.1
1919-20	61	72.7	45.0	11.2
1920-21	59 $\frac{1}{2}$	68.0	43.4	10.2
1921-22	61	71.7	43.8	10.3

Effect of Weather at Harvesting on Nature of the Grain.

A further point that must be taken into consideration, when harvesting, is the effect of weather conditions upon the nature of the grain.

Rapid ripening of the grain takes place when air and soil are hot and dry and the nights warm, and these conditions increase the gluten in the grain, and, generally speaking, the flour-strength.

Provided the weather during the previous growth of the wheat has been favourable, hot and dry conditions at the period of harvesting are beneficial. When the opposite conditions prevail at harvest, that is to say, when air and soil are moist and cool, the result is a plump, soft, starchy grain, yielding a less glutinous and generally a weaker flour. When droughty conditions have prevailed during the winter and spring and the ears are not well-filled, rapid ripening results in a parched, shrivelled grain.

On the whole, the conditions that tend to diminish the quantity of the grain are those that are productive of a better quality.

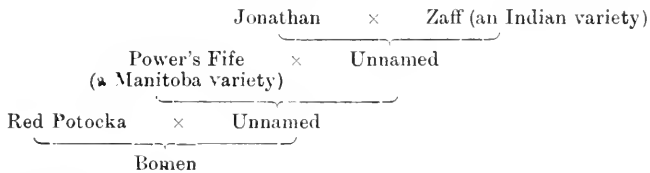
The nature and extent of the damage done to grain by bleaching was tested two or three years ago, when bleached and unbleached samples of two varieties (Federation and Jade—the latter no longer recommended by the Department) were forwarded from Parkes. The unbleached samples were harvested at the end of November, and the bleached samples were from the same crops after $7\frac{1}{2}$ inches of rain had fallen. Apart from colour and appearance, the difference was very marked, and to the disadvantage of the bleached grain, the chief difference being in the bushel weight, which was lower in the case of the bleached sample of Federation by 5 lb. per bushel and in the case of Jade by $3\frac{3}{4}$ lb. There was less difference than might be expected in the actual behaviour in the mill, but the bran from the bleached samples was in both cases thicker and broader, and rather greater in quantity, while the gluten content in the bleached grain was lower, especially in the case of Federation.

DESCRIPTIONS OF RECOMMENDED VARIETIES.

Bomen.

This is a variety produced by the Department by cross-breeding.

The cross was made at Wagga in 1901, and until fixed it was grown in the bunt experiment section, where it proved itself a resistant variety. In 1910 it was sown in larger plots, and it has yielded well since at Wagga, and has also done well at Cowra. It was not named until the Departmental conference of 1913. Its pedigree is as follows:—



Bomen's season is about the same as Warren's, and it ripens a little later than Federation. It has a good head, well filled, bald and white in colour, with a good length of white straw, without much dead flag. The grain is a pale brown. The straw of the ripe crop has been said to "cut like sticks."

It shows a slight tendency to shell and it is somewhat liable to frost.

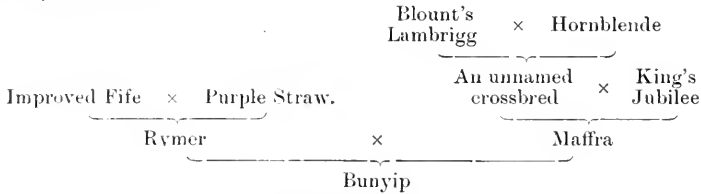
Its flour belongs to the "Medium Strong" class.

In the farmer's experiment plots, Bomen has yielded consistently well, and in some cases has beaten Federation.

Bunyip.

Bunyip is rather an erect, compact, quick-growing variety, which stools sparsely, and is of medium height. The foliage is fairly broad, inclined to limp, and of good colour, though on the light side. The straw is yellowish and stout in appearance, but it has thin walls; sown at the proper season, however, its shortness enables it to stand up satisfactorily for harvesting. The ears are good, stout, well-tipped, with slight tip beards, and the grain is large, plump, attractive, and yellowish-white in appearance.

It is a crossbred, produced as the result of mating two other crossbreds—Rymer and Maffra. Rymer, the mother plant, was produced as the result of crossing Purple Straw on to Improved Fife, the latter being a Manitoba variety. Maffra was the product of King's Jubilee, mated with an unnamed crossbred (Blount's Lambrigg x Hornblende). The pedigree is, therefore, as follows :—



The cross was made in 1897, and named in 1901.

It is a very early variety, and because of this extreme earliness it should not be sown early in the season; to do so is to court failure, unless precautions are taken to eat it off. If sown early, the straw will be rather tall, and break down easily, so that the yield will often be less than when sown late. Early-sown crops of this variety are much damaged by frost. Sow well after the middle of the planting season.

Under normal conditions the straw of Bunyip is on the short side, and rather coarse, and on that account it is not suitable for hay. It is bunt and rust liable, but is early enough to escape rust in most years. As it does not stool too freely, the seed should be sown comparatively thickly.

The grain is attractive in appearance, but the variety is chiefly grown for early hay and is not now among the Department's recommendations.

Canberra.

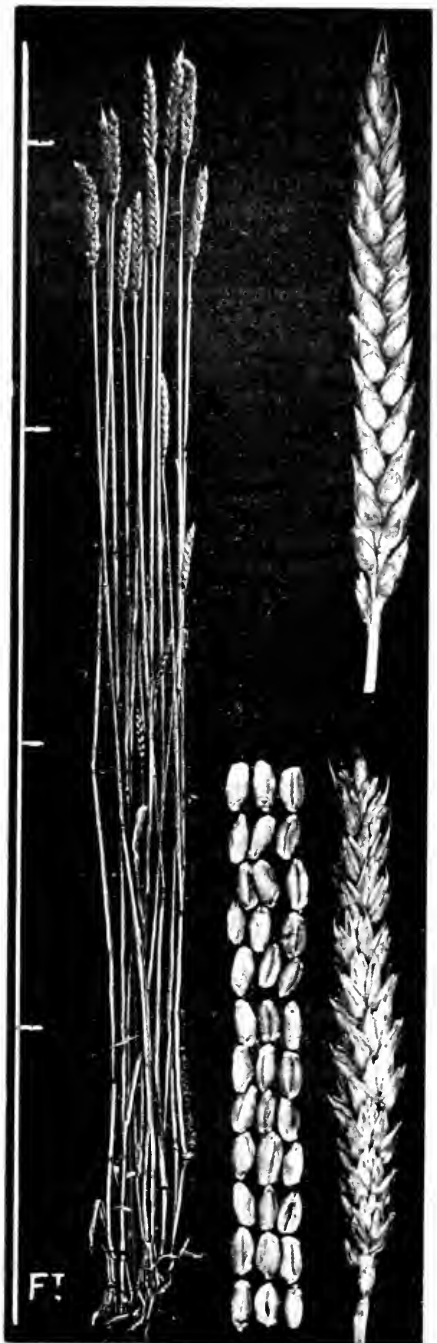
The young growth is rather erect, the leaves medium dark green, somewhat glaucous, and medium broad. The straw is of medium height, hollow, white, and rather slender. It stools fairly, with a moderate quantity of erect leaves. The ears are smooth, light brown, half erect, slightly awned at the tip, of medium length, open and uniform with an acute tip. The spikelets are irregular and medium to widely spreading with medium sharp-pointed glumes, which are not firmly attached. The grain is of medium size, slightly elongated, yellow, opaque, with a medium deep crease.

The variety is the result of an attempt to produce a hybrid between Federation (the dam) and Volga barley, a two-rowed sort obtained as an impurity in a sample of wheat received from Russia. That the attempt was successful has always been a matter of doubt, however, for while it behaved from the start like the progeny of a violent union (say, of two widely diverse races of wheat), no barley characteristics have ever been seen in it. Probably the variety is the result of accidental cross pollination with another wheat. It has been suggested that a Durum wheat may have been the male parent, but no Durum varieties in the same paddock came into flower until two days after the cross was made. It is a new variety, only having been named at the 1914 conference of departmental officers.

It ripens quite as early as Thew and is very useful for grain throughout the wheat belt. It is somewhat weak in the straw, but it is such a heavy yielder of grain that it deserves attention from growers, notwithstanding its liability to lodge under growthy conditions. In the north-west it should not be sown on the black and heavy soils. In the Riverina and South-western



Bomen.



Bunyip.

Slopes it has been tested for several years on the experiment plots, and has proved its superiority over all other early maturers as a grain producer. It has easily outyielded Bunyip in practically every instance where the two varieties have been grown together. It matures a shade later than Bunyip, is just as weak in the straw, but the straw is not so brittle. It is important that it should not be sown until the latter portion of the sowing season, otherwise there is a tendency for it to lodge.

It yields a high percentage of flour, which is of excellent colour and belongs to the "Medium Strong" class.

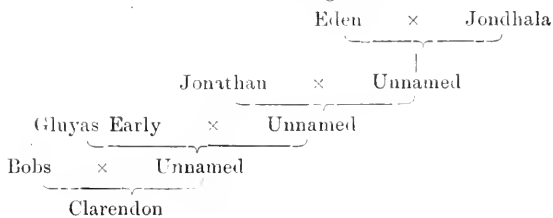
Clarendon.

In its young growth Clarendon has fairly dark green leaves of medium breadth. It is of medium stooling habit. At heading time the leaves are erect, and the foliage rather sparse. It matures very early, ripening a day or two after Canberra. The straw is fairly tall, white, medium stout, and not very strong. The ear is erect, slightly awned at the tip, fairly open, uniform, light yellow, and has rather widely spreading spikelets which are regularly placed. The glumes are fairly long and sharp pointed, being securely attached. The grain is medium hard, a little superior to Canberra, white, medium size, plump, fairly opaque, flour strength about 48.

Clarendon threshes easily, but does not shatter: partly resists rusts from its Gluyas parentage and partly escapes attack because of its earliness. It yields rather less grain than Canberra, but is less liable to lodge. It is superior to Bunyip in most years, and compares favourably with Thew for coastal conditions, maturing at the same time.

It has attracted attention in California, and is doing well in Canada.

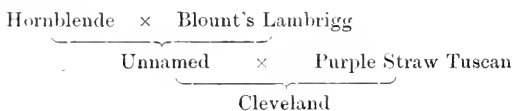
The pedigree is indicated in the following table:—

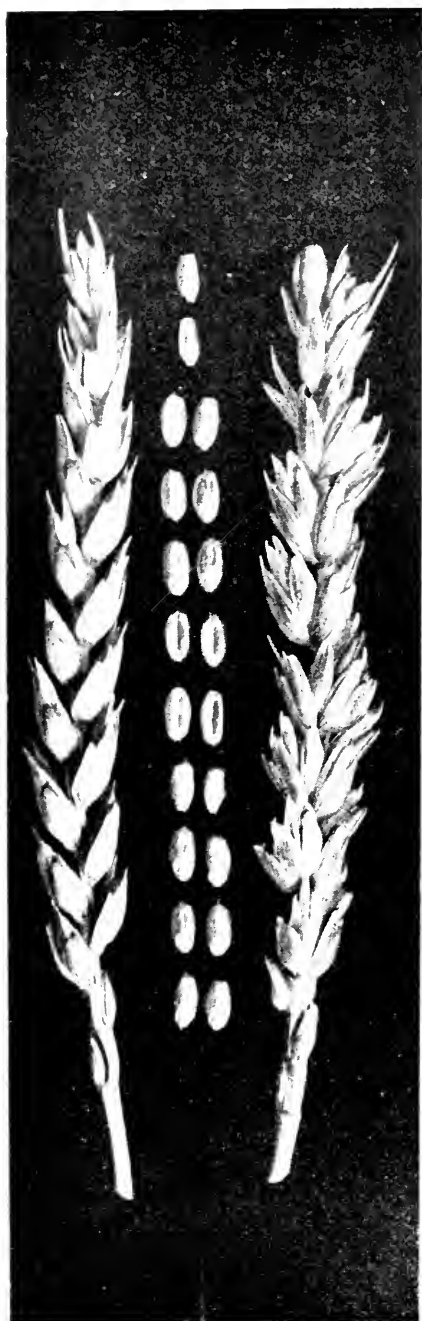


Cleveland.

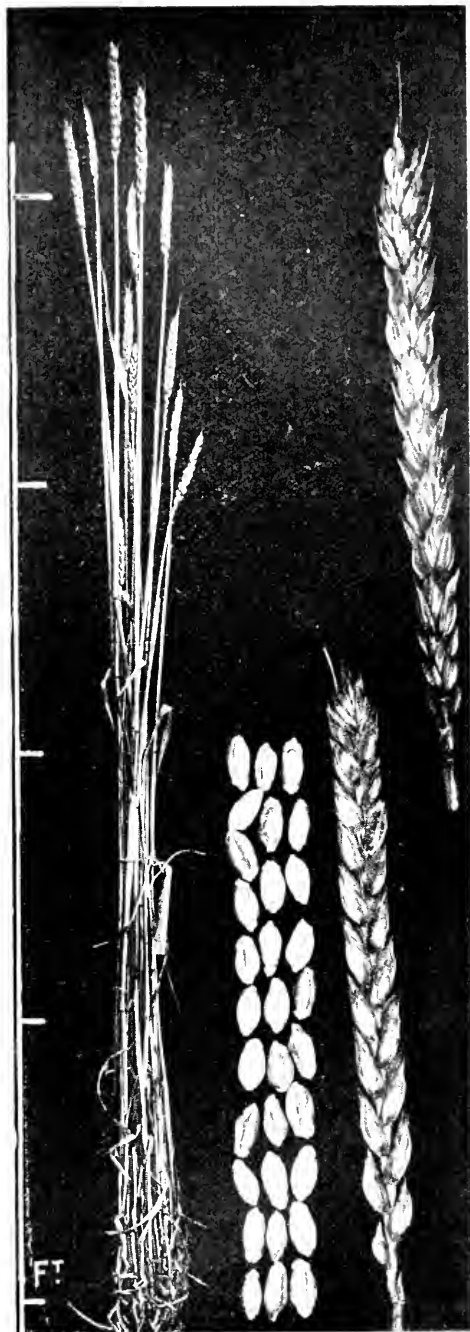
Cleveland is a vigorous, rather tall-growing variety. It stools abundantly, and in its young state has rather a spreading habit. The foliage is fairly abundant, and of a good dark green colour; the leaves are narrow and erect. The straw is white, and on the stout side. The ears are of medium size, and slightly tapering, with white, smooth chaff. The grain is of medium size, white and plump.

This variety is a crossbred, produced by mating Hornblende with Blount's Lambrigg, and then crossing Purple Straw Tuscan on to the progeny. Its pedigree is therefore:—





Clarendon.



Cleveland.

Cleveland is a late variety, and for this reason is more particularly suitable for planting early rather than late in the season. It is a good general-purpose variety, being equally suited for hay as for grain. It prefers a cool climate. At Bathurst Experiment Farm it has proved the best variety yet grown.

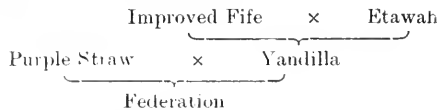
It is rather a good rust-resister, and is not very susceptible to bunt.

As a milling variety it is in the "Medium Strong" class.

Federation.

Federation is a short, strong, erect-growing variety, which stools well. The foliage of the young plant is of good colour, with broad, stiff leaves, while the straw of the ripe plant is yellowish-white, stout and short. The ears are bald, of medium to large size, full tipped, uniform and compact, with the spikelets set rather closely. The chaff is brownish coloured, smooth and fairly close. The grain is of medium size, white, soft and plump.

Federation is the result of a cross between a strain of Purple Straw and Yandilla. The latter was produced by crossing Improved Fife with an Indian variety called Etawah. Its pedigree is:—



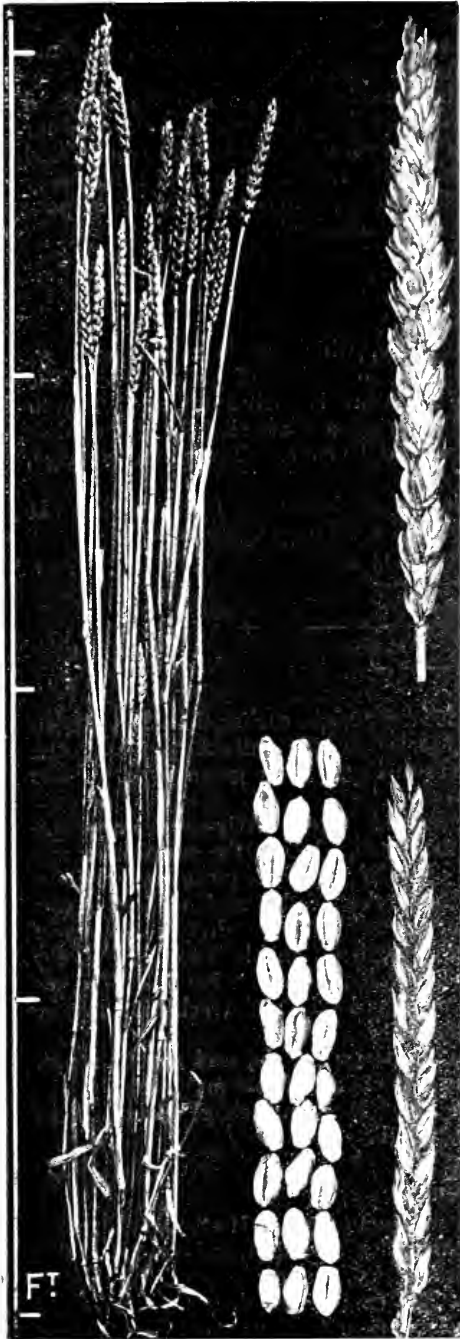
This variety is the most popular farmers' variety in New South Wales at the present time. It has reached this position because of its remarkable ability to yield well and consistently throughout the whole of the wheat areas not only of New South Wales, but also of Victoria and South Australia. In some districts it is estimated that it yields at least a bag more per acre than any of the old varieties.

The production of Federation was the result of a deliberate attempt on the part of Mr Farrer to produce a variety with short straw, specially suitable for the Australian methods of harvesting with the stripper. The remarkable popularity of this variety, as the result of its behaviour in the field, affords abundant evidence that he was singularly successful.

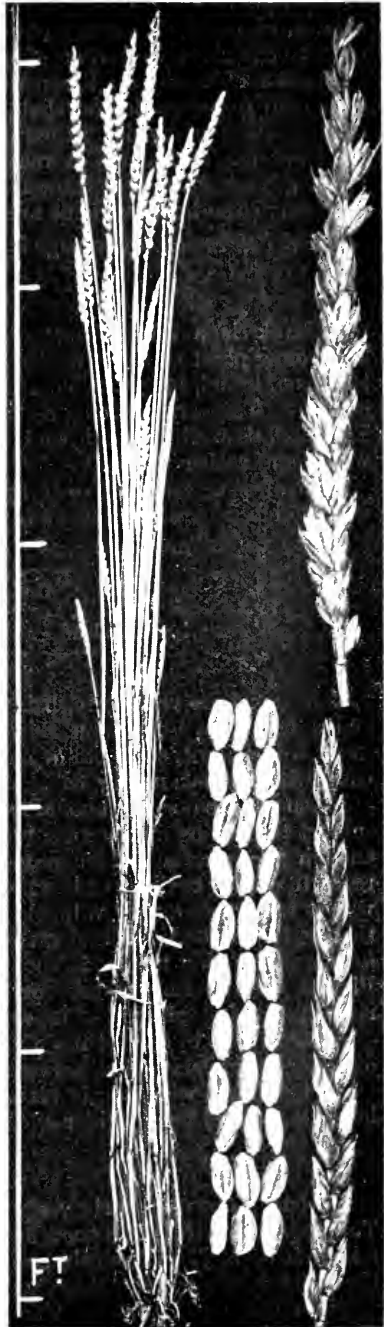
On account of its short straw and erect growth, it is not an attractive variety in the field, and does not appeal to the farmer who has been accustomed to the luxuriant growth and pleasing appearance of Purple Straw and similar varieties. If judged by appearances, Federation would never have become popular. Fortunately for it, and for the farmers of the State, it is the number of bags per acre which turns the scale when the merits of any particular wheat are in the balance. As Federation, despite its unattractive appearance, is able to produce the necessary bags, it has become, and remains, the most popular variety of the present time.

It produces the maximum amount of grain for the minimum amount of straw. Its upright head enables the operation of stripping to be done easily. It holds its grain tightly enough to prevent shattering, yet strips without difficulty. It is not easily damaged by storms, and because of this some farmers have called it "storm proof." The shortness of the glumes, or chaff, and the erect carriage of the head allow the rain to enter the ear, so that the grain becomes bleached as the result of showers more readily than most varieties, which makes it less acceptable in the North-west.

As a milling wheat, it is in the "Medium Strong" class, and it is an improvement upon varieties of the old Purple Straw type.



Federation.



Fu bank.

Federation is liable to rust, flag-smut and bunt. It also seems specially susceptible in the spring, chiefly in the cooler and moister districts, to attacks of powdery mildew (*Erysiphe graminis*), which, however, does not seem to exercise an injurious effect upon the yield.

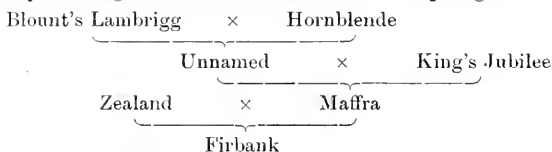
Because of its short, stiff straw and brown colour, it is not a hay variety, and cannot be recommended for that purpose, especially if the hay is intended for market. Farmers use it for their own stock with very satisfactory results, and the stock are said to eat it readily and with relish. The yield is also very much greater than appearances would indicate, 2 tons per acre being quite common; even heavier yields are frequently obtained.

Hard Federation.—See page 322.

Firbank.

Firbank is a tall, erect-growing variety, which stools rather scantily. The young plant carries a moderate amount of foliage of good colour. The leaves are broad, long and limp. The ripe straw is fairly stout, and white in colour. The ears are long, open and tapering, and are slightly tip-bearded. The chaff is white, smooth, and inclined to be close. The grain is large, white, and rather plump.

Firbank is a half-sister to Bunyip, both varieties having the same sire. It was produced by mating Zealand with Maffra. Its pedigree is:—



This variety is very early, being about a fortnight earlier than Steinwedel, and a few days later than Bunyip. It is specially suitable for hay, the straw being sweet, soft, and of excellent quality. It is green right to the base, with little or no dry flag.

It should be sown about mid-season or late. Early-sown crops are subject to frosting and become ready for cutting before the weather is hot enough to cure the fodder properly. But if sown early the crop will be ready to cut for ensilage or hay before the black oat falls, and if utilised in this way it will prove a very valuable aid in profitably ridding dirty paddocks of that pest. Its earliness and sparsely stooling habit enable it to thrive in dry soils, and for this reason it should be a valuable wheat for the Western Plains. As a hay wheat for sowing headlands and tracks it may be recommended on account of its early maturity.

After it is fit to cut for hay the straw becomes brittle, and should rough weather be experienced at harvest time a good deal of loss may occur.

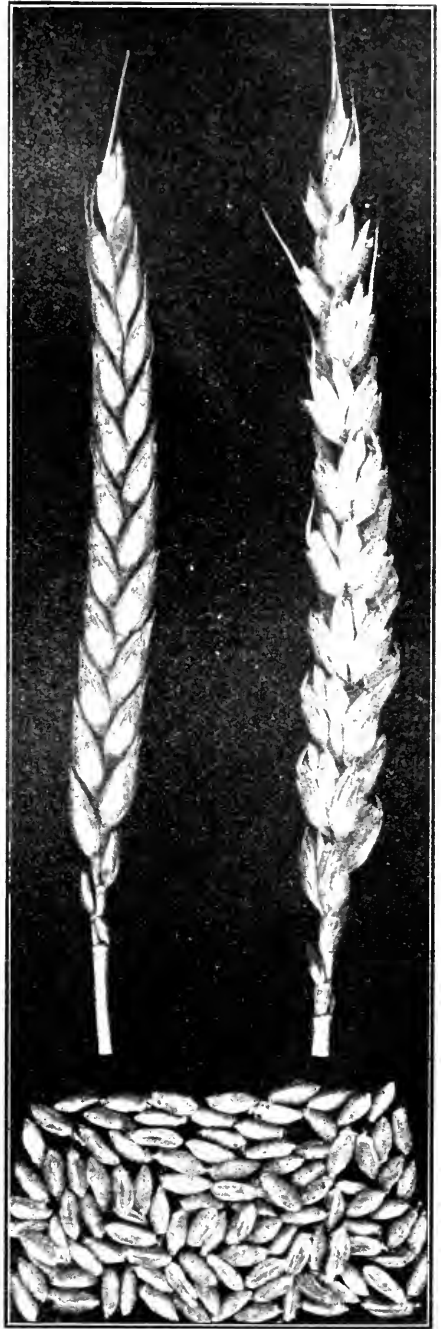
As a milling wheat it is placed in the "Medium Strong" class. It is, however, a good flour yielder and easy to mill.

Florence.

Florence is a very early variety, of medium height. It stools fairly well. The young growth is of a good, dark colour, vigorous, erect, and compact. The foliage is of medium quantity, with rather stiff, narrow leaves. When ripe the straw is white and rather slender. The ears are slightly tip-bearded, of medium size and tapering. The spikelets are not set very closely together. The chaff is white, smooth, and rather open. The grain is good, rather horny, of average size, and inclined to be plump.

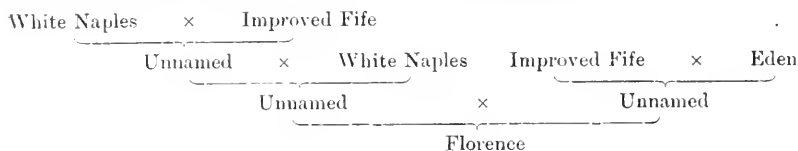


Florence



Gresley.

Florence is a crossbred, produced as the result of an effort made to obtain a smut-resisting variety. The cross was made in 1901, and introduced into larger plots for trial in 1907. The pedigree is as follows:—

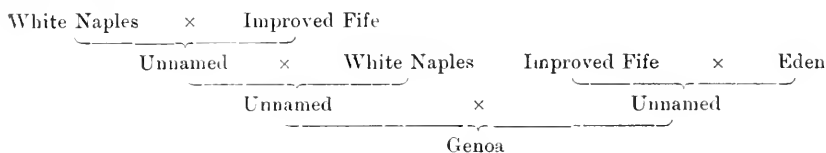


Florence is suitable for hay or grain, particularly in the north-western districts. It is somewhat apt to shell, and being very early it should be fed off if sown before mid-season.

As a milling variety the grain is of satisfactory quality; in fact, it is one of the strongest in the "Medium Strong" class.

Genoa.

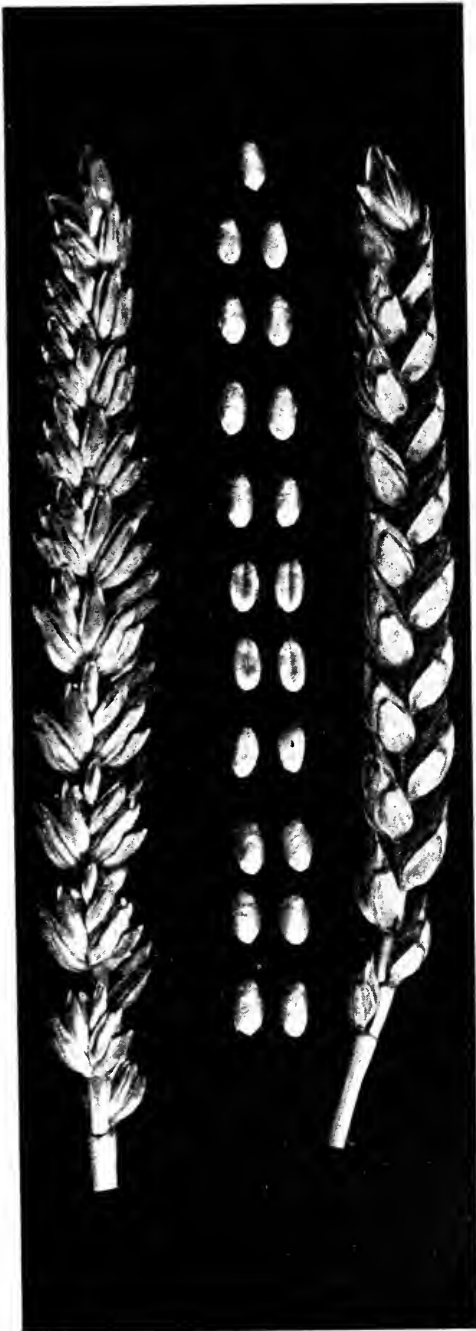
The young growth is spreading, the leaves dark green, glaucous, and rather narrow. The straw is fairly tall, hollow, white, and medium stout, the plants stooling rather freely, with fairly abundant, rather erect flag. The ears are of medium size, yellowish-white, rather open, slightly tapering, smooth, slightly awned at the tip, and rather erect, with regular, medium, widely-spreading spikelets. The glumes are blunt-pointed, slightly incurved at the tip, and fairly strongly attached. The grain is of medium size, regular, yellowish-white, rather horny, with crease of medium depth. Its pedigree is:—



This variety is a sister to Florence, but ripens much later; it is a good bunt-resister, and not susceptible to rust, but a moderate yielder in most districts. At Glen Innes, however, it thrives well; although its stooling capacity is much less than that of Haynes' Blue-stem, its better grain-holding qualities have brought it into favour for that district.

Gresley.

From information supplied by Mr. Grasby, of the *West Australian* newspaper, we are able to give the history of this wheat. Gresley is the result of a cross between Federation and Huguenot, made by the late Mr. Charles Harper, of West Australia, in 1909. The seed was handed over to Mr. Grasby who, about 1918, named the crossbred after a son of Mr. Harper, who fell at Gallipoli. It was received by us in May, 1917, under the number 83, and has thus been grown for five years. We have three milling analyses of this variety: the flour strength is very uniform (about 45 each season), though the percentage of gluten varies. The flour is satisfactory from the miller's point of view, with a fairly good colour. In its early growth, Gresley is a sparse stouter, erect, with light green leaves. Maturing early, it comes into head at the same time as Canberra, but the straw is taller



Hard Federation.



Haynes' Blue-stem.

and much stronger. The ear is white, tip-awned, long and lax, with few grains (two usually) to the spikelet. The grain, which is large and yellow, does not shatter, though it strips readily, and is opaque in appearance. It is a very fair general-purpose wheat, though more adapted for hay on the whole than for grain production. While not particularly rust resistant, it is only moderately susceptible. Gresley may be classed with Firbank, but is hardly so suitable for very dry districts, though it will quite likely beat Firbank as a dual-purpose variety in other localities where Firbank is grown. Very good results have been obtained with it in field areas at Cowra Experiment Farm.

Hard Federation.

Hard Federation is a selection from Federation, and is believed to be the product of a natural cross. It was first selected in the stud plots of Federation at Cowra Experiment Farm in 1907 or 1908, it having been observed that a single plant had threshed grain of remarkably hard and flinty appearance. The plant had the distinctive brown head and general appearance of Federation in the field, but the grain was of a class that had never been seen in Federation before. The seed of this head was propagated, and during the early years of its growth at Cowra it produced quite a proportion of white heads—so much so that when sold to farmers as Federation comment was freely made on the seed that was being supplied by Cowra farm. This character was gradually eliminated by selection, however, and the quality of the grain created a demand for the strain, which was not named until 1914.

In outward appearance Hard Federation much resembles Federation, but the heads are less dense (the spikelets not being so closely set together), and are more full and bold looking. The plant is a more vigorous grower from the start than the older type, and it stands feeding-off well. It grows a little taller than Federation and ripens a week earlier, and it stands weather well without bleaching.

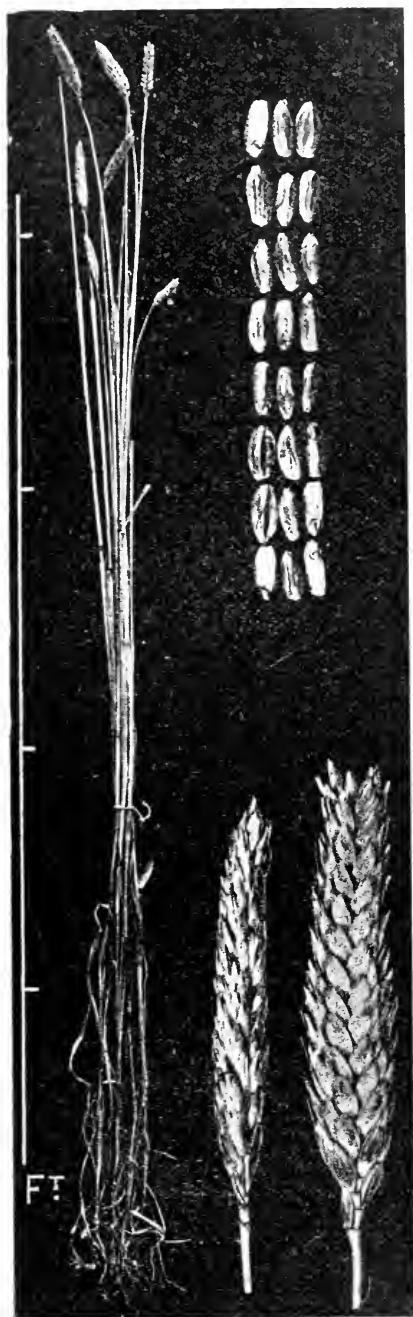
Hard Federation received its name from the quality of its grain, and it is in this respect that the most striking difference is seen between the two varieties. Hard Federation has grain of a rather flinty appearance, and does not bleach easily; this feature, together with its superior flour qualities, has brought it into favour with millers. Harvest results have shown it to be a heavy yielder of grain, especially in the western and north-western portions of the wheat belt, but as a rule it does not give quite as good yields as the ordinary Federation in the southern districts and Riverina.

In liability to disease Hard Federation is about on a par with Federation, but its earlier maturity enables it to escape many troubles.

Haynes' Blue-stem.

Haynes' Blue-stem is a tall variety, stooling freely. The foliage is of good colour, and the straw when ripe is white and is rather slender, but very elastic. The ear is very slightly tip-bearded, and has white chaff, which is covered with fine velvety hairs. The chaff is very open, and grips the grain so loosely that it often protrudes from the glumes. The grain, which is not very large, is reddish, hard and plump when grown under good conditions.

Haynes' Blue-stem is one of the varieties selected and distributed by the Minnesota Experiment Station, and is also called by them "Minnesota No. 169." It is considered by that station to be one of the best varieties for



Huguenot.



Improved Steinwedel.

their conditions, and was the parent of a crossbred which for some years was considered the most prolific and best all-round variety they had produced. It is also known as "South Dakota No. 1."

It is a late variety, and only suitable for cool, moist, districts similar to Glen Innes. It is resistant to rust, but shells so easily that it is quite unsuitable for harvesting with the stripper, and should always be harvested a little on the green side.

For hay in cool districts, it is admirably suited. At Glen Innes Experiment Farm it has so far proved the best for that purpose, consistently yielding heavy crops of fodder of excellent quality, though it is no longer definitely recommended.

Haynes' Blue-stem is the only Fife-wheat grown locally which does not belong to the "Strong Red" class. Its flour is one of medium strength, and the wheat is classed with the "Medium Strong" wheats.

Huguenot.

Huguenot, or "Le Huguenot" is a very tall variety, which stools very sparsely. The young growth is rather compact and erect, and is of only a fair colour. The amount of foliage is moderate, with leaves which are broad and stiff. The straw is stiff, coarse, and solid near the ear. The ear is bluish-black, and is rather short, flat sided, uniform and beardless. The smooth chaff clings to the grain tightly. The grain is of the macaroni type, and is large, long, hard, fairly plump and translucent.

Huguenot is a selection from Medeah. A fairly beardless head was noticed in a crop of Medeah, and from this head the grain carrying least beard was selected and planted; the resultant seed was sown, and the ears showing least beard again selected, until an even, beardless Medeah was produced, when the name "Le Huguenot" was given it. The variety originated with Mr. J. Correll, of the Arthur River, West Australia.

On the North Coast it has proved the most prolific variety ever grown for green feed, and it is only recommended for coastal districts.

Sown in conjunction with field peas or vetches, it gives heavy yields of fodder, the strong stalks of the Huguenot acting as supports to which the peas cling. Yields of 11 tons of Huguenot alone and 13½ tons of Huguenot and field peas together have been obtained on the North Coast.

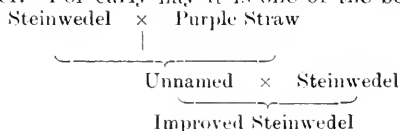
It is fairly rust and smut resistant.

As a milling variety it is remarkable for the large amount of gluten the grain contains. This ranges from 20 to 22 per cent., which is the largest amount found in any variety examined by Mr. Guthrie.

Its flour yield is very low, and the bread-making qualities inferior, though the protein content is high. The colour of the flour is so bad (almost black) as to make it useless from a miller's and baker's standpoint.

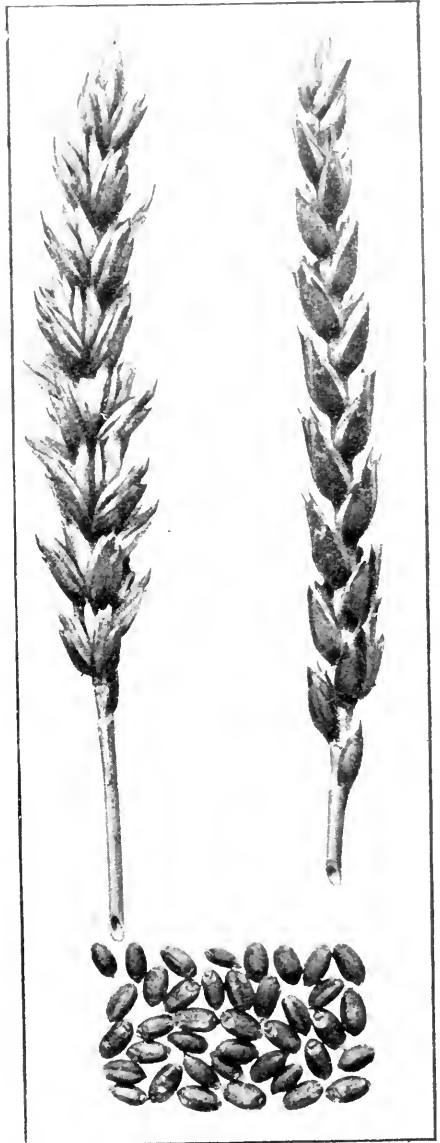
Improved Steinwedel.

Improved Steinwedel has latterly taken the place of the original strain in the Department's recommendations. Its pedigree according to Mr. Pye, who evolved it, is shown in the following genealogical tree. It is particularly adapted to dry conditions, where its dual-purpose character makes it valuable as an early maturer. For early hay it is one of the best.





Marshall's No. 3.



Sunset.

Under average conditions it produces a heavy grain of bright, attractive, plump appearance. As a milling variety it produces a large percentage of white, starchy flour, of a quality that places it in the "Medium Strong Flour" class.

Improved Steinwedel is a fairly early, rather erect, free-stooling variety, of medium height. The young growth is vigorous, of rather a pale colour, and fairly erect. The foliage is abundant, with the leaves limp and drooping. The straw is purple, stout and strong. In colouring, the ears have a characteristic mottled appearance, while in form they are large, full tipped, and tip-bearded, with the spikelets open and rather irregularly placed. The chaff is white, smooth, and loosely attached to the grain, which is fairly large, white, and plump.

Steinwedel was originally a selection from a field crop made by a South Australian farmer of that name. It proved rust and smut liable, but also highly drought-resistant, and, like Furbank, it was admirably adapted for the production of fodder in the hottest and driest parts of the State. It was also a prolific yielder of grain, but is extremely liable to shelling.

Marshall's No. 3.

Marshall's No. 3 is a late mid-season variety, which is usually of medium height, but which occasionally grows tall. It stools freely; the young growth is fairly vigorous, and creeping rather than erect. The foliage consists of an abundance of broad, rather limp leaves of fairly good colour. The ripe straw is purple, stiff, hollow, and stout. The yellowish-white ears are of medium size, slightly pointed and slightly tip-bearded. The spikelets are set moderately close together; the chaff is white, smooth, and open. The grain is of fair size, but not very plump, except under good conditions.

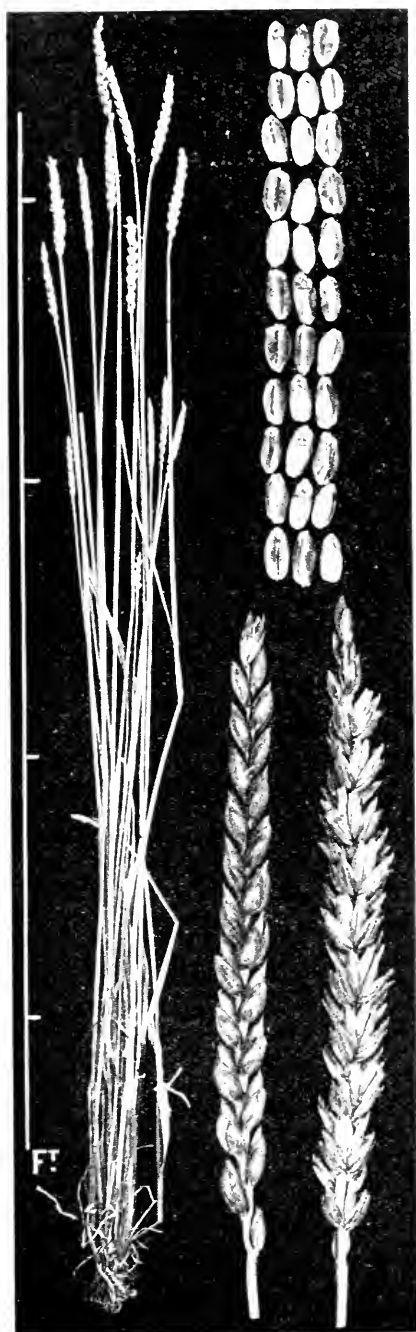
This variety is a crossbred which was produced by Mr. R. Marshall, of South Australia. It is fairly rust-resistant—a quality which it derives from one of its parents (Ward's Prolific).

As a milling variety it belongs to the "Medium Strong" class.

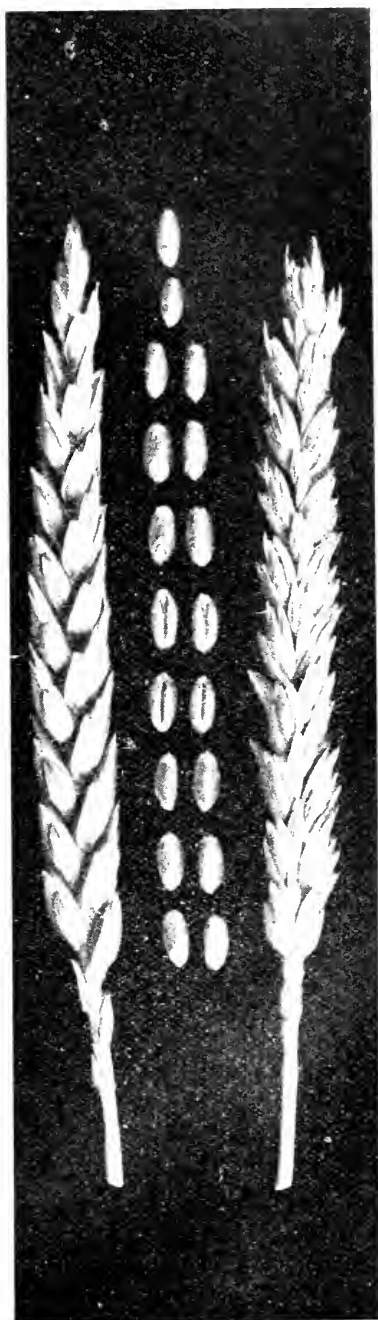
It is as valuable as a hay wheat as it is as a grain yielder. It should usually be sown early, and it can be recommended for the Central Tablelands, the Riverina, and the western slopes from north to south. Ten years' trials on the farmers' experiment plots in central western districts have proved it to have a marked utility as a general-purpose wheat in that part of the State.

Sunset.

The young growth is erect, with medium light green, moderately broad, leaves. The straw is below medium height, hollow, white, medium slender, and slightly brittle. Its stooling capacity is sparse; the flag is medium in amount and rather inclined to droop. The ears are rather erect, yellowish white, smooth, awnless, of medium size, fairly open, uniform, with widely-spreading spikelets. The glumes are sharp-pointed and sufficiently firmly attached. The grain is of medium size, soft, regular, pale yellow, medium opaque, with medium deep crease. This variety usually lies between the



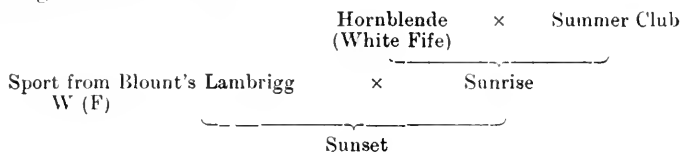
Thew.



Warden.

“Medium Strong” and “Weak Flour” classes, and of those recommended it is the earliest wheat to ripen. It yields satisfactorily for both hay and grain in districts of low rainfall.

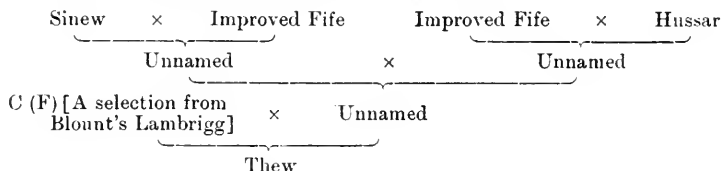
Its pedigree is as follows:—



Thew.

Thew is an early, medium tall, and fair stooling variety. The young growth is vigorous, rather spreading, and of good colour. It has a medium amount of foliage, which is green to the base of the plant. The leaves are rather stiff and narrow. When ripe the straw is white, not very stout, and inclined to be weak under good conditions. The ears are beardless, of medium length and tapering, with the spikelets fairly open. The chaff is white, smooth, and not very close. The grain is white, not very large, and fairly plump.

Thew is a crossbred, with pedigree as follows:—



It is probably its earliness that enables it to escape rust rather than any constitutional ability to resist the pest, for in some districts it has been reported as rusty.

Its soft straw, and habit of carrying green foliage right to its base, render it a very suitable variety for hay.

On the South Coast it has eclipsed all other varieties of wheat for the purposes of green fodder for cattle in the early spring, when the pastures are generally somewhat bare.

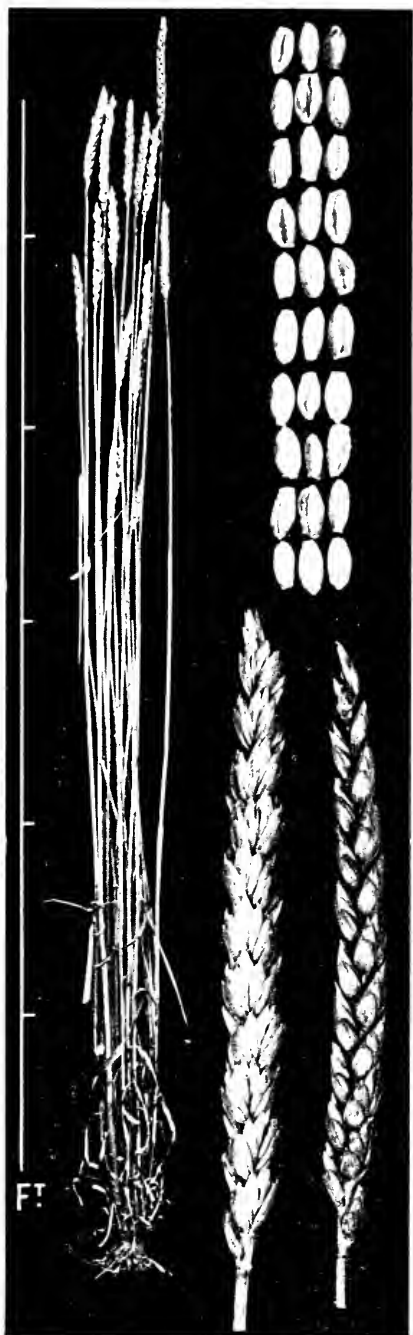
As a milling wheat Thew belongs to the “Medium Strong” class, though the colour of its flour is not quite up to the standard.

Warden.

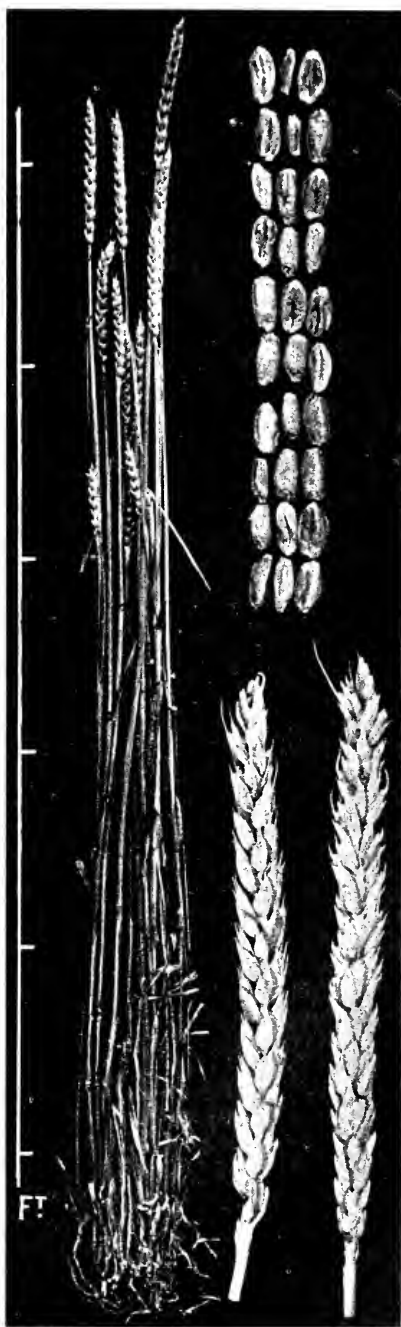
In the early stages of growth Warden is rather profuse in habit. At heading time, it has dark green leaves which are rather glaucous, narrow and erect. The straw is quite tall, white, strong, hairy, stout, and tough, but not coarse.

It is pre-eminently a hay wheat, showing a decided green tinge to the foot, and the straw not carrying too much flag. The ear is white, erect, having a slight tip awn, long, medium, open, uniform, with an acute tip; spikelets narrow and regular, and with firmly attached glumes.

The grain is soft, of medium size, elongated, pale red and opaque, and belongs to the “soft flour” class.



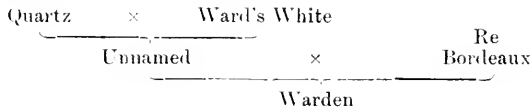
Warren.



Yandilla King.

Warden is a fair grain yielder, and threshes readily. It is mid-season to late in habit, ripening slightly before Zealand. This latter variety not infrequently beats Warden for yield of hay, but the hay lacks the prime quality exhibited by Warden.

The cross was effected by Mr. Pye, the breeding being as follows:—



Warren.

Warren is a mid-season variety, which stools well, and which in height is from medium to tall. The young growth is rather more prostrate than erect, of good colour, with the leaves fairly abundant, limp and broad. When ripe the straw is white, fairly stout, and rather long. The ears are beardless, long, tapering and open. The chaff is smooth, white, and set fairly close to the grain. The grain is of good size, white, and fairly plump.

Warren is the result of crossing Bobs with Jonathan, and then mating the progeny with another crossbred called Warner.

It has proved one of the best rust-escaping wheats grown at the Hawkesbury Agricultural College, and is specially valuable for this quality. It is suitable for both hay and grain. In inland districts its straw is inclined to become weak. As a milling variety the quality of the grain is fair. It yields a satisfactory quantity of flour of excellent colour, but of low flour-strength. It is one of the "Weak Flour" wheats.

Yandilla King.

Yandilla King is a free-stooling, late variety of medium height. The young growth is inclined to be prostrate rather than erect. The leaves are a good dark colour, limp, and not very broad. When ripe the straw is white, not very long, and rather stout. The ears are slightly tip-bearded, fairly long, the spikelets set rather closely together. The chaff is white, smooth, and fairly closely attached to the grain. The grain is white, large, and fairly plump, and the yield good, notwithstanding that empty chaff often occurs at the tips.

Yandilla King is the result of a cross made by Mr. R. Marshall, of Parkside, South Australia, between Yandilla and Silver King (the latter being also known as Marshall's No. 3 White Straw). It is interesting to note that Yandilla King is a half-sister to Federation, both varieties being the progeny of the common parent Yandilla. Yandilla is a crossbred produced by Mr. Farrer, as the result of mating Improved Fife (a "Manitoba" variety) with an Indian variety called Etawah.

It mills a "Medium Strong" flour of excellent colour, and is recommended for use on the Central Tableland, western slopes from north to south, and Riverina.

Zealand.

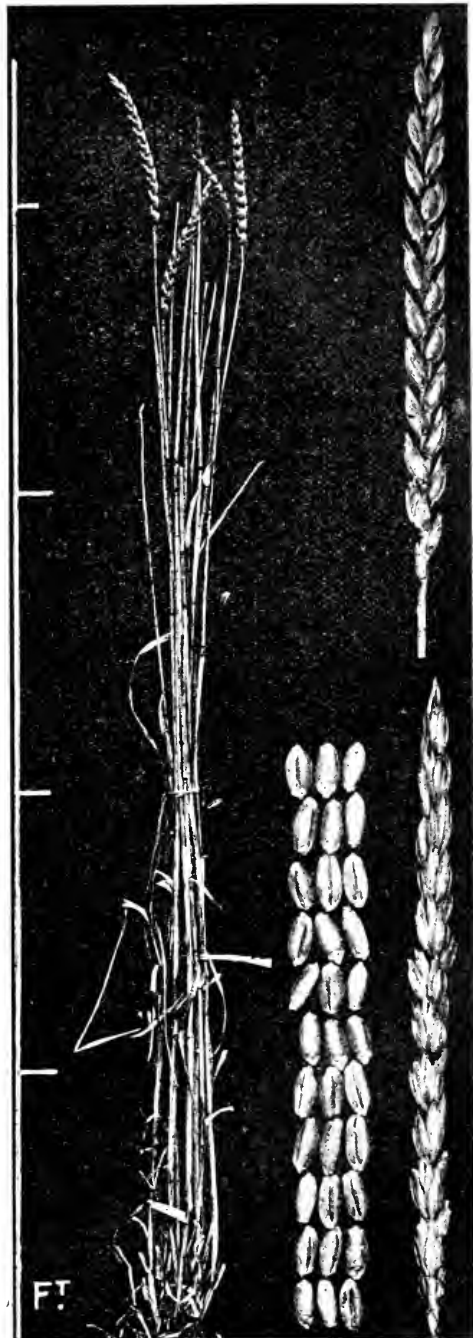
Zealand is a tall-growing, free-stooling, late variety, of attractive appearance. The young growth is fairly vigorous, and its foliage colour dark; the leaves are broad, limp and abundant. When ripe the straw is long, hollow, rather strong and stout, and yellowish in colour. The ears are beardless, long and tapering, with the spikelets rather open. The chaff is smooth and white. The grain is large, plump, soft, and dull white.

Zealand is an old-established variety, and is regarded as one of the very best grown in this State for hay, but for best results it must be sown early. The Manager of Wagga Experiment Farm regards it as a valuable hay wheat.

Zealand, which is also known in South Australia as "Berthoud," appears to give a heavier fodder than Warden, though the quality of the chaff is not quite equal to it.

Zealand should be grown by farmers who cater for the Sussex-street trade and who make a specialty of growing wheat for hay, but where there is much grain to be harvested this variety is altogether too late. There is not sufficient time to deal with it before stripping is begun.

Under favourable conditions Zealand produces a satisfactory amount of grain, but for grain production it is being ousted by earlier varieties. In the matter of colour its flour is rather below the standard required by millers, though so far as flour-strength is concerned it must be classed with the "Medium Strong" wheats



Zealand.

FUNGUS DISEASES OF WHEAT.*

Among the common troubles that the wheat-grower has to fight are Stinking Smut or Bunt, Take-all, Flag Smut, and Rust. All are due to fungi, and from time to time are responsible for considerable losses. Rust, fortunately, is somewhat intermittent in its attacks—several years sometimes elapsing between serious outbreaks in the grain districts; but Bunt is ever present, and the farmer's only means of controlling is by treating his seed wheat with a fungicide before sowing. Efforts have been made to produce varieties resistant to these fungi, and some success has been achieved in relation to Rust, mainly by the production of wheats that grow so quickly that they mature before that parasitic enemy; but with Bunt the case has been different, those that have proved resistant are not generally prolific enough for cultivation on an extensive scale.

Bunt or Stinking Smut (*Tilletia tritici* (Bjerk) Wint.; *T. teres*, Kuehn.).

Two pests are usually known as Smut—Bunt or Stinking Smut, and Loose or Flying Smut. When, however, the farmer talks about "smut," he almost without exception refers to Stinking Bunt or Stinking Smut, which is caused by one or other of two closely-related fungi whose scientific names are given above. Stinking Smut is so called from the objectionable smell which is quite noticeable even if only a little be present in a large quantity of grain.

There are considerable differences between Stinking Smut and Loose Smut; but, from the wheat-grower's standpoint, the chief one is that Stinking Smut (Bunt) can be readily prevented by treating the seed wheat before it is sown, whilst Loose Smut requires special treatment of the seed for its prevention in the resulting crop.

The minute black particles which are found adhering to a wheat grain, and which are commonly called "smut," but which would be better called "bunt," are the seeds or spores of a plant (a fungus), just as the grains of wheat are the seeds of another plant. Fig. 3 illustrates a part of the brush of a grain of wheat, and shows how very minute the spores are. Treatment must be very thorough to kill these spores, as they cling to the fine hairs, and when the grain is dipped bubbles of air are often caught amidst the hairs and help to prevent the spores from being wetted and killed. Any spores that retain their vitality after the treatment of the grain with the fungicide, may germinate in the soil when the grain is sown. Under suitable conditions they enter the young plant, grow with it, living on its tissues, and finally cause the "bunted" wheat ear.

The spores do not escape from the wheat ears in a powder, but are enclosed in the ovaries and glumes, and although at first somewhat greasy, they soon become dry and hard. The mass of spores in an ovary is known as a "bunt ball"; hence it is frequently spoken of as "ball smut," and sometimes, on account of its hardness, as "stone smut."

Fig. 5 shows the various stages during which a developing plant may be attacked.

The fungus growing in the plant reaches the developing ear, and produces its spores, forming the dark grain-like bodies (bunt balls) which take the place of the normal grain (Figs. 1 and 2).

* Compiled by Officers of the Biological Branch.



Fig. 1.—Ears of Wheat with Bunt. (From McAlpine's "Smuts of Australia.")

- A. Ear showing spikes standing out from axis and somewhat separated.
 B. Ear with glumes removed to show the bunt balls and grains.

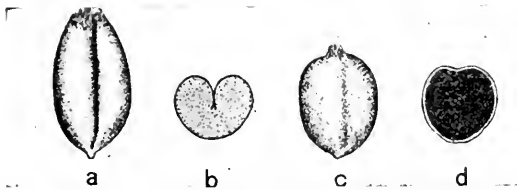


Fig. 2.—Healthy and Bunted Wheat Grains. (From Purdue Univ. Circ. 22.)

- a. Normal grain, showing the longitudinal furrow.
 b. Cross section of (a), showing furrow.
 c. Bunted grain, showing absence of furrow.
 d. Cross section of (c), showing absence of furrow and the black spore mass which has replaced the normal contents.

The plant may also become affected with Smut as result of infection from soil which has previously grown smutty crops. This, however, is relatively rare. The chief cause of Smut is the sowing of seed which has healthy spores adhering to it. It follows, therefore, that if the vitality of these spores can be destroyed, or if the plants resulting from the germination of the spores are destroyed, the grain crop will be "clean." Methods have been introduced for successfully destroying the vitality of the spores,

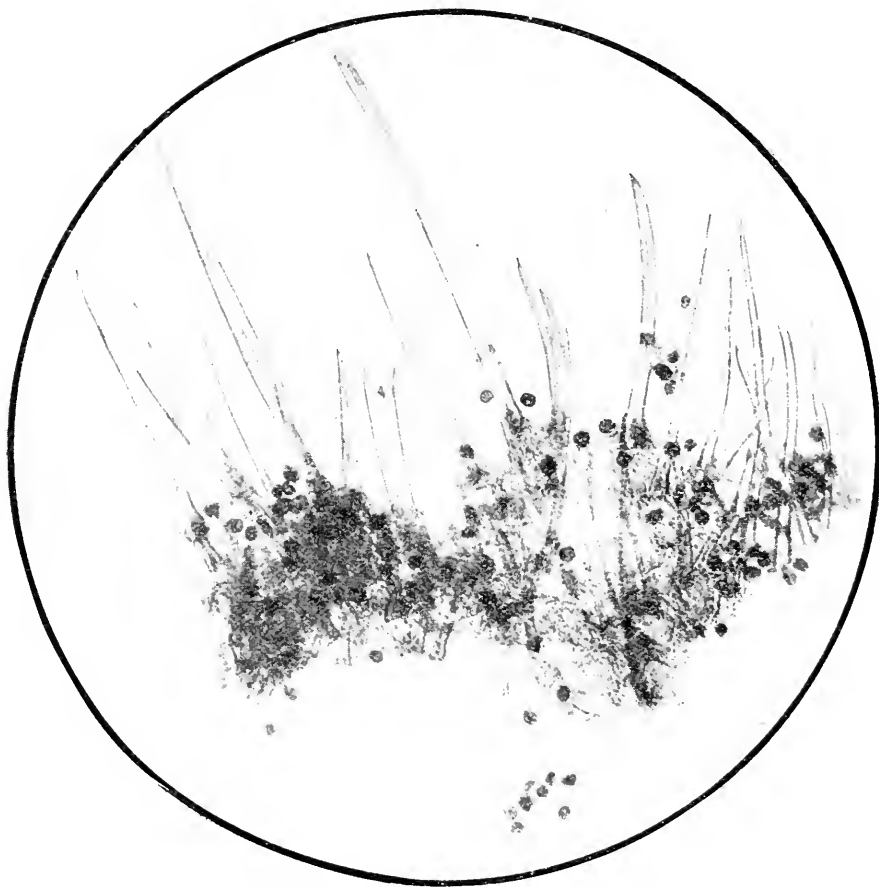


Fig. 3.—Part of "Brush" of Wheat Grain.

This illustration shows spores caught by the hairs of the brush, and affords a comparison of the size of the spores and hairs.

but no practical method has yet been devised for killing the smut plants after they have germinated. Occasionally, as in the case of self-sown crops, the natural conditions prevailing at the time the seed is planted are the cause of a "clean" crop being produced from untreated smutted seed; but to depend upon this chance method of obtaining clean crops is very unwise and likely to lead to disappointment. It is far wiser and more business-like to destroy the vitality of the spores, and thus prevent them growing.

Whilst the methods recommended for treating seed grain will destroy the spores which have become free from the bunt balls, NONE OF THEM IS EFFECTIVE FOR DESTROYING THE SPORES WHICH ARE CONTAINED IN UNBROKEN BUNT BALLS. IT IS, THEREFORE, NECESSARY, IF ANY TREATMENT IS TO BE EFFECTUAL, THAT THE UNBROKEN BUNT BALLS BE EITHER REMOVED OR BROKEN BEFORE THE SEED IS "PICKLED." If this is not done the bunt balls are likely to become broken, during the subsequent operation of planting, and their contents (a myriad living spores) spread over the treated grain, thus nullifying all that has been done: the effect of the treatment is mainly to destroy the spores adhering to the grain; it does not render the grain absolutely immune to the attacks of Smut or to other spores that may become attached to it after treatment.

It has been calculated that in a single bunt ball—no larger than a grain of wheat—there are about



Fig. 4.—Bunt Balls.

The "Pickle" has no effect on the spores contained in the unbroken balls.

4,000,000 spores, each of which is capable of causing one wheat-plant to be smutted. In a bushel of wheat there are 600,000 to 1,000,000 grains. There are, therefore, in a single bunt ball enough spores, if regularly and evenly distributed, to provide each grain in a bushel of wheat with from four to six spores. The great necessity for removing the bunt balls or breaking them so that the fungicide can act upon their contents, is obvious.

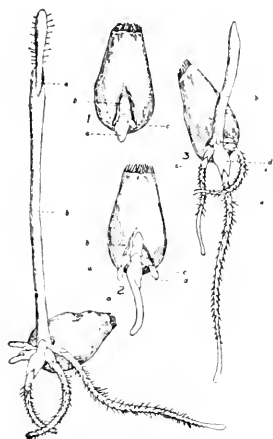


Fig. 5.—Various Stages of Germination of Wheat during which Infection by Bunt Spores may take place.

(a) Primary rootlet, (b) stem, (c) secondary rootlets, (d) protective sheath, (e) point where first green leaf pushes through the sheath, after which stage no infection occurs. (Ottawa Bul., 73. Drawings from diagrams in Kensington Museum.)

Fortunately, it is easier to remove the bunt balls than to ensure that all are broken. Bunt balls are very light and float in water, so that if the wheat to be treated is poured slowly into the "pickle," and in such a way that the bunt balls are not carried down by the grain, the bunt balls will float on the top and can be skimmed off and destroyed. As a further precaution, and in order to release any bunt balls which may have been carried down by the grain, the grain should be stirred or raked; this is also likely to break up any partially-broken bunt balls which have sunk and become soft.

Until bunt-resisting varieties have been introduced and are in general cultivation it is advisable, in order to ensure clear crops, to assume that all seed is more or less smutty, and requires to be "pickled." The spores are so minute that it is quite possible for enough to be present on the seed-grain to cause considerable smut in the crop and yet to escape detection.

Experiments made in Italy have shown that a wheat seed which is severely infected with the spores of Bunt does not necessarily give rise to a plant which will be attacked by the disease. The factor which in this case determines the susceptibility to the parasite is the temperature at the time of sowing and during the days of the early phases of development. The more rapidly the wheat grows the more certainly it escapes from the attack of the parasite, and *vice versâ*. The same seed can produce 0 per cent. of infected ears in the first case, as against 80 per cent. in the second. These observations show that when it is wished to determine the efficacy of a fungicide—a special method for Bunt control—the condition of the soil and weather at the time of sowing and afterwards must be taken into consideration.

Effect of Formalin upon Germination of Wheat Grains.

Formalin is sometimes used as a pickle at the rate of 1 lb. to 40 or 45 gallons of water, but of late years experience has established in many quarters a decided objection to its use as a Bunt preventive, more particularly under our drier Australian conditions. Some experiments carried out by Dr. Darnell-Smith in conjunction with Mr. W. M. Carne* on the use of formalin as a fungicide demonstrated that the principal objection to the use of this fungicide lies in its inhibiting effect upon germination. When formalin-treated grain is sown damp just after treatment, the germination afterwards approaches closely to that of the untreated. If kept for a few days, however, before sowing, the germination is much slower and the total less. The formalin appears to have a hardening effect upon the pericarp, rendering it difficult for the embryonic roots to develop normally. Even when germinating, treated seed does not swell to the size of untreated seed. Furthermore, germination is considerably delayed, and when it does occur, in all cases the first root instead of rupturing the root-sheath, breaks it away as a cap, or else never emerges. The first root, instead of being the strongest, either does not develop or is much less developed than the lateral second or third roots. The sowing of formalin-treated grain in dry soil usually results in very poor germination.

The Treatment of Seed Wheat for Bunt.

Complaints are made from time to time of the efficacy of the bluestone treatment, but when these are investigated, it is generally found that either the bluestone was impure or the work had been carried out carelessly. To secure good results, good bluestone must be used and the directions carefully followed.

The bluestone treatment is favoured by the Department after many years of testing with all kinds of specifics, the solution recommended being $1\frac{1}{2}$ lb. bluestone to 10 gallons of water. The wheat is immersed for three minutes

* The Effect of Formalin on the Germination of Plants: G. P. Darnell-Smith and W. M. Carne. Third Report of the New South Wales Government Bureau of Microbiology, 1912.

and then removed and drained for ten minutes; then immersed for about three minutes in limewater made by stirring $\frac{1}{2}$ lb. freshly burnt lime in 10 gallons of water.

Method of Pickling.—Seed wheat can be economically pickled in butts of about 1 bushel when the wheat is free from bunt balls; but when these are present, some method must be adopted which will enable their removal to be effected. If they are not taken out the wheat will probably become re-infected before or during sowing; it is failure to remove bunt balls which frequently causes wheat that has been treated to produce a smutty crop. Pickling outfits which have a copper vessel for the treatment of the wheat are very handy, but if one is not available, the wheat can satisfactorily be freed from bunt balls (and incidentally other rubbish) with the aid of a piece of hessian. This is used as a sort of loose lining for the cask, with its edges overlapping the rim. The wheat is poured gently in, and bunt balls and other rubbish which is so troublesome when drilling will float on the surface and can be skimmed off.

After the seed has been dipped for the three minutes, it should be removed and drained for ten minutes. Planks, hollowed logs or a sheet of bark should be used for the draining platform; galvanised iron is very unsuitable. The solution can be allowed to run back into the cask, and immediately it ceases to trickle from the grain the butt should be hung up on poles or straddles for a day to dry before sowing.

The bluestone is best dissolved by tying it in a small hessian bag and suspending it in the water. In this way the bluestone will dissolve in a short time, whereas if thrown into the vessel containing the water it will take a considerable time to completely dissolve. Cold water serves the purpose well, and there is no need to use boiling water. On no account should the vessel holding the solution be of a metal other than copper; the most useful vessel is a wooden cask.

The process of pickling kills the tiny spores or seeds of the bunt which adhere to the outside of the grain; but bluestone also has the power to impair the vitality of the grain, and even to kill the germ. If the seed is to be sown in damp ground, no further treatment is required; but if it is probable that germination will not take place for some time, it is advisable to dip the seed in limewater. This is made by stirring* $\frac{1}{2}$ lb. of freshly burnt lime into 10 gallons of water. The mixture is allowed to settle; then the clear limewater is decanted, and into this the bluestone-treated seed is dipped for from two to three minutes. The lime neutralises the effects of the bluestone, and so preserves the full vitality of the wheat germ.

When using limewater, care should be taken to make a fresh mixture now and again, as the constant dipping of the bluestone-saturated butts of wheat will change the solution from an alkaline into an acid one, in which case it would be useless; and for that very reason bluestone and lime should never be mixed together in a solution used for pickling wheat.

* Should it be found impossible to obtain freshly burnt lime, it is recommended that $\frac{1}{2}$ lb. of slaked lime be mixed with 10 gallons of water, thus making milk of lime, into which the butts of the bluestoned wheat should be dipped for a period of from two to three minutes.

Milk of lime differs from lime water in so far that in the former the particles of lime are not dissolved but held in suspension, whereas in the case of clear lime water the particles are dissolved.

Lime can usually be obtained readily in most farming centres; but if this is not the case, it is advised that after draining off the bluestone solution, the wheat be dipped in water. This washes off the excess of bluestone, and while not so effective as limewater, it minimises the risk of the bluestone damaging the grain.

While the above solution of 1½ lb. of bluestone to 10 gallons of water is recommended as a general treatment, a 1 per cent. solution, *i.e.*, 1 lb. bluestone to 10 gallons of water, is strong enough when the seed is apparently clean. It does less damage to the grain, and on this account is preferable when limewater is not used. The stronger solution, followed by lime water, however, is the more effective, and the lesser strength should only be used when for any reason the limewater is not employed.

Dry Copper Carbonate.—Recent experiments have shown that the dusting of wheat prior to sowing with a powder—dry copper carbonate—gives an effective control of Bunt, and does not depress the power of germination in the grain.

This method is not yet in extensive use, but may be preferred to the bluestone and lime when a suitable machine for carrying out the dusting has been placed on the market.

Loose Smut of Wheat (*Ustilago tritici* (Pers.), Jens.).

Wheat affected with this smut usually has the stalks somewhat stunted. The smut is produced in the ovaries, and destroys the various parts of the flower (Fig. 6). The spores produced form a blackish powder, which is easily blown about, and infected wheat ears are sometimes spoken of as "smutty ears." The looseness of the spores serves at once to distinguish the disease from Bunt, in which case the spores remain compacted inside the wheat grains. Loose Smut has no objectionable odour. Infection takes place, not through the soil, but through the flower, and when the grain is formed the fungus threads lie within it and can give rise to the disease again the next year in a proportion of cases, provided the grain is not entirely destroyed. The treatment recommended for Bunt has, therefore, no appreciable effect.

As Loose Smut requires special treatment of the seed grain for its prevention the most practical way of getting rid of it after it has made its appearance on a farm is to use for seed only grain which, as the result of an examination of the growing crop at the proper time, is known to be entirely free from this disease. *To determine whether Loose Smut is present in a crop the examination should be made from flowering time onwards.*

Hot water treatment of the seed is recommended in America, but the treatment is tedious and is rarely employed by the farmer, and, of course, does not prevent infection of the flowers in the field by wind-borne spores. The Jensen (modified) hot water treatment requires pre-soaking of the seed for from five to seven hours at ordinary room temperature. The seed is then put into hot water. For wheat the time of immersion is ten minutes at 54 degrees Cent. (129 degrees Fah.) It is important to maintain the temperature carefully. If the temperature increases, the time of immersion must be shortened, while if the temperature decreases it must be lengthened. The successful margin of safety is very slight.



Fig. 6.—Loose Smut of Wheat, showing the various stages in the development of a smutted head. Heads emerging from boot (sheath), completely smutted mature heads, and bare stalk after spores blown off.

(U.S. Bureau Plant Industry. Bul. 152.)

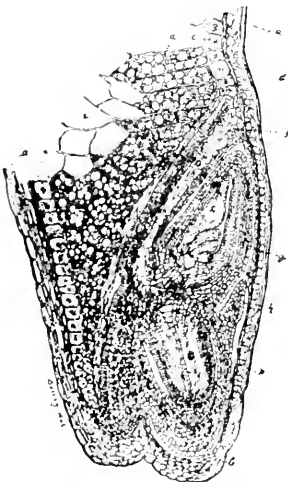


Fig. 7.—Longitudinal Section of a Fine Wheat Grain, through the embryo and deepest part of the groove.

The section shows the location of the embryo with reference to the bran layers. In an infected grain the mycelium of the Loose Smut fungus (*Ustilago tritici*) lives in the tissues of the embryo.

(a) Outer bran layer, (b) inner bran layer, G the first root of the embryo, L the first leaf (plumule), q sheath covering bud end of the embryo, O feeding organ (Scutellum).

(After Colley)

Flag Smut of Wheat (*Urocystis tritici* Koern.)

Flag Smut is a disease at times responsible for serious losses in our wheat crops. It may sometimes seriously affect the yield—reducing it from 10 to 15 per cent. Reduction of the yield by 50 per cent. and even more has been occasionally recorded.

It is a disease that is difficult to detect in the early stages, but as growth advances it is noticeable that affected plants in the crop have a leaden or sometimes faintly bluish colour in the leaves or flag, instead of the normal greenish colour. As the crop heads out it is observable that these plants fail



Fig. 8.—Wheat plant curled at the top by Flag Smut, thus preventing the formation of an ear.
(From McAlpine's "Smuts of Australia.")

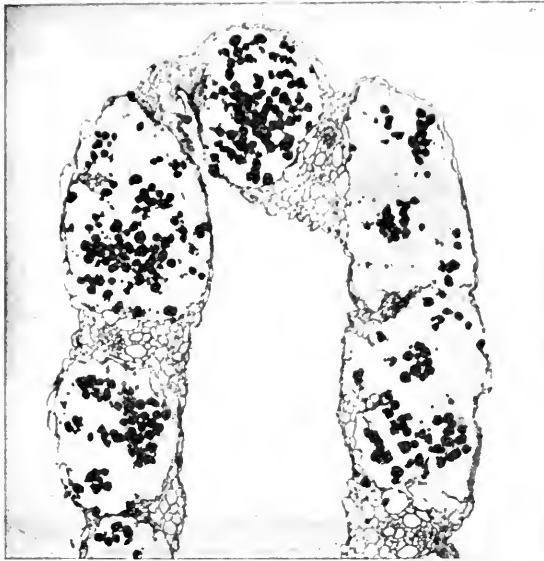


Fig. 9.—Cross Section of a small piece of Wheat Leaf.

Showing the masses of Flag Smut spores, which occupy large cavities extending longitudinally in the tissues. These cavities rupture and the spores escaping produce the long black streaks.

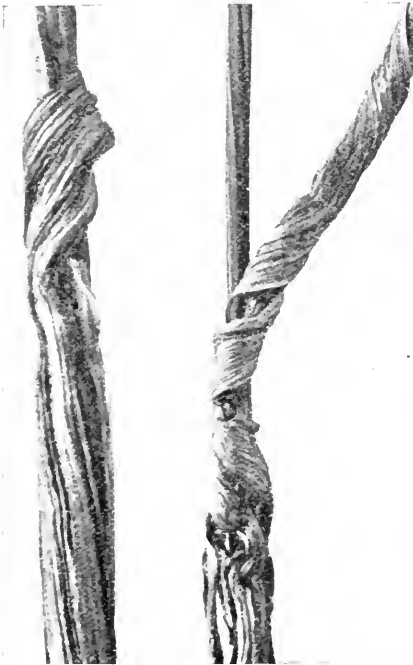


Fig. 10. Wheat plants malformed as a result of Flag Smut.

Slightly magnified to show smutted masses (spores of Flag Smut) within the tissues.

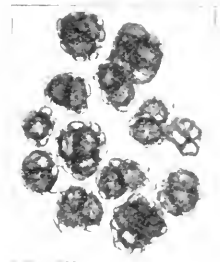


Fig. 10a.—Spores of Flag Smut.

Note the bladder-like cells surrounding the spores. These help the spores to withstand unfavourable conditions.

to mature heads, and on drying out, the flag, now curled and abnormally grey, gives rise when crushed to a fine, sooty, black dust. This dust consists of the spores of the Flag Smut fungus (*Urocystis tritici*.)

During the harvesting operations these diseased plants are knocked about, and the fine sooty dust is distributed through the soil, often, too, adhering to otherwise healthy grain. If the young wheat plant at the time of germination be in contact with spores of the Flag Smut which may be lying in the soil, it is liable to become diseased. If, as sometimes happens, the land is otherwise free from the disease and the spores happen to be adhering to the grain, infection is again probable.

The control of this disease on the farm is difficult. The greatest danger lies in allowing the soil to become thoroughly infested with the spores of the smut. Pickling will help to prevent the infection of new land.

Rotation of crops is very desirable, as this parasite is not known to attack other hosts. The introduction of an oat crop and of a bare fallow period into the farm rotation is possible, and also profitable in most of our wheat districts.

Early preparation of the seed-bed is recommended, because it assists in the conservation of moisture, and in the germination of Flag Smut spores prior to the sowing of the wheat. The opinion that Flag Smut is worse with a dry sowing is very generally held, and there is a good deal of experimental evidence to support this idea. It seems probable that under such conditions the spores of the fungus remain with the wheat ungerminated until rain provides the necessary moisture, and that the parasite and host then germinate together, and infection results.

If wheat must follow wheat, then the land should be ploughed as early as possible after the harvest, and thoroughly worked during the short fallow period with a view to providing a seed-bed with adequate moisture. Rapidity of germination gives the wheat a chance to escape its parasite.

Burning off of a crop which is badly affected is sound practice. An effort should be made to secure a very thorough burn of the diseased portions of the crop, so that isolated patches of the diseased straw do not escape the fire.

Seed harvested from an infected crop should not be sown without pickling.

Pickling the wheat in bluestone, as recommended for the prevention of Bunt or Stinking Smut, can also be recommended for this disease.

McAlpine has shown that the spores of this Smut can pass uninjured through animals, and so stock fed on diseased hay or straw can convey the infection to otherwise clean paddocks, or re-infect a renovated fallow.

Wheat Rusts (*Puccinia graminis* and *P. triticea*).

There are only two kinds of wheat rusts in Australia—the positively injurious *Puccinia graminis* and the comparatively harmless *Puccinia triticea*; this latter does not cause the grain to shrivel like the former. In the following notes when speaking of Rust, *Puccinia graminis* is referred to.

Warm weather, with frequent showers and heavy dews, favours the development of Rust. Wheat, the straw of which is badly rusted, fails to develop the grain properly. The presence of the Rust appears to prevent the food material elaborated by the plant being transferred to the grain, which, in consequence, remains small and pinched. Affected wheat does not appear to lose any of its nutritive qualities when chaffed, and when fed to horses and cattle is often greatly relished. Growing on wheat, Rust

produces little brown tufts on the stem and leaves (Fig. 11), which are found to consist mainly of spores upon short stalks; sometimes these spores are one-celled uredospores (summer spores)—sometimes they are two-celled teleutospores (Fig. 12).

The one-celled uredospores are produced throughout the season in immense numbers. They are very minute and light, and are easily distributed by the wind. They aid in carrying over the Rust from year to year by infecting self-sown wheat on headlands, and they are frequently to be found caught in the "brush" of wheat grains (see Fig. 3, Bunt spores).

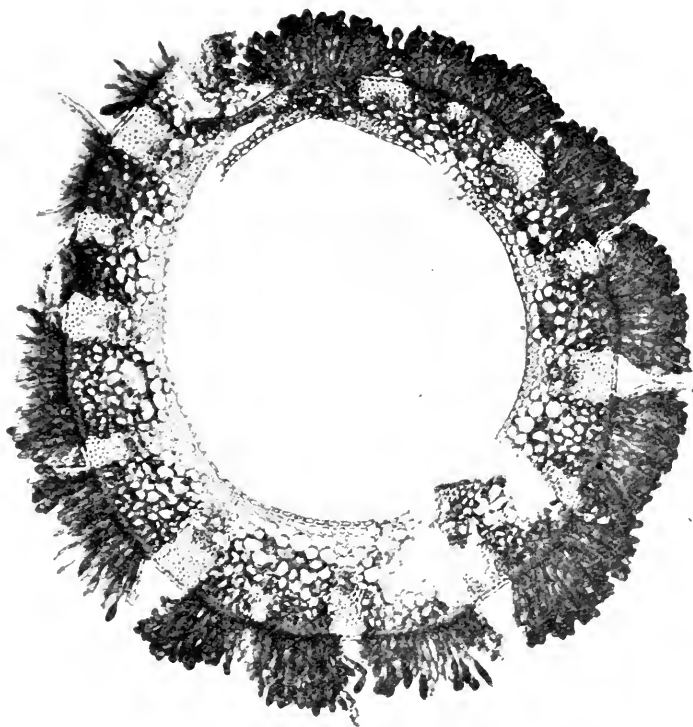


Fig. 11.—Rust. Cross section of a small piece of Wheat Stem.
Showing patches (sori) of the two-celled spores (teleutospores) of *Puccinia graminis*.

The two-celled teleutospores are produced towards the end of the season. They will not germinate immediately, but only after a period of rest. The teleutospores of the Wheat Rust of Europe are capable of infecting the small barberry shrub, and when they do so a third kind of spore is produced. In Australia barberry shrubs have only been introduced in a few places, and are not at all common. It has recently been shown by Mr. W. L. Waterhouse that the teleutospores of the Australian Rust, *Puccinia graminis*, can be used to artificially infect the barberry. It seems that this

stage serves no useful purpose in the life-history of the Rust in Australia, seeing that barberries are practically unknown here. It is simply a survival stage of the life-history now useless in the Rust's economy.

Various remedies have been suggested for Rust in wheat, but none have proved entirely efficacious. Wheat which has in any way been checked—as by a dry spell at the early growing period—is particularly liable to suffer. Often wheat grown upon land previously irrigated, or upon well fallowed land, is only slightly attacked—perhaps because of its increased vigour. Burning stubble, rotation of crops, manures, and pickling the seed have all been tried without any markedly good results. A light rainfall, absence

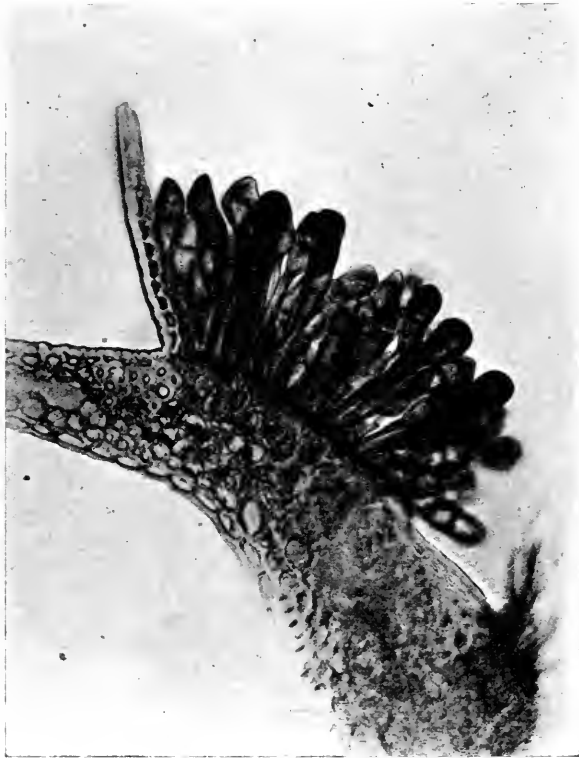


Fig. 12.—A single sorus of teleutospores of *Puccinia graminis*.

Note the two-celled spores, and on the left the epidermis which has been ruptured by the development of the spores.

of muggy weather, and a crop that ripens early, all tend to produce wheat free from Rust. Protracted moist weather and high humidity during the growing season generally result in a serious epidemic.

By judicious selection and cross-breeding, wheats have been produced that are more or less rust-resistant, and it is by progress in this direction that the greatest hope of freedom from the rust pest is to be entertained. Experiments in this direction have been and are being continually carried out by the Department, and a number of "Rust-escaping" wheats are to be obtained in Australia to-day, but it is to be noted that none of them are *absolutely* Rust-resistant.

It should be specially noted that wheats that are Rust-resistant or Rust-escaping under the conditions obtaining in Australia are not so when grown in Europe, and, conversely, varieties that are Rust-resistant in Europe are not Rust-resistant in Australia. We must concentrate all attention on breeding plants suitable for local conditions. We have the wheat, the Rust, and the environment maintaining, as it were, an equilibrium; alter the environment and the equilibrium of the other two is at once upset.

Susceptibility to Rust disease, together with resistance to the same, form perhaps one of the most important instances to which Mendelian method has yet been applied. Using a variety susceptible to the Rust (*Puccinia glumarum*) and another practically immune to its attacks, Professor Biffen, who worked in England, found that the first cross (F1 Generation) between the susceptible and the rust-resistant variety was not perceptibly less attacked than the rusty type. When, however, a further series of plants (the F2 Generation) was raised from the F1 Generation, ordinary segregation (that is, the sorting out of characters in the F2 Generation) was found

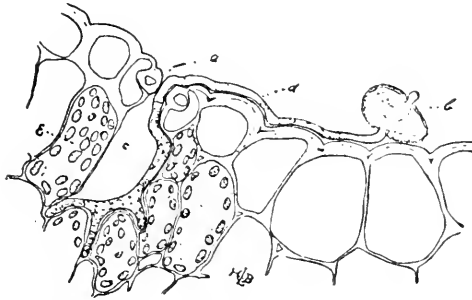


Fig. 13.—A small part of a section through a Wheat Leaf.

Showing a uredospore (*b*) of *Puccinia graminis* resting on the surface, germinating, and sending its branching filament (*d*) into the leaf through the breathing pore or stomata (*a*). (After Bolley and Prüchard.)

to take place, and the green resistant plants, standing among the yellow ones, formed a very striking spectacle. It has not yet been shown to what the resistance is due, but it has been suggested—and some experiments that have been made strengthen the hypothesis—that wheat plants containing a larger amount of acid in their sap are the more resistant.

While temperature and water content in many cases play an important part in the incidence of plant disease, the supply of food and other materials in the soil is often of the greatest importance. In experiments conducted at Rothamsted and at Woburn it has been shown that the susceptibility of wheat to yellow rust has been increased by growing the plants with large amounts of available nitrogen. Conversely, by starving highly susceptible varieties, plants practically immune can be grown; but the yield is not great enough to be profitable. From experiments carried out by Spinks we now have to recognise that merest traces of different salts in the soil may profoundly modify the plant's susceptibility to disease. The question has arisen as to whether immunity to disease and susceptibility to disease are characters inherited by plants. If so, it would seem possible by cross-breeding to associate the valuable feature of immunity with the other

characteristics that the cultivator requires. With the recognition of the work of Mendel, and the method of segregation pointed out by him, the old vague conception that crossing "broke the type" has given way to methods of greater range and precision in plant-breeding. Breeding for immunity from disease along Mendelian lines presents special difficulties, but among plants wheat presents one of the most favourable subjects, and some progress has been made as indicated above by Prof. Biffen. The problem presented by many plants attacked by fungi—and perhaps also even by wheat in regard to Rust—is that when the life-history of the fungus has been worked out it does not indicate the *primary* cause of disease, which, in the majority of cases, is a physiological one. Our knowledge of the physiology of plants, though extending, has given us so far no clue to the answer to this problem. There is no doubt that immune plants can be found in any given place if sufficient attention is given to the subject, but common experience has proved that such plants, when cultivated at a distance from their place of origin, lose their immune properties.

In the attempt to find and produce immune forms, the idea is sometimes held that a plant can be so modified that its fungus parasite is unable to attack it, but it must be remembered that a fungus is as capable of modifying its mode of attack as its host plant is of modifying its method of repelling it, and, in fact, in adaptability the fungi are usually superior to green plants.

The recent work of Stakman and others on the American Rusts has shown that the species *Puccinia graminis* is a complex one, and consists of a number of races or biologic forms, and that while some wheats are resistant to several forms they are not resistant to all. Quite recently Mr. W. L. Waterhouse has undertaken work on the biologic forms of the species existing in Australia, and there is thus being made available to the wheat-breeder a mass of information which may eventually lead to our coping with the Rust problem in our wheat varieties by a scientific breeding against clearly recognised races of the Rust in particular districts. While superficially many of these races appear quite identical, when analysed they show differences which are of the greatest importance in breeding for rust-resistance.

At present the farmer's greatest hope of combating Rust lies in growing the varieties which the Department of Agriculture recommends for growth in his district. Rust avoidance is considered as one of the vital factors in drawing up the variety lists for the different districts.

Wheat Mildew (*Erysiphe graminis*).

This fungus disease is prevalent in damp seasons. It is known in some localities as "flag fungus."

It grows for the most part on the surface of the first leaves produced in spring, forming white or pink patches, more or less extended and of varying thickness. Some of the fungus threads grow outwards, and become constricted into a number of small cells like a string of beads (Fig. 14A). The outermost of these cells or spores are being continually set free as a fine white powder; these spores germinate readily and diffuse the disease. The fungus is often reddish-grey in appearance, and is then sometimes mistaken for Rust.

If the weather be favourable the fungus changes as summer approaches into a greyish-white thick felt, embedded in which can be seen with the naked eye numerous minute black or brown spore cases (Fig. 14B). Soon

after these spore cases have begun to appear the leaves that were covered by the mildew felt die, and at length the felt drops off. Each spore case contains a number of small sacs, each of which holds eight spores (Fig. 14c). It is these spores inside the black spore cases that carry the infection forward from year to year.

The disease is usually most prevalent where the growth has been particularly vigorous, and feeding off in June and July will, therefore, be effective in reducing leaf growth, and admitting sun and wind, in the

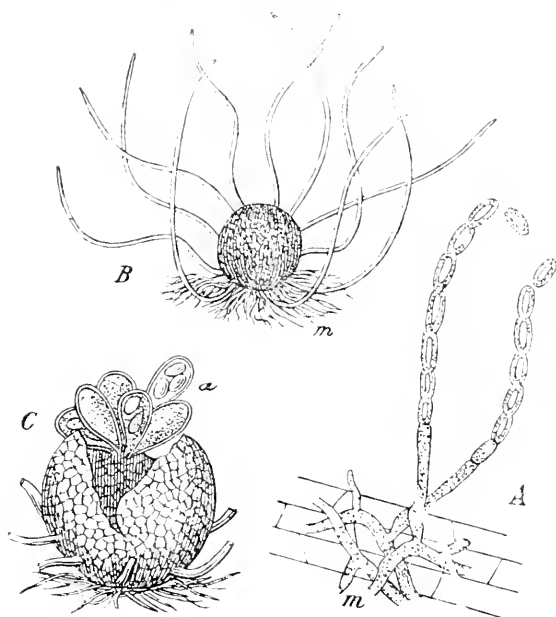


Fig. 14.—Wheat Mildew (*Erysiphe graminis*).

- A. Oidium stage, showing the production of conidia.
 B. Perithecium with appendages.
 C. Perithecium (more magnified) showing asci and ascospores. (After Frank.)

presence of which the fungus will die. Crops attacked by mildew usually recover on the advent of summer, but occasionally the disease has proved very malignant, and it distinctly reduces the yield in such cases. The burning of stubble is likely in large measure to prevent the continuance of the disease.

Take-all (*Ophiobolus graminis*).

This disease is to be distinguished from Foot Rot disease (*Helminthosporium*), an account of which appears on page 349.

Take-all is caused by a fungus which exists in the soil, and attacks the roots of the wheat plant. The disease makes its appearance in patches which are usually round, but which may be large or small, according to the severity of attack. Not infrequently the yield on large areas is seriously diminished—even by 50 per cent.

When the wheat is checked before it is out in ear, the disease is usually referred to by farmers as Take-all. Sometimes affected plants give rise to ears which are white and possess no grain; only in rare cases do the ears contain pinched grain. This condition is referred to as "whiteheads."

If the straws of such plants are examined at the base or butt they will be found to be discoloured and usually blackened from the ground level upwards, for as much as two inches in bad cases. The roots, especially in later stages of the disease, show an abnormal development of root hairs, giving them a "fuzzy" and woolly appearance. The roots become brittle and break off readily if the plants are pulled up. Sometimes an excessive development of secondary roots is noticed. The butts of the plants at the ground levels are, in late stages, usually rotted through, which gives rise to the signs of mal-nutrition in the ears referred to above. When examined microscopically, a felt-like



Fig. 15.—Take-all on wheat.

Bases of young wheat plants killed by Take-all fungus (*Ophiobolus graminis*). Note the characteristic blackened areas on the lower parts of the stems ("Black feet").

mycelium (fungus threads) or plate of a black to brown colour is noticed encrusting the stems and leaf sheaths of the plants at the base. These fungus threads are ramifying in the basal leaf sheaths and in the straw, and result in the early death of many of the cells. In very advanced stages there may be noticed on the blackened straw of the dead plants a development of the fungus spore cases. These shed their spores into the soil.

Infection takes place from the soil, the young and growing wheat plant being attacked by the fungus, whose threads fasten upon it near the ground level and in the root-system and grow on its tissues.

Various grasses are also affected with and can convey the disease, e.g., Brome grass (*Bromus sterilis*), barley grass (*Hordeum murinum*), and *Agropyrum* sp. The occurrence on oats is rare in Australia, though not entirely unknown. Barley is attacked.

Controls.—Stubble from a diseased crop should be burnt off. This is not a completely satisfactory method of control, as the spores in the soil and on the base of the plant are seldom destroyed. Starve out the fungus in the soil by rotation and bare fallow. Oats and bare fallow can be employed in the rotation system. Oats are very rarely affected, but barley should be avoided. Barley should not immediately follow wheat nor should wheat

follow barley, where the disease has been in evidence. Bare fallowing in which the fallows are kept clean of weeds like barley grass helps to keep down the fungus. Early fallow is regarded as particularly beneficial.

Rotations which have been suggested include :—

1. Wheat badly attacked by Take-all.
2. Early and well prepared fallow.
3. Oats.
4. Early fallow.
5. Wheat.

Or modified as follows :—

1. Wheat badly attacked by Take-all.
2. Early fallow.
3. Oats (grazed).
4. Oats (sown on stubble land for reaping).
5. Fallow.
6. Wheat.

Avoid ploughing through Take-all patches when the land is in a very dry and dusty state, as this apparently helps to disseminate the infection more widely. Some authorities consider that late fallowing is worse than not fallowing at all. The reason apparently is that late fallowing only serves to distribute the spores of the fungus which are present on the stubble and on the grasses of stubble land, and does not provide an adequate programme for starving the fungus out.

At all times keep land clear of the grasses on which the fungus can grow.

Foot Rot (*Helminthosporium sativum*, var.).

This disease is known to attack barley, rye, and a large number of grasses, e.g., barley grass (*Hordeum murinum*), Brome grass (*Bromus inermis*) and spear grass, as well as wheat.

The disease, which has been styled Foot Rot, and which is distinguishable from Take-all (*Ophobolus graminis*), is rarely noticed by the farmer in the early stages of his crop. Though a careful examination of the butts and the

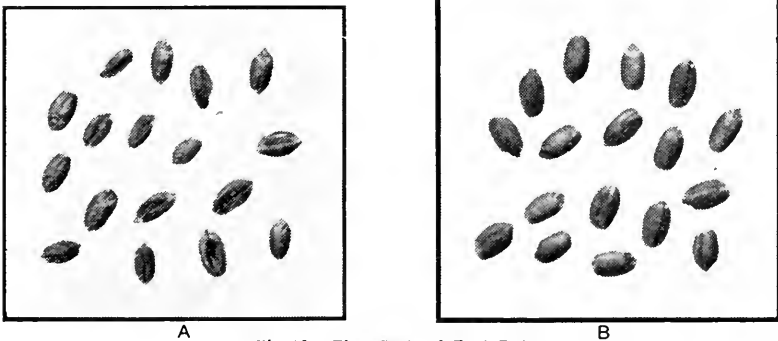


Fig 16.—The effects of Foot Rot.
A.—Pinched grain from diseased plants. B.—Plump grain for comparison.

affected plants would reveal its presence, nothing unusual is normally noted until about the "heading-out" stage, when it is observed that many plants, sometimes scattered through the crop, sometimes in patches, are stooling poorly and drying out earlier than the other healthy wheat plants, and that they yield only a small amount of pinched grain or none at all (Figs. 16 and 17).

Plants can be traced as having died from the disease at all stages (Fig. 18). Some are much reduced in growth with only a single head. In all cases stooling is very poor; sometimes only one straw develops to form a



Fig. 17.—Two Diseased and two Healthy Heads.

head, but more commonly two or three straws develop. Often it will be noticed that other straws have started but failed to develop (Fig. 19). Sometimes an extreme unevenness of relative development in the straw and heads of the individual plants is noticed (Figs. 20 and 21). If diseased plants are more carefully examined, the butts will be found to be "tobacco coloured" or "cresote coloured" near the ground level, and to have a very poorly developed root system. Microscopic examination shows that the



Fig. 18.—Plants that have died of Foot Rot in various stages of development.

stools, roots and basal parts of the straws are destroyed by the invasion of the parasitic fungus *Helminthosporium*. If the crop is examined in a late stage, the tobacco coloured part of the straw is seen to be rotted and to have turned to an ashen grey colour. When pulling the plants up the brittle roots break off near the butts. The leaves may show symptoms in a moist climate, spots of an elongate type, yellowish, and with black and brown centres being developed.



Fig. 19.—Hard Federation Wheat, affected by Foot Rot.

Note the poor stooling, the tendency to form secondary roots, and the diseased straws.

Distinction from Take-all.—The main naked-eye difference from Take-all disease due to *Ophiobolus graminis* are summarised:—

Take-all.

1. Base of stems blackened.
2. Occurs in patches.
3. Whiteheads rarely contain grain.
4. Ears bleached white.

Foot Rot.

1. Base of stems brown or tobacco coloured, and, on dying, ashen-grey.
2. Occurs in patches and scattered through a crop as well.
3. Some of the ears contain grain in a pinched condition.
4. Ears rarely bleached quite white, but have a faded dull appearance, and may be more or less flat-sided.

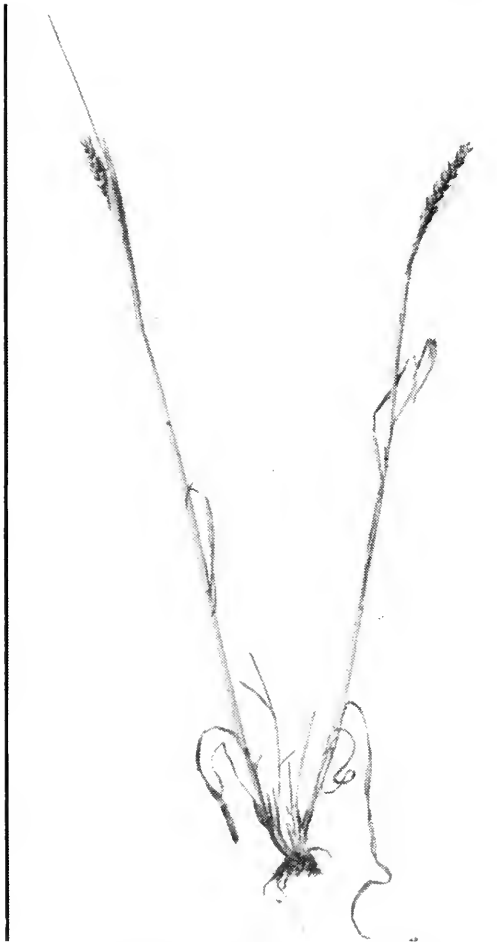


Fig. 20.—Another Plant affected by Foot Rot.

Note again the poor root system and scanty stooling. The straw is dark-brown at the ground level.

Plant attacked by Foot Rot always seem to be more susceptible to leaf affections than healthy plants growing alongside, such fungi as *Septoria*, *Erysiphe* (mildew), and the rusts (*Puccinia* spp.) being found on the flag and straw.



Fig. 21. Bearded Gluyas affected with Foot Rot and a Healthy Plant.

Infection takes place in the soil. Stubble and refuse from a diseased crop harbour the disease, and enable it to carry over in the soil from year to year.

Weather conditions will always be a great factor in determining the prevalence of the disease or otherwise. Our experience in 1920 indicates that in a good season following a long drought, wheat should be relatively free from Foot Rot disease, whereas seasons like 1921 (the second of two relatively wet years) will prove favourable for its development.

Control.—To avoid, as well as to control the disease in paddocks where it is already in evidence, the following suggestions are made:—

(1) Adoption of some form of rotation in place of the methods of continuous cropping with wheat, which are far too general in our farming districts. Investigation shows that the Foot Rot disease has been worst in paddocks which have been continuously cropped to wheat. While the fact that the fungus may possibly live on other cereals—oats and barley, and more particularly the latter—makes the planning of a suitable rotation difficult in most of our wheat districts, some immediate alteration in routine is necessary where this disease appears. Where, as in the north-west, it is possible to grow summer crops like maize, it is desirable to rotate them with wheat.

The clean cultivation given to the summer crop cleans the land of weeds and grasses on which the fungus can live.

(2) Use of *Bare fallow*.—Weeds like barley grass should be removed by cultivation. Feeding off with sheep, while it keeps down the growth, does not remove the butts of the grasses on which the fungus can live. Bare fallow should starve the fungus out.

(3) Early preparation of the seed-bed to allow a proper decay of old stubble, on which the fungus will live, and with the object of promoting germination and destruction of the spores before sowing.

(4) Obtain seed from good reliable sources. It should be plump and well filled. A sample with many pinched grains should be rejected. All seed should be graded, but it would be unwise to use plump seed graded out of a crop with much pinched grain.

(5) The use of superphosphate. At least 56 lb. to the acre should be used.

(6) Some success is hoped for by the selection and breeding of resistant varieties, but nothing has yet been done under Australian conditions.

Ergot (*Claviceps purpurea*).

Hard, dark violet excrescences, which usually fracture easily and are white inside, make their appearance from time to time upon the ears of cereal crops and grasses. These excrescences are known as Ergot, and as they occur most frequently upon rye, the Ergot of rye is by far the best known. Ergot, however, is found occasionally upon ears of wheat in the form of black or dark violet protuberances, sometimes as large as a maize grain (Fig. 22.) These replace the grain in the head and are thus a source of definite loss.

Ergots are really dense masses of fungus threads—or sclerotia—intended to carry on the fungus from year to year, and capable of lying dormant for a considerable period without germinating. They fall from the wheat ears to the ground, and there remain dormant for some time. When they do germinate they give rise to a number of fragile stems, each terminating in a globular head. In each globular head vast numbers of spores arise which are usually set free at the time when the cereal blooms. The spores are carried by the wind, and some of them, coming in contact with the open blooms, stick to their stigmas and again cause infection of the embryos. Ergots are very poisonous, and rye bread much infested has produced serious disease. Wheat affected with Ergot should on no account be given to poultry or cattle, unless it has been stored some time, when the poisonous qualities will have greatly diminished.



Fig. 22.—Ergot (*Claviceps purpurea*) on Wheat heads.

The ergots or sclerotia will not germinate if sufficiently covered with earth, hence the stubble of an infected crop should be deeply ploughed, so that the ergots lying upon the ground are buried. Ergots or portions thereof should be separated from harvested wheat grain by sifting.

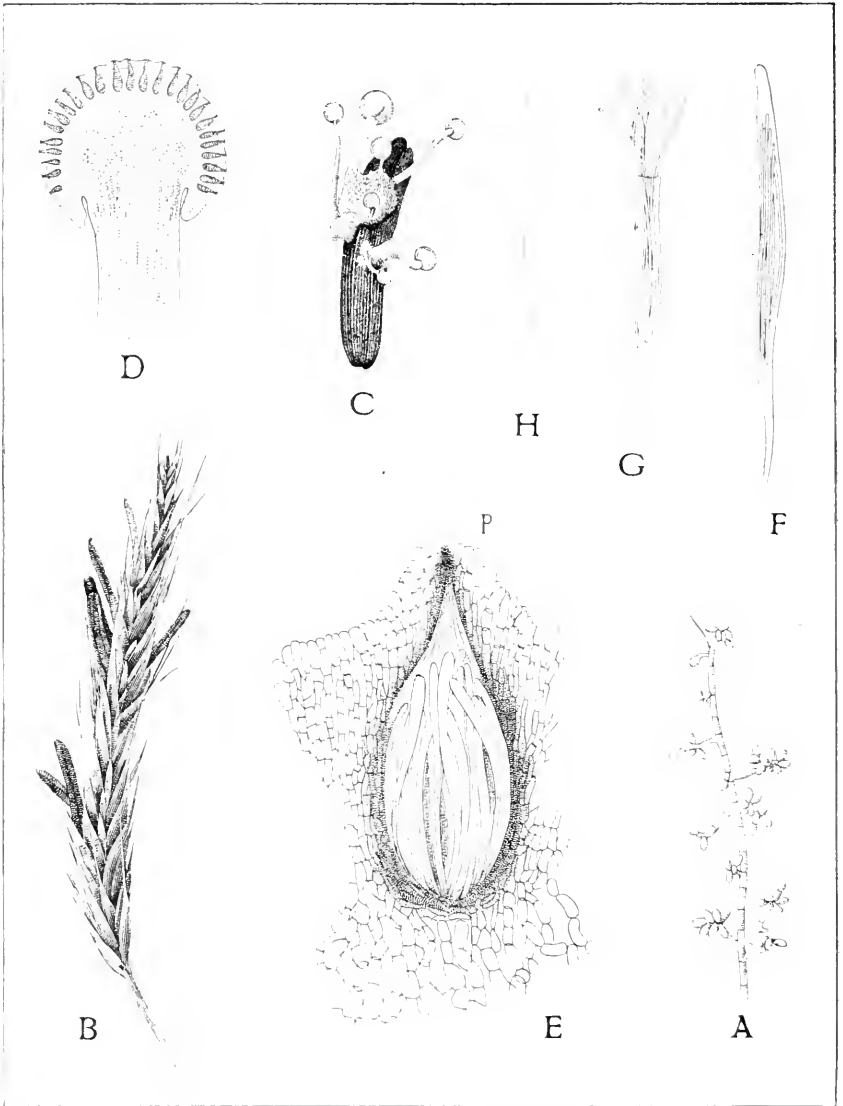


Fig. 23.—Life History of Ergot (*Claviceps purpurea*).

A.—Conidial or sphaecelial stage. B.—Ear of rye with several ripe sclerotia (ergots). C.—An ergot producing stalked bodies with swollen heads. D.—A longitudinal section through one of the heads, showing the cavities in which the spore-sacs are borne. E.—A single cavity showing the spore-sacs. F.—An ascus, or sac, showing eight thread-like spores. G.—A ruptured sac with escaping spores. H.—A single spore. (A, after Brefeld; B, after Strasburger; C-H, after Tulasne.)

Wheat Blight (*Septoria* sp.)

During a cold and backward season the young leaves of wheat often turn yellow and die prematurely. With this premature withering, fungi belonging to the genus *Septoria* are frequently associated. These fungi produce on the leaves very numerous minute brown or black specks scarcely visible to the naked eye. Each speck is a small flask-shaped depression in the leaf blade, containing innumerable fungus spores, the spores themselves are elongated, and are frequently provided with a row of drops or with cross walls.

Three fungi belonging to the genus *Septoria* have been recorded upon wheat in Australia. Occasionally the crop may be seriously checked by the presence of species of *Septoria*. It is not possible, however, to apply a remedy, but burning the stubble would destroy a large number of spores, and thus diminish the spread of the disease.

“Contortion.”

Several cases came under notice during the season 1913, in which wheat straw had buckled or twisted in its growth, as if constricted or hindered in its normal rate of extension. A kink in the straw resulted, and, as it ripened, the wind caused the affected straw to break at the weak point, the result being that the crop sometimes looked as if people had been trampling recklessly through it. The appearance of the affected straw is shown in the accompanying illustration (Fig. 24).

Mr. Pridham, Plant Breeder, reported the occurrence of wheat so affected at Nyngan where field plots of Steinwedel showed many of the straws broken down, at Wagga, where two selected bulk sowings, the one of Rymer, the other of Bobs, were affected, and at Cowra, in the case of two crossbred wheats which appeared to have strong straws. The particular character of the straw seemed to be of little importance, for the wheats at Nyngan and Cowra had strong straw, while those at Wagga were inclined to be weak.

Two explanations have been offered of the cause of this kinking of wheat straw, viz., that it is due to the attack of insects, and that it is due to disproportionate growth in one direction as contrasted with that in another.

Wheat affected similarly to that above described was reported from Carrathool and Deniliquin in 1900 (*Agricultural Gazette*, vol. xi, p. 1169).

Mr. Froggatt visited the former place, and found that instead of the Hessian fly (as had been suspected) the damage was caused by *Aphido*.

These insects attacked the wheat stalk when about 6 inches high, sheltered in the enveloping flag, sucked up the sap on one side, and caused the young wheat stem to bend over or to twist almost into a knot before shooting again.

The aphides were subsequently destroyed by parasites: the wheat then shot up, but when about 4½ feet high, and when the heads were filling, the weight caused many of the stalks that had been attacked by aphides to break off where the stems were twisted.

Specimens of straw affected in the season 1912-13 did not reveal the presence of any aphides or of any fungus disease when examined at the Biological Branch, neither were aphides observed attacking the wheat crops at Nyngau, Wagga, or Cowra during this year.



Fig. 24.—Portions of Wheat Straw, showing buckling near the lower nodes.



Fig. 25.—A Contorted Head of Wheat.

Mr Maiden, Government Botanist, who examined some of the affected stems, stated in his report, "It will be noticed that buckling takes place nearer the lower nodes, that is, in the region of the greatest restriction of growth. A phenomenon of this kind is called 'contortion' by Masters

(‘Vegetable Teratology,’ page 316), and is defined as follows:—‘An irregular twisting or bending of the stem or branches, the inducing causes being often some restriction to growth in certain directions, or the undue or disproportionate growth in one direction as contrasted with that in another.’”

Unfortunately the kinking of wheat straw, due to the attack of aphides, or due to an abnormal growth contingent on an irregular rainfall, does not admit of the application of remedial measures.

Mr. Pridham has called attention to another abnormal growth, seen in some seasons when late rains come, viz., the formation of additional spikelets in the ear, giving it a crowded appearance. Seeds planted from these ears do not again produce ears with additional spikelets unless identically similar weather conditions occur during growth.

A specimen showing a somewhat similar condition was met with during 1921, and is illustrated in Fig. 25, the difference being that the contortion was located at the base of the ear. Its occurrence was observed to be confined to wet spots. No causal organism was found associated with the condition.

INSECT PESTS OF WHEAT.

The more common insect pests of wheat are also pests of maize, and are dealt with under that crop (see page 429).

SECTION V.

Cereals other than Wheat.

OATS.

OATS are not cultivated to the same extent in New South Wales as they are in New Zealand and Tasmania, for the simple reason that the climatic conditions and rainfall of this State are much more adapted to the growing of wheat. The conditions that favour the successful cultivation of oats cannot be considered altogether satisfactory from a wheat-growing point of view. Speaking generally, our best oat-producing countries have a cold climate associated with a high average rainfall, whereas with wheat the best results are usually obtained in comparatively warm countries, with only a moderate or even a low average rainfall. United States of America is the greatest oat-producing country of the world, the proportion of oats to wheat grown being as three to four—in other words, 3 acres of oats are grown to every 4 acres of wheat.

Apart from the climatic conditions and rainfall required for the successful cultivation of this crop, the demand for the grain for making oaten meal is never very strong, as this commodity is only used to a limited extent, whereas from wheat the principal food of the human race is manufactured. Oats, therefore, are never likely to be grown on anything like so extensive a scale in this State as wheat.

The success attained by the Department in the raising of oats suitable for all the districts in which wheat is grown is of very great importance to farmers, providing, as it does, a change of crop, which is of considerable assistance in combating Take-all. The sowing of oats in rotation with wheat has been recognised as a means of overcoming this disease, and the new varieties under discussion promise to produce profitable yields under climatic conditions unfavourable to the older ones.

Some idea of the area devoted to oats each year may be gained from the following figures, taken from the Government Statistician's reports for the past four years:—

AREA under Oats in New South Wales.

Year.	Grain.		Hay.		Green Fodder.	Total Area.
	Area.	Production.	Area.	Production.		
	acres.	bushels.	acres.	tons.	acres.	acres.
1918	82,591	1,455,111	118,917	150,097	20,120	221,628
1919	85,474	1,273,752	152,842	145,638	29,719	269,035
1920	76,117	586,758	172,310	138,137	43,282	291,709
1921	77,709	1,642,700	259,991	399,415	27,027	364,727

A small quantity of the grain is purchased for the manufacture of oaten meal, but by far the most important use is as feed for all classes of stock.

Climate and Districts.

Oats may be grown with a fair amount of success under a diversity of climatic conditions, but they thrive best in a cold climate, associated with a good rainfall that is evenly distributed throughout the crop-growing season. As previously mentioned, the climate of this State, taken on the whole, is much more adapted to wheat-growing; but in some of the colder districts oats may be grown almost to perfection. In a general way, it can be said that a good potato district will, as a rule, prove suitable for growing oats, as these crops require similar conditions of climate. As an example of this, we may take portions of the Northern Tablelands of the State. Some of our very best potato districts are situated there, and at the same time some of our best oat districts. Glen Innes, in particular, is a district where the climatic conditions are favourable to the production of potatoes and oats of the highest quality; and there are other portions of the State that are similar in their suitability for the two crops.

On the Central Tablelands, from Blayney to Orange, is the pick of the oat country, although some exceptionally good returns have been obtained in the Bathurst district. On the Southern line, the best oat districts are situated in the vicinity of Goulburn, Taralga, and Crookwell; and some excellent crops have been grown in the country between Junee and Albury. The districts mentioned can be classed as about the best for oat-growing, but good crops can be grown in any wheat district by choosing varieties adapted to the local climatic conditions. So that to-day the position is far different from that of ten years ago, when Algerian was the only variety grown in the warmer districts.

In districts with a lower average rainfall than 25 inches the short, white oat favoured in Scotland and New Zealand for oatmeal cannot be grown to perfection, but in such districts oats may be largely grown if proper early maturing varieties are employed.

Soils.

Oats may be grown successfully on soils entirely unsuited to wheat, and also on low-lying situations where it would be extremely inadvisable to plant wheat. They may be sown on land that is too strong and rich for wheat, and also upon heavy, wet soils, that have a natural tendency to be cold and sour. The red basaltic soils met with in the best potato-growing districts produce excellent crops of oats; but the crop will do well on practically any soil, provided it is worked into good tilth previous to planting and the rainfall is not too low. Oats are often grown on new land which has not been sweetened after clearing of timber, and although yielding a better crop on undrained soil than wheat and barley, they respond well to drainage and good cultivation.

The Preparation of the Land.

Land intended for oats should be prepared in a similar manner to that intended for wheat, except that in the more favoured oat districts slightly deeper ploughing may prove advantageous. In the drier districts fallowing is essential to obtain the best results; and, in regard to the time the operation should be commenced, the same general remarks apply as to wheat,

and the implements to use for working the fallow are also the same. Clean cultivation paddocks are very necessary to the growing of prime oaten hay, as nothing detracts so much from its general appearance when placed on the market as the presence of weeds, thistles, burrs, &c. When oats are grown for green feed on the coast, the land should always be prepared early, say, about two months prior to sowing, provided, of course, the weather conditions will permit. It is wonderful how great is the effect on the resulting crop of a short fallow. A good, moist seed-bed, is absolutely essential for the reception of the seed, and every farmer who wishes to obtain the best results with this crop must do all in his power to bring this about by stringent methods of cultivation before planting.

In wheat districts where the rainfall is fairly good, the practice now being largely adopted by farmers is to sow portion of the wheat stubble land with oats for hay. This enables them to make more use of their land than would be the case if it were all fallowed.

When to Sow.

This will depend upon a number of factors, the chief being the object of the grower—whether for green feed, hay, or grain—the district, and the season of the variety it is intended to sow. If Algerian is sown on the coast for green fodder it should be put in in February, as it covers the ground, growing slowly for some time before it is fit for feeding off or cutting. Earlier varieties, however, can be sown with good results in March or April, and be ready for the cows in July and August. On the tablelands and in most of the large wheat districts oats are commonly sown after wheat seeding is finished. This is sound practice with an early maturing variety of oats, but if Algerian be employed the grower must delay his wheat sowing until the oat crop is planted, which is hardly advisable when wheat is the main consideration. Like wheat, the longer the growing season of the variety, the earlier should the seed be sown, and *vice versa*.

In the colder parts of the Northern Tablelands, particularly in Glen Innes and higher country, it has been found in recent years that, owing largely to the depredations of rabbits, it is advantageous to sow oats about August or early September. Sown then the crop comes along at a time when grass is becoming plentiful, and when it is not therefore so liable to the particular attentions of the rabbits. On account of being able to sow oats thus late, the farmer finds it a very suitable crop to follow maize, ample time being available to prepare the land after the maize is off. For such sowings the variety must be selected with care. The most suitable is White Tartarian. Algerian and similar sorts are liable to run to head too quickly.

In some districts the farmers sow any oats they intend growing as early as in the first and second week in March before the wheat planting commences. In individual localities the circumstances will be altered, but for the majority of districts in this State Algerian oats should be sown between the last week in March and the last week in April, for both hay and grain.

If sown before this, and the weather conditions are very favourable to growth, they may grow too rank, and are apt to lodge unless the growth is checked by feeding-off. Where sheep are of more importance to the grower than his grain crop, February sowing of Algerian oats for feeding off may be quite justified.

From a hay point of view, very early sowing has a tendency to induce a heavy growth of flag, which in wet seasons may turn brown and much detract from the quality of the resultant crop.

Selection of Seed.

Oats for seed should be obtained from a reliable source, and only sound, plump grain, preferably graded, should be sown. Cultivated oats are supposed by some to have originated from the wild oat (*Avena fatua*), and there are farmers who believe that they throw back to the original wild strain; this idea has arisen from the appearance of dark-coloured grains in a sample having a hairy end or point. These are retrogressive mutations which occur in cultivated oats, but are not derived from the wild oat, as breeding tests have proved. This fact, together with the extreme prevalence of the wild oat as a weed, has probably led to the notion. There are scores of instances where wheat paddocks are overrun with this pest, though oats



A Good Crop of Lachlan Oats, Cowra Experiment Farm.

have never at any time been sown in them. Farmers need have no fear that by growing oats in their wheat paddocks they are likely to introduce black oats on to their farms, unless, of course, the seed contains seed of that pest. As a matter of fact, the cultivated oat is botanically quite a different plant from the wild or black oat.

For hay purposes, seeds oats from a cooler district appear to give more vigorous growth than seed raised in a relatively warm climate. For grain production, however, seed oats grown in the district where they are intended to be sown is recommended. It has also been noticed that seed taken from a cool district to a hot one has a tendency to become paler in the colour of the husk; brown oats raised in New England have a darker tint than the same variety raised in the western or Riverina districts. The thickness of the husk varies too with the climate.

Treatment of the Seed for Smut.

If the crop is sown for green feed, pickling is unnecessary; but if it be intended for hay or grain, the seed should always be pickled, otherwise there is a great risk of Smut appearing in the crop. Some farmers will argue that a little Smut in the hay is of no consequence; but smutty heads always detract from the appearance, reduce the value from a feeding point of view, and if the infection is serious, lower the prices obtained on the market. Cases have been reported where stock have actually refused to eat hay that has been badly smutted.

The same remarks apply to the grain. Large quantities of oats are purchased to feed racehorses and animals doing fast work, and trainers and agents authorised to buy will not touch grain that contains Smut in any quantity. It will thus be seen that methods of prevention must be employed if a clean crop is to be harvested and top market prices obtained.

During the last few years the proportion of Smut in oats has largely increased. This is evidently due to lack of pickling of the seed.

Both formalin and bluestone have proved effective fungicides; but as the former requires much more careful handling, and is somewhat risky under certain conditions, farmers are advised to use bluestone and lime-water in the way recommended for pickling wheat. (See page 336 of this Handbook.) The same general method may be followed in every particular, except that it is advisable to allow oat seed to remain in the pickle a little longer than in the case of wheat. The reason for this is easily understood when it is pointed out that the spores of Loose Smut of oats (unlike Stinking Smut or Bunt of wheat) are blown about by the wind before all plants have formed their seed; the result is that some of these spores often find their way between the scales that ultimately clasp the seed firmly, and any fungicide that merely wets the outside of the grain may not reach the enclosed spores. Hence any treatment of the seed, to be effective, must be sufficiently prolonged to allow the solution to reach the spores which have been enclosed beneath the hull of the oat.

If the seed is treated in a chaff bag, constant agitation whilst in the bluestone is very necessary to ensure thorough wetting of all the grain. Owing to the different formation of the seed, oats take considerably longer to dry than wheat, more particularly if lime-water is used after the bluestone. The quickest method of drying is to spread the seed out on a piece of canvas or a tarpaulin, which is raised from the ground on a stand, so as to allow of a free current of air underneath the cloth. It will be found that the seed will dry much quicker in this way, and that there is much less risk of stones, sand, or grit of any description getting mixed with the seed.

Late maturing varieties are more subject to Smut than early ones.

Varieties.

Oats may be divided into two classes with reference to the appearance of the head—

- (1) Tree type or those having erect branching panicles, such as Algerian and Lachlan;
- (2) Side oats with contracted panicles, like White Tartarian.

Class (1) may be divided into several types—

- (a) Long brown oat, such as Algerian and Brown Calcutta;
- (b) Short brown oat, such as Lachlan and Guyra;
- (c) Long white or pale oat, as Sunrise and Mulga;
- (d) Short white oat, as Abundance and Giant.

Class (2) may be confined to White Tartarian, and Reid's New oat which is only now under trial.

This classification is not intended to be complete by any means, but it is sufficient for the needs of the State.

The following varieties are recommended by the Department for various portions of the State as shown:—

Coastal.—Algerian, Ruakura, Sunrise.

Central Tableland.—Algerian, Guyra, Abundance, Lachlan.

Northern Tableland.—Algerian, White Tartarian, Guyra, Sunrise, Lachlan.

South-western Slopes and Riverina.—Algerian, Sunrise.

Central-western Slopes.—Algerian, Sunrise, Lachlan.

North-western Slopes.—Algerian, Sunrise.

Under Irrigation.—Abundance, Algerian, Guyra, Sunrise.

New Varieties.—Mulga, Quandong, and Fulghum are proving themselves very suitable for late sowing, and may replace Sunrise in certain districts. Seed is available in limited quantities only.

Algerian.—This is more widely grown than any other variety, and is a most useful oat for green feed, hay, silage, and grain. It is rather drought-resistant. Although a profuse stooler, spreading over the ground for a considerable time after planting, it has fairly fine stems, purplish straw, and should be sown early to get the best results.

Guyra.—This variety matures in about the same time as Algerian, with straw about equal in height to that variety, but rather coarser, though not as coarse as the late ripening white oats. It may be called a moderate stooler, has a compact head, and dark-brown grain with a fairly strong awn, like its parent (White Ligowo). The grain is plump, and the husk fairly thin. Guyra will be found suitable to typical oat districts.

Lachlan.—This variety is the result of a cross between White Ligowo and Algerian. It combines the chief qualities desirable for our warmer districts which are found in the two parent varieties. Lachlan is a vigorous grower, maturing a plump sample of grain in almost any season. The straw is stronger than that of Algerian, so that it can be stripped without fear of lodging when ripe. At the same time, the stems are not too coarse for hay purposes. It resembles Algerian in the brown colour of the grain and purple tint of the straw, but the awn is much coarser. This is not a serious disadvantage, except for seed purposes; the grain needs to be thoroughly threshed to render it satisfactory for drilling. Lachlan ripens a little earlier than Algerian, but its young growth is erect and the leaves rather broad, while the foliage of Algerian is prostrate and narrow. Lachlan stands

feeding off well and is just as susceptible to rust as Algerian, but being a few days earlier sometimes counts in its favour in a rusty year. It always ripens a plumper sample than Algerian.

Ruakura.—This oat was imported from New Zealand, it having originated as a variation in a crop of Argentine oats at the Ruakura Experiment Farm, in the Dominion. It is more rust-resistant than Algerian and does well on the coast; the straw is too brittle as a rule for inland districts.

Sunrise.—A sport discovered in Algerian oats. It is very early, sparse stooling, with tall medium coarse straw, which shows only a trace of purple colour. The grain is greyish-white, of large size, has a thin husk, and is borne in a head resembling Algerian, but larger. The awn is rather stout, but comes off in threshing. Sunrise stands feeding-off well, and requires to be sown more thickly than Algerian, being a shy stooler.



Lachlar.



Ruakura.

Abundance.—This variety is considerably later in season than Algerian. It is medium coarse stemmed, and has white, fairly stout grain. It should be sown early and fairly thickly for hay, and is only suitable for cold districts.



Abundance.

White Tartarian.—This is the only one of the side-bearing varieties worthy of special mention. It has given excellent results on the Northern Tableland for both hay and grain. It is supposed to be very bitter, and not so palatable as other varieties, particularly if cut on the green side. It is late in maturing, has a good length of straw, and a long, thin, white grain. This variety is particularly suitable for late planting on the tablelands. Excellent crops of hay are obtained on the Northern Tablelands from sowings made as late as the end of August.

Mulga (recently Cowra No. 25) is a selection from Sunrise oats, made at Cowra in 1915. The young growth is erect and sparse, and the leaves of medium breadth, glaucous, and not dark green. It heads a few days before

Sunrise; the straw is tall, with a decided purple tint, and stands up slightly better than Sunrise. The grain is of good size, pale brown, with thin husk and somewhat stout awn.

Quandong (or Cowra No. 22) is a selection from Ruakura oats made at Cowra in 1914. The young growth is sparse and medium prostrate. It comes into ear earlier than Ruakura—about the same time as Sunrise. The straw is slender, tall, white and somewhat inclined to lodge, but stronger



Algerian.



White Tartarian.

than Ruakura at Cowra. The awn is not coarse and the grain is pale dun, plump, and of medium length. The kernel has a comparatively high feeding value and thin husk. Quandong should succeed in the drier inland districts.

Fulghum.—An American variety, rather like Algerian in its young growth, but the foliage is paler, with fewer stools. It ripens as early as Sunrise, and is a productive variety, with straw of medium height, the grain being brownish and rather short.

Quantity of Seed per Acre.

This depends upon a number of circumstances, the chief among which are: the method of sowing (whether broadcast or with the drill), the use to which the crop is to be put (whether for green feed, hay, or grain), the time of sowing, the district, and the habit of the variety (whether it is a scanty or profuse stooler).



Algerian Oats.

Manured with $1\frac{1}{2}$ cwt. superphosphate per acre.

Yield: 11 tons 4 cwt. 1 qr. 6 lb. per acre.

Algerian Oats

Unmanured.

Yield: 5 tons 10 cwt. 0 qr. 4 lb. per acre.

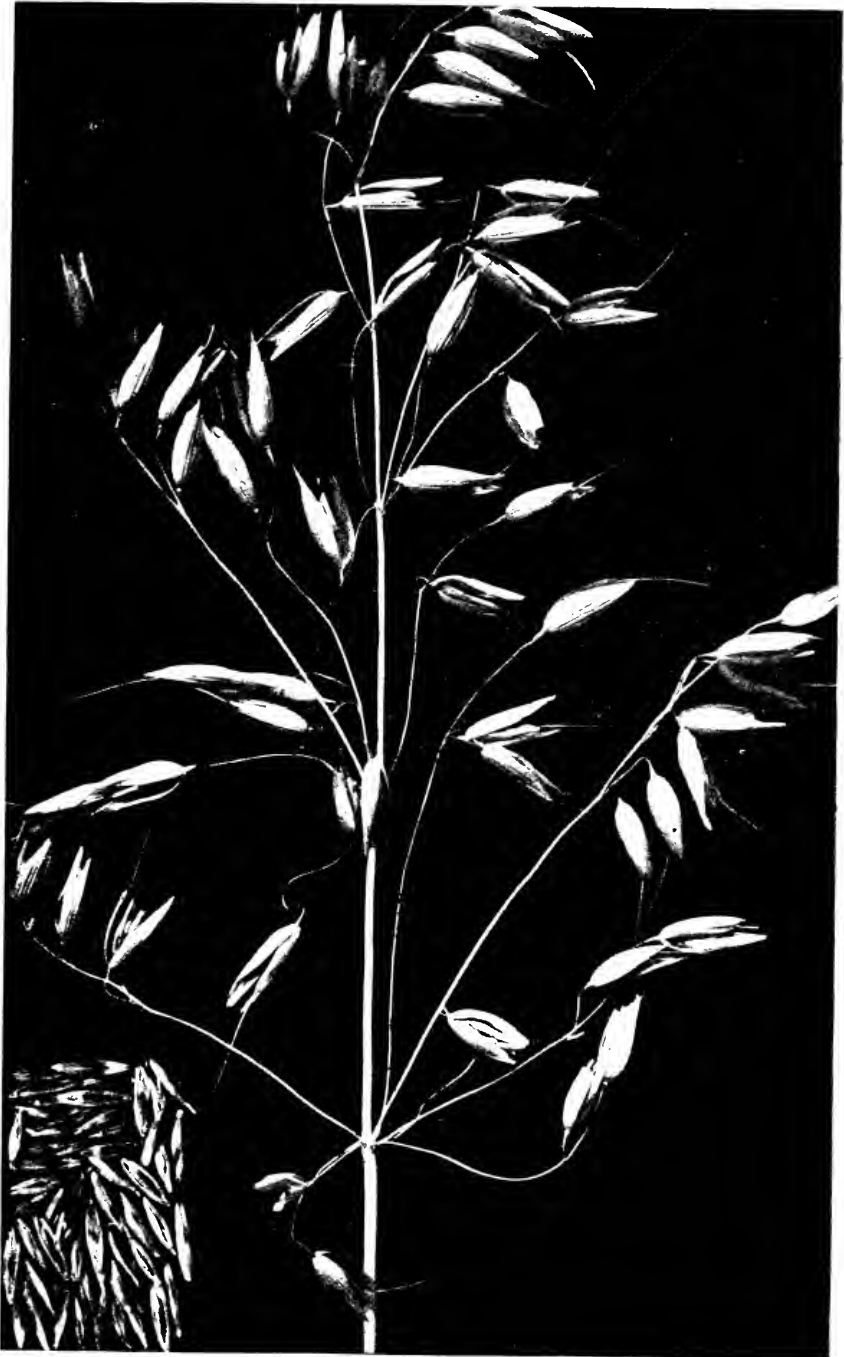
Oats on Farmers' Experiment Plots, Stewart's River.

On the coast, where oats are largely grown for green feed, and where the sowing is usually done broadcast, from 2 to $2\frac{1}{2}$ bushels per acre should be sown. If sown too thickly, and heavy rain or showery, windy weather is experienced, the crop is liable to lodge, and as a result it may be partially or totally spoilt before it can be cut. A few farmers on the South Coast have seed drills, and where this method of sowing is adopted the amount of seed can be reduced to half that recommended for broadcasting. No matter what the crop may be intended for, drilling will always give the best results.

For hay on the tablelands, $1\frac{1}{2}$ to 2 bushels per acre is ample when sowing is done with the drill. Like wheat, oats may be sown a little earlier for hay than for grain, but the season of the variety must not be overlooked. In the drier wheat districts, 1 to $1\frac{1}{4}$ bushels per acre is sufficient for a hay crop, provided the variety being sown is not too coarse in the stem. Very coarse-stemmed varieties should always be sown thicker than varieties with comparatively fine stems such as Algerian, as the thicker the sowing the finer the stems will invariably be in the resultant hay. Where the rainfall is sufficient, thick seeding is preferable, especially for hay, as the finer stems



Sunrise—a natural crossbred from Algerian.



Guyra.

make better quality hay and a better sample of chaff. This is a very important point, as there is always considerable waste in feeding hay with coarse stems or chaff that has been cut from coarse-stemmed varieties. Under certain climatic conditions, and with certain varieties, 3 bushels of seed per acre might not be an excessively heavy seeding for hay.

Oats for grain on the tablelands should be sown at the rate of 1 to 1½ bushels per acre, according to the time of sowing and the variety. In the drier districts, a bushel to the acre is ample for grain; but under moist conditions it may be advisable to sow as much as 2 bushels per acre, for a heavy seeding under such conditions generally induces a more even ripening.

Manuring.

Oats, like wheat, require manuring under most conditions, and respond bountifully to the application of superphosphate. On most soils, from 40 to 56 lb. per acre will be found sufficient; but on poorer lands the quantity can be increased up to ¾ cwt. with beneficial results. They appear to respond much more to heavy manuring than wheat. When sown early in the season, ½ cwt. of superphosphate is ample; but as the sowing season advances, the quantity can be slightly increased. In coastal districts, where there are practically no drills, and the manure (if used) has to be broadcasted, the quantity per acre should be increased to double that recommended for sowing with the drill. In some experiments conducted by the Department the addition of a little nitrogenous fertiliser in combination with superphosphate has resulted in slightly higher yields.

Treatment of the Growing Crop.

Oats do not root as deeply as wheat, and do not appear to be benefited to the same extent by frequent harrowing during the growing period, and they are also much more readily torn up by the spikes of the harrows. If the crop is sown very early, and has a tendency to grow too rank, it will be advisable to feed it off; but considerable judgment must be used in this matter, as it is very easy to do more harm than good. It is wise to avoid feeding off if possible, as in the majority of cases the effect is to reduce the yield. This has been very apparent from a hay point of view. However, if the crop has a tendency to grow too rank, and it is decided to feed off, the earlier in the season the sheep are turned in the better.

When to Cut for Hay.

Although it is recommended that wheat should be cut for hay at the flowering stage, to preserve the colour, &c. (one of the most important points for the Sydney market in prime wheaten chaff), such is not the case with oats. The best stage to cut oats for hay is when the upper tips of the heads turn white; at this stage the grain is fully formed, but only in the dough stage. The presence of grain in oaten chaff is absolutely essential for the Sydney market, and the chaff should be of a nice purplish-green colour. In selecting varieties for hay, those that ripen from the top should be selected.

Some varieties, if cut before the seed has reached the stage indicated, produce hay decidedly bitter in taste.

Harvesting for Grain.

In the cool, moist districts, where the binder is usually used for harvesting, the crop should be cut when the heads are well whitened, of a nice even colour, and the grain firm. It is very necessary to harvest before the chaff opens, as otherwise a considerable quantity will be lost through shedding. When the stripper or harvester is used, a considerable quantity of the grain has usually shelled before the crop is quite ready to strip, consequently the yield from a stripped crop is never as high as would have been the case had the reaper and binder been used.

Oaten Hay for Market.

There is always a good demand for oaten hay on the Sydney market, and if the sample is bright and clean, and has fine stems, not too long, and of a nice, purplish-green colour, good prices are assured. It should be pressed in bales about $1\frac{1}{2}$ cwt. in weight, but certainly not heavier than 2 cwt. The bulk of this commodity is utilised by horse-trainers for rack purposes, and from these men the best prices are obtained. They prefer hay that has been cut with the mower and cocked in the field, as it is usually more evenly made. Algerian is the variety in greatest favour. The hay, if cut with the binder, should have the bands taken off the sheaves, and should be shaken up before being put in the press. On no account should the hay be pressed with the butts showing all the one way at the ends of the bale. The bales should have three wire bands of No. 8 or No. 10 inch gauge. The hay should not be pressed with a derrick press, but with one of the "Clyde" or "Koertz" type.

Oaten Chaff.

There is always a strong demand for prime oaten chaff on the Sydney market. It should be about $\frac{3}{8}$ of an inch in length, clean cut, of pleasant odour, free from mustiness, and of a nice, purplish-green colour. Like oaten hay, the bulk is used by horse-trainers or for horses doing fast work. Unlike wheaten chaff, oaten chaff is preferred with a fair quantity of grain. It should be put up in new bags, weighing from 85 to 112 lb. Algerian is preferred to "white oaten" on account of its generally being sweeter.

Oats as a Check to Take-all and Flag Smut.

Throughout the wheat-belt of this State the wheat diseases, Take-all and Flag Smut, appear to be getting more prevalent from year to year, and unless methods of checking them are adopted they will be the means of seriously reducing the annual production of wheat in this State. Flag Smut has never been known to attack oats, and there is only one case on record in this State where Take-all has been found on this cereal. Each of the diseases is due to a fungus, and the growing of oats in paddocks where the previous wheat crops were badly affected with either disease materially assists in starving the fungus out.

Where Take-all or Smut are present to a very large extent the following rotation is recommended:—

- 1st year. Wheat crop affected with Take-all or Flag Smut
- 2nd year. Bare fallow, or fodder crop of oats.
- 3rd year. Crop of oats for hay or grain.
- 4th year. Bare fallow, or fodder crop of oats.
- 5th year. Wheat.

Where the attack is comparatively light it will only be necessary to grow a crop of oats occasionally in rotation with wheat.

In the above rotation, if it be decided to sow a fodder crop on the land instead of bare-fallowing, this crop would be sown in February, fed off with sheep throughout the winter months, and the land ploughed in spring and fallowed as a preparation for the main crop the following autumn. Such treatment to a paddock over a period of three years should help very materially in stamping these diseases out. Oats are a valuable crop to sow for sheep feed, but for this purpose the sowing should be done not later than February or early March.

Diseases and Pests of Oats.

LOOSE SMUT (*Ustilago Avenae* (PERS.) JENS).—This smut occurs on the flowers of the oat, and is readily recognised because affected spikelets present a black sooty appearance, without any skin or covering membrane to enclose the smut spores. It is related to Loose Smut of wheat, but has a somewhat different life history. The spores are known to be very long-lived and to persist in the soil for seven years. They germinate in the soil and infect the young growing seedling. The fungus grows with the plant to maturity and then, instead of grain, there is produced in the spikelets a mass of smut. The smut spores are blown from a diseased plant to healthy plants by the wind and may become entangled between the glumes and the seed. Seed so affected gives rise to a proportion of smutted plants on germinating the following season. A certain amount of infection may take place by adherence of the spore to the outside of the seed, and, probably, but very rarely, by infection from spores of the smut in the soil.

As the spores of the fungus are often entangled within the glumes, which adhere to the oat seed, the bluestone treatment used for Stinking Smut of wheat is only effective after prolonged action by the bluestone. This is liable to interfere with germination. The hot water treatment has been used successfully, but the satisfactory control of temperature is troublesome. Many investigators favour the use of one per cent. formalin sprayed over the seed, which is then covered with a bag and allowed to be exposed to the formalin vapour for about four hours. It should be sown shortly afterwards in a moist seed-bed. Seed should always be obtained from clean crops.

MILDEW (*Erysiphe graminis*).—A biologic form of this fungus sometimes attacks oats in moist seasons. See article under the heading of "Wheat Diseases" on page 346.

RUSTS (*Puccinia* spp.).—Rusts are exceedingly common in oats, but systematic cross-breeding and selection has resulted in the production of some varieties showing immunity. The best method of combating these diseases is to select varieties which are normally free from serious or epidemic attack when grown in that particular district.

TAKE-ALL (*Ophiobolus graminis*) is relatively rare in oats under New South Wales conditions.

FOOT-ROT (*Helminthosporium*).—A condition resembling the Foot-rot of wheat has been met with in oats in this State. The introduction of a clean fallow into the rotation is the best method of controlling the disease in both wheat and oats.

Insect Pests.

The insect pests of oats—wireworms, cutworms, grasshoppers, and grain weevils—are dealt with in the section on maize.



Loose Smut of Oat (*Ustilago avenae*). Natural size
From McAlpine's "The Smuts of Australia."

BARLEY.*

Barley is extensively grown in America for stock food as well as brewing, and until pig raising is a very big industry here there will not be great scope for barley growing. Although barley is the ideal ration for baconers, very satisfactory results are obtained with lucerne, topping up with wheat grain. In this country, wheat is universally grown and is likely to be the chief source of wealth (with wool) for some time to come. The screenings and by-products of wheat can most economically be fed to pigs, poultry, and dairy cattle, so that in most parts of the State there is not the same place for barley as a crop that we find obtaining in the closely-settled districts of older countries. As farming becomes more diversified, with increased population and smaller holdings, barley is likely to be more grown, as it is pre-eminently the crop for a relatively small mixed farm, responding well to intensive cultivation.

The total area sown to barley in New South Wales in the season 1921-1922 was 5,969 acres; the yield was 123,290 bushels, or an average of 18 bushels per acre.

Uses of Barley.

Although most of the grain produced is utilised for malting purposes, the object of these notes is mainly to draw attention to the feeding value of the crop. If a sample is not good enough for the brewery it may be used for feeding to stock. As a grain food barley is coming more into favour in Victoria, mainly in the western districts and in the north-east. Professor Henry, of America, says that "barley lies between oats and maize in protein and carbohydrates, and has less oil than either. On the Pacific Coast of the United States of America it is much used for horse feed, because maize and oats do not grow so well there. . . . If ground it forms a pasty mass in the mouth; it is better to crush the grain between iron rollers." At the Wagga Experiment Farm working horses have been fed either wheat or barley at the rate of 4 lb. per day with good results. The grain is scalded or boiled, and for horses not at work barley straw is preferred to wheaten. Professor Perkins, of South Australia, says that "taking yield into consideration, barley is one of the cheapest concentrated foodstuffs that we can grow, and if not satisfied with local prices it can always be converted into pork or mutton at a profit, or fed to horses instead of oats." In Asia, North Africa, and Southern Europe horses are fed on barley grain and straw; the climate is too warm for oats.

Barley is useful as green fodder, both on wheat and sheep farms, and also in the coastal districts for dairy stock. It is the earliest straw crop for green feed the farmer can grow, and a succession of feed can be maintained. Barley as human food is limited to a preparation known as pearl barley. As poultry food it is valuable, and all pig-raisers attest to its high qualities as a producer of pork and bacon of the best grade.

Classification.

The barleys in cultivation may be classified in the following way:—

Two-row barleys.	Six-row barleys.
Erect-eared as Standwell.	Drooping Ear or Chevalier as Kinver.
	Cape. Skinless or Naked.

* J. T. Pridham, Plant Breeder.

The two-rowed barleys are so called because they have a row of grains on either side of the mid-rib of the ear, while what we call the six-row type has six rows of grains to the ear. These rows are not all level to the eye if an ear is broken across (as in the true six-row type which is not commercially grown), but six-row barley is a convenient term for the group.

Skinless barley, though included, is a very distinct type: there are no beards to the ear, the grain is enveloped in thin chaff, and is easily threshed, the absence of husk giving it the appearance of wheat. In the bearded barleys the six-row type can be identified by the presence of two smaller twisted grains for each large straight one, while in the two-row type there are no twisted grains. The seed of the latter is usually fuller and more rounded with less husk than that of six-row barley.

Climate.

A district with a comparatively good rainfall and a cool climate is well adapted for two-row barley. The western and southern wheat districts produce good samples, as do also the northern districts, except where a good deal of summer rainfall is registered. In the warmer districts, where the grain ripens quickly, it is not possible to grow a good sample of this class of barley, and the six-row varieties will be found more profitable. Of course, the latter will not command quite such a high price as two-row barley, but the increased yield more than compensates for a lower price per bushel. Skinless barleys are drought-resistant and well adapted for grain production in dry districts, as well as for silage, the earliness of the crop enabling the grower to fill silos before haymaking begins. They are also much used for green fodder on the coast, where there is a good demand for the seed. In districts of good rainfall this barley grows weak straw that lodges badly if the crop is left to ripen grain.

Soil.

For barley the soil should be only moderately rich; the best grain is obtained after a crop of wheat or oats, given a sufficient period of fallow between. The most important consideration is the condition of the soil; although any wheat soil will grow good barley, it should be so worked that it is in a mellow and a friable condition when the crop is sown. The firm seed-bed required for wheat is not at all essential for barley. It is an early ripening cereal, and the root growth is shorter and less abundant than that of oats and wheat, so that it is necessary to sow it on land that is in a high state of cultivation. Too rich a soil will cause the crop to lodge; while low-lying undrained land is unsuitable, as barley cannot withstand a great amount of moisture in its young stages.

Rotation.

Barley should follow a straw crop, such as wheat or oats, though on light or poor land it would be better to come after rape or a good fallow. The plan followed by a farmer in the Wellington district, who has grown barley for many years, is to sow it after wheat which has been cut for hay. If the hay stubble is ploughed as soon as possible there is time for a few months fallow before sowing barley in May. Another most important consideration is that by this method there is no risk of self-sown wheat in the barley, and if a hay crop of wheat is again sown after barley, the farmer will be



Cape Barley.

able to keep his land free from self-sown barley. Sheep turned on to the stubble will usually pick up any fallen grain. Millers strongly object to barley mixed with wheat, and such a sample is useless for seed; there are graders on the market, however, which will remove barley from wheat.

In many districts where wheat-growing and sheep-raising are combined the rape crop is not a success, and barley under such circumstances will be found an excellent substitute either alone or sown in February or March, as a mixture or in alternate rows. Early and field peas are an excellent mixture, the peas germinating better than rape when early rains do not fall in January and February.

Varieties.

The varieties recommended by the Department are:—

Two-row type (commonly called "malting barleys").—Standwell and Pryor for districts similar to Bathurst, and Kinver, Golden Grain, Pryor, and Goldthorpe for climates similar to Wagga.

Six-row type (commonly called "feed barleys").—Skinless for green fodder for winter, and grain for stock in districts with mild winters. Malebo is also recommended for trial. Cape, Trabut, and Reka for green fodder, and grain for stock in the cooler districts.

The following are brief notes on these varieties:—

Kinver.—This variety has a long ear and ripens about midseason. It suits the cooler districts and is a typical malting barley.

Standwell.—Possessed of a broader ear than Kinver, and ripens a little earlier; the grain is similar to Kinver.

Golden Grain and *Goldthorpe* are barleys that have done well in the Riverina. They mature about the same time as Kinver.

Trabut.—A rather short, compact-eared barley of the Cape type, with attractive yellow grain. About the same season as Cape.

Cape.—A very largely grown six-row type variety, ripening early, and with long awns and grain of a bluish-green tint. Though usually regarded as a feed barley, bright samples are suitable for malting purposes.

Skinless.—Awnless, very early; grain very distinct in appearance, as the hull comes off in threshing.

Pryor.—This variety matures about the same time as Cape, and may be sown at the same time. It is a good variety for the wheat districts, as it may be harvested before wheat-stripping starts. It has a head like Kinver, but slightly shorter.

Malebo is a cross between Volga and Skinless, and is similar in appearance to the latter.

Reka.—A variety of the Cape type, but rather later maturing, and with less beard or awn to the ear.

Seed of these two last-named varieties is available in limited quantities only as yet.

Varieties not Recommended.—Farmers are advised to be cautious in the growing of introduced sorts until they have been tested under our conditions. As varieties of this kind are sometimes advertised, brief descriptions of a few may be useful.

- “O.A.C. 21” barley originated in Canada, where it is very successfully grown. It is very early, but stools sparsely, and has given very fair yields here for silage. It is not quite so good as Skinless, and for grain it is risky to grow, as the brittle neck causes a large percentage of ears to break off when ripe.
- “Black Hulls” or Purple Skinless is a variety resembling Skinless, but the grain is of a dark purple tint and the ear bearded. The beards, however, readily fall off, and the crop is easy to thresh. The yield is not quite equal to that of Skinless.
- “Chevalier” is a class or race of two-row malting barley represented by the variety Kinver. Some of the Chevalier strains ripen rather late for our conditions.
- “Mariout” is a variety much grown in California, closely resembling Cape.
- “Trebi,” “Californian,” and “Chilian” are variations of the Cape type.
- “Shorthed” and “Roseworthy Oregon” are Algerian six-row barleys selected and grown successfully at Roseworthy Agriculture College, South Australia. They are productive here, but apparently not superior, on the whole, to the well-known Cape variety.

Time and Rate of Sowing.

May is the best month to sow in the warmer districts for gram; April in the cooler parts of the State. The crop should ripen before the hot weather sets in, and if sown much earlier or later than the months indicated the grain is liable to be more or less shrivelled. Very early sowings induce heavy stooling, and the plants are unable to fill the unduly large number of heads. The quantity of seed usually drilled is about 50 lb. per acre, and 2 bushels if sown broadcast, as is general on the coast. If sown too thickly the crop is very apt to lodge, and as barley stools freely there is no advantage in heavy sowings.

Manuring.

The requirements of barley are much the same in this respect as those of wheat, a similar amount of superphosphate being used and, if necessary, a little potash fertiliser. Large applications of fertiliser are only necessary on very poor land, but it should be borne in mind that barley is a short-lived plant: its roots grow rapidly; they are ill-adapted to surmount obstacles such as are presented by a compact soil or to utilise fertilising matters which are not ready and waiting to be assimilated.

Harrowing and Feeding-off.

Harrowing is not often necessary, as it is with wheat, though circumstances may arise in which rolling followed by harrowing will be beneficial, or a stroke of the harrow alone.

Where the crop is grown for seed it is not advisable to feed-off unless the winter has been mild and the growth too rank; in such a case it should be thoroughly fed down with sheep. There is no crop that responds better after being fed-off with sheep than barley, provided the land is not tramped out of condition; but it is not wise to put stock on to the crop if cold, frosty weather has set in.



Skinless Barley.

Harvesting.

This should be done with reaper and binder, if possible, though with care a satisfactory sample can be made with the harvester. By the use of the binder the grain is mellowed and improved by lying in the stooks; and the risk of loss from winds by harvesting when the grain is dead ripe, as is necessary with the harvester, is avoided. The best time to cut is when the grain is in the dough stage.

Stooking and Stacking.

Barley should be stooked the same day as it is cut to prevent discoloration of the grain, and it must be dry before stacking. This is more important than in the case of oats and even wheat; if barley becomes heated in the stack the colour and vitality of the grain will be affected.

On account of the soft absorbent nature of its straw, a barley stack requires to be well protected.

Threshing.

When threshing barley the machine must be set so that the grain is not clipped and closely dressed—a little "tail" or beard left on the seed is not objected to. If the harvester is used the combs should be more open than is necessary with wheat, and it is an advantage to remove the concaves. All machinery agents will supply full information in regard to harvesting, as they recognise that their machines require a little adjustment before going from wheat into barley. A new threshing machine will break the grain more than one that has been in use for a while. On the other hand, if a machine is much worn the grain will be threshed more closely at the ends than at the centre of the drum, and new parts must be put in to even up the threshing. The sheaves must be fed very regularly and steadily, avoiding rushing the crop through. Proper care should be taken in adjusting the machine. Six-row barley will need different setting of the machine to two-row barley.

As a combined harvester is very often used instead of a thresher it may be said that the various machinery firms hold testimonials to the effect that their machines will satisfactorily deal with barley. Instructions for each make will vary slightly, but as a rule barley requires more sieve-room and a wider aperture in the comb than wheat. Barley-straw hangs together more than wheat-straw, and more cavings result from the threshing, but by watching the sample of grain as it comes through any necessary adjustments can be made. The less straw taken into the machine the lighter is the work for both machine and horses. For a brittle dry crop a little more space should be allowed under the beaters than when the crop is not quite so fully ripened. A reaper-thresher makes a rather better sample than a stripper as a rule, and there is no pulling up of the roots and waste of grain.

The main consideration in a sample for the brewer is that the grain should be evenly ripened, plump, bright in color, mealy rather than flinty when broken, and free from cracked and damaged kernels, which cause faulty germination and moulds in the process of malting.



Trabut Barley (Six-row Type).

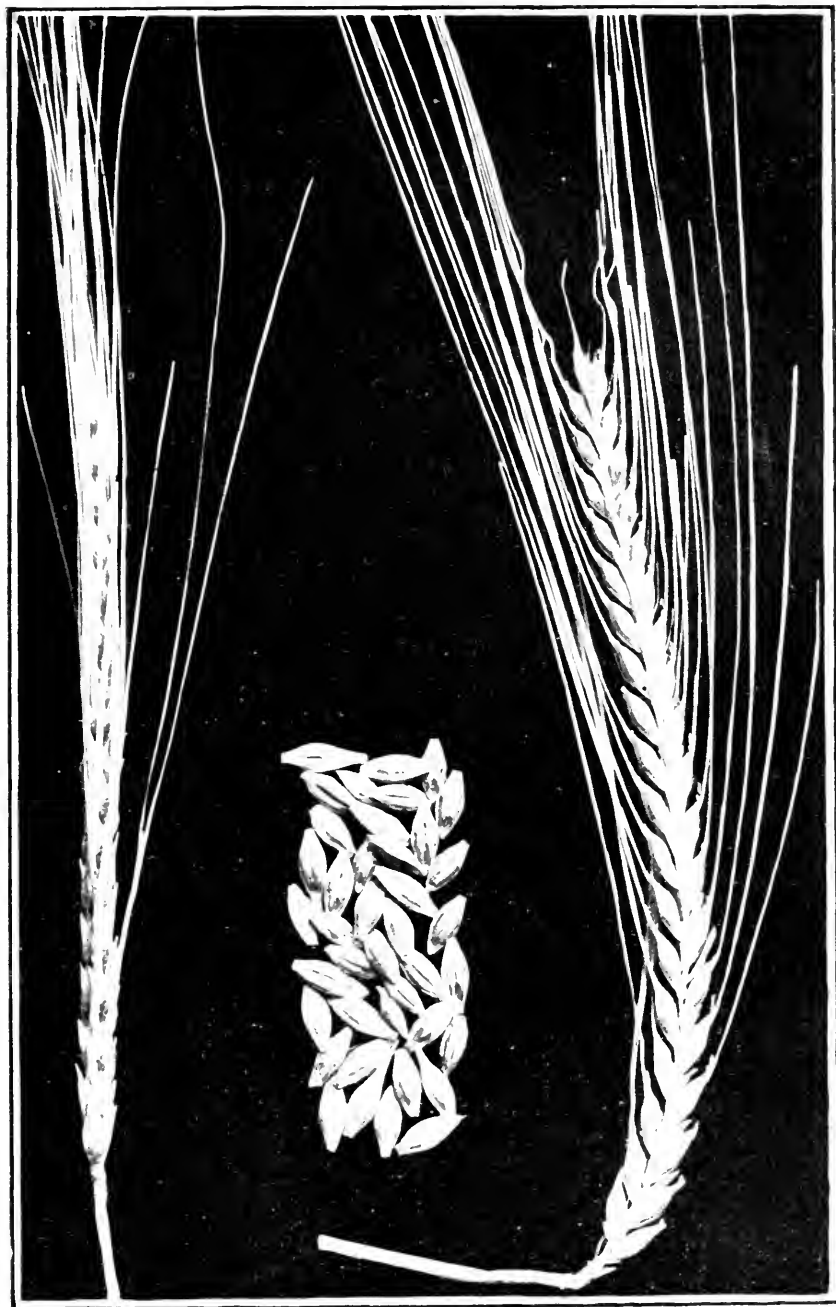
Improvement of the Crop.

A prime sample of barley is high in starch and low in nitrogen, so that it is not a difficult matter to increase the yield of this crop since proteids, which are expensive to produce, do not enter largely into its composition. A start should be made just before harvesting the crop in selecting a number of vigorous, healthy plants. The seed of these should be bagged, and sown again next season in a small plot, as described in methods of wheat improvement. This plan will result in increased yields, as well as smut-free crops; a stock of high-class seed can soon be raised in this way, and the grower will be well repaid for his trouble. In Wisconsin the average yield of pedigree barley for six years, as produced by the members of the Wisconsin Experiment Association, is given as 34 bushels per acre, as against 29.3 bushels with other varieties. Pedigree barley at the Experiment Station yielded an average of 44.8 bushels per acre over five years, while common barley grown by Wisconsin farmers averaged, for the same period, 27.7 bushels. Mr. Beaven, in his barley experiments at Warminster, England, when testing a variety of barley, grows it in alternate short rows with a standard sort, twelve seeds to each row, and the total number of rows would be about 100. Each pair of rows is considered as a separate experiment, so that the average of a large number of results is taken, affording a reliable conclusion as to the relative value of the two varieties. When harvesting, the eight central plants of each row are weighed.

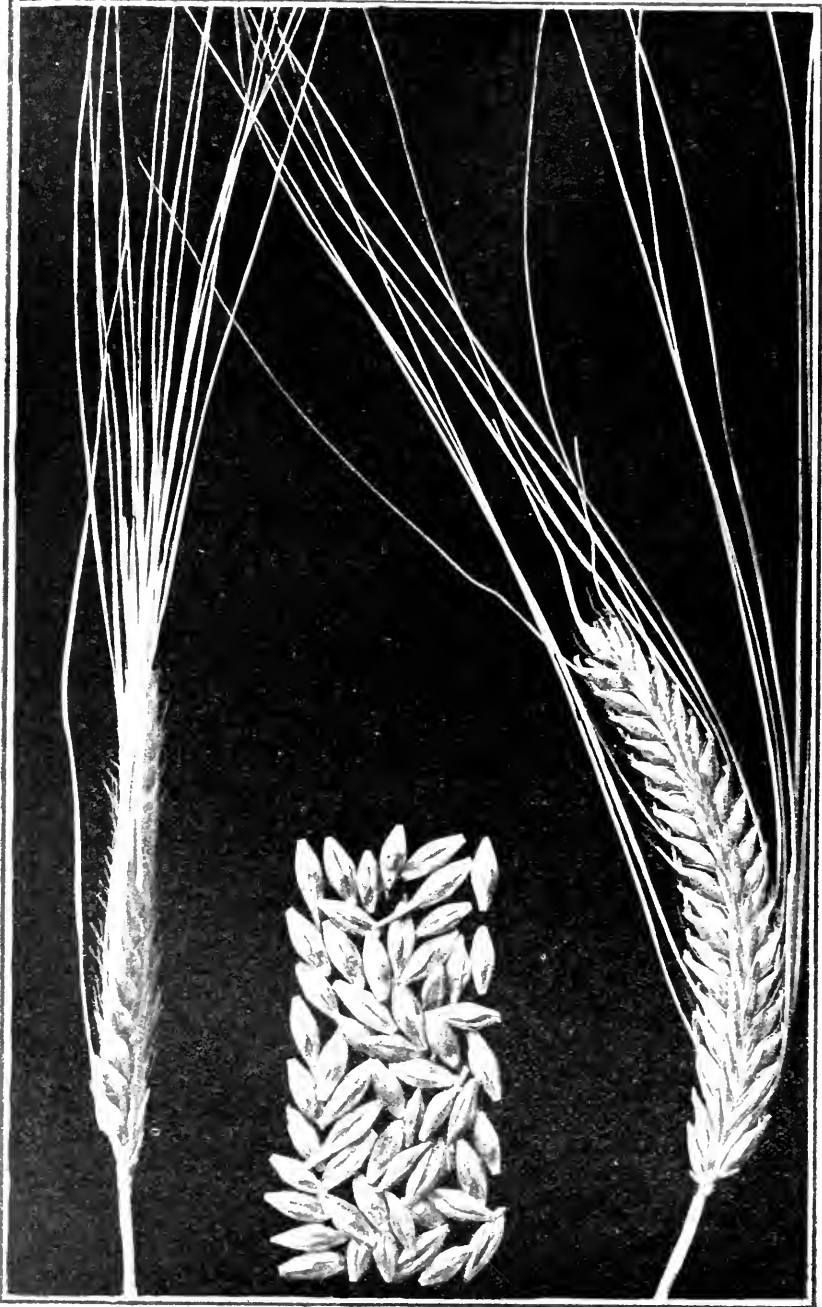
Some artificial crossing with barleys has been done by the Department, but with the exception of Malebo, above-mentioned, and Cowra 37—a cross between Kiurver and wild barley which is still being tested and appears promising—nothing of any particular value has been secured as yet. A beardless barley with fairly strong straw would be valuable for fodder.

Disadvantages.

There are certain drawbacks to barley-growing, the chief of which is the fluctuation in price. When there is a good season and a full supply the merchants cut down the price, which is not regulated as in the case of wheat by the world's market, but has a purely local value. An export trade would relieve such a state of affairs, also the more extended use of barley as a food for farm animals: it is becoming more popular in America for this purpose. Damage by unfavourable weather occurs in some seasons, causing a big drop in prices; rain at harvest time discolours the seed, and is more apt to cause lodging of the crop than in the case of wheat. The harvesting of barley demands more care and attention than need be given to wheat; cracked or chipped grains are very objectionable. Although, as Professor Perkins says, the farmer who grows barley is not compelled to advertise the fact in his wheat fields, the mixing of wheat with barley grain is found a source of trouble on some farms. This can be overcome by proper management, as stated under the heading "Rotation." The fact that barley is subject to "Foot-rot" disease is rather against its inclusion in a rotation with wheat. If field-peas or rape be grown, however, it could be profitably included though hardly with the same success as oats, which are comparatively resistant to this disease.



Kinver Barley.



Sandwell Barley.

Pests and Diseases of Barley.

The insect pests of barley are common to other cereals and are referred to in connection with maize. (See page 429.)

Covered Smut (*Ustilago Lordii* (Pers.) Kell and Sw.).

This smut is so called because the smut mass occurs in place of grain in the heads of barley, but remains covered by a membrane somewhat resembling that found in Bunt of wheat. The disease is spread by the breaking of the smut balls and the spread of the spores to healthy seeds. Smutted heads may be threshed with clean ones and in this way the clean seed becomes infected, the spores adhering to the outside of the seed and resulting in infection of the barley seedling. Soil infection may also occur.

The bluestone and lime treatment as described for wheat (page 336) will be effective for Skinless barleys.

Other barleys should be treated by thoroughly sprinkling a heap of the seed with a 1 per cent. formalin solution and covering the wet heap with a bag for four to six hours to allow the vapour of the formalin to penetrate the mass. Sowing should then be carried out soon after treatment in a moist, well-prepared seed bed. Where formalin is used seed should be obtained from clean crops where practicable, and sowing should not be made in land infected by the smut.

Barley should be grown in a rotation with other crops.

Loose or Flying Smut (*Ustilago uvula* (Pers.) Kell and Sw.).

This smut can be readily distinguished from the Covered Smut by the appearance of the heads. The smut heads are ruptured fairly early and the spores are blown by the wind on to the flowers of healthy plants. There they infect the seed and the embryo within it. Such seed when sown produces smutted plants.

Fungicide treatments of the seed are unsatisfactory. The most practicable method of avoiding the smut is to select seed from crops that are disease free. This can be most effectively accomplished by growing a seed plot for the production of smut-free seed for the main crop. If seed treatment is to be used the hot water treatment described under Loose Smut of Wheat (page 338) will be found effective. The temperature used should be 52 deg. Cent. (126.6 deg. Fah.) and the time of immersion fifteen minutes. It is to be noted that the temperature is slightly lower and the time of immersion longer than for wheat.

Foot-rot (*Helminthosporium*).

This disease is known to affect barley as well as wheat. The use of an absolutely clean fallow period is recommended. (See page 349.)

A species of *Helminthosporium* is also known which causes Barley Leaf Stripe. This disease is best dealt with by the use of a resistant variety and by clean fallowing. It is usually only serious in very wet seasons.

Other Diseases.

Take-all, Black Stem Rust, Ergot, and Mildew, which are discussed at length as diseases of wheat, are also diseases of barley.

RYE.*

Rye (*Secale cereale*) is grown to a very limited extent in Australia, and of the area under the crop, New South Wales generally contributes about one-third. The area devoted to rye is decreasing gradually each year, owing mainly to the fact that oats are being grown successfully for grain on land formerly considered only suitable for rye. Rye is grown for grain, hay, and green feed, but where wheat and oats grow well it is unwise and wasteful to grow rye.

The following table shows the acreage under rye and the yields obtained in New South Wales during the years 1917 to 1921:—

Year.	Grain.		Hay.		Green feed.	Total Area.
	Area.	Production.	Area.	Production.		
1917 ...	acres. 2,314	bus-hels. 30,860	acres. 754	tons. 759	acres. 917	acres. 4,012
1918 ...	1,677	19,296	995	1,146	997	3,669
1919 ...	1,425	16,387	997	1,161	1,014	3,436
1920 ...	1,207	11,493	1,015	856	1,059	3,281
1921 ...	1,733	31,500	843	1,180	1,166	3,742

The Uses of Rye.

Grain.—In other countries rye grain is principally used in the making of bread and alcoholic beverages. In Australia it is used to a limited extent for feeding live stock; it is usually ground and fed in combination with other grains to horses and pigs.

Green Manure and Forage.—Rye is chiefly valuable in New South Wales (a) for the production of early winter feed on very poor country, and (b) as a green manure crop on very poor soils, on account of its hardiness and ability to grow on those soils most in need of assistance. The adaptability of rye to poor sandy soils has been shown by its growth at Hawkesbury Agricultural College, where it has been cultivated as a green manure crop on the sandy parts of the orchard, and has given better results than any other crop. Rye used for pasture and silage is especially valuable for late winter and early spring feed. Owing to its hardiness it grows during the cold period of the year. Planted early, it may be pastured some time in early winter and again for a few weeks in spring. Its suitability for the production of green fodder has been tested on various farms and on a number of farmers' experiment plots on the coast. Though on average land wheat and oats have given better results, it has also been shown that there is an advantage to be gained by growing rye on the poor soils. While rye will yield the largest amount of green feed if cut when the ear is just peeping through the sheath, it yields a fair amount of palatable fodder if cut early,

*J. O. Henrick, B.A., B.Sc. (Agr.), Instructure in Agriculture, Hawkesbury Agricultural College.

and experience shows it is relished by stock when it is young. The value of rye as green feed is greatly enhanced if vetches or field peas are grown with it.

Hay.—Rye makes poor hay for feed purposes, as the straw is too hard and more or less solid. Rye hay is used for stuffing horse collars and for bedding.

Soil and Climate.

Rye is adapted to wide climatic ranges, and will do better at high altitudes and in exposed situations than any other cereal. On account of being a fairly deep rooter it is also drought resistant. It responds well to good soils, cultivation, and manuring, but is especially suited to light sandy loams.

It is sometimes called "the grain of poverty," because it can be grown on soils too poor, or where the climate is too severe, to grow the other cereal crops successfully. If the farmer has a very poor patch of pasture from which he desires to obtain an improved quality of feed, and if it is not considered suitable for oats or wheat, it is a good plan to plant it to rye. Good feed will be obtainable from this crop in the early stages of its growth.

Preparation of the Land, Sowing, &c.

The preparation of the land for rye should be as thorough as for other cereals for the best results, but even on badly or roughly prepared land good crops can be obtained. Rye should be sown in autumn, earlier or later according to when the feed is required: it is a quick grower, and matures early. One to two bushels of seed are required per acre. Where conditions are favourable and long coarse straw is desired, the smaller quantity is used, but under less favourable conditions and where the crop is intended for green feed or green manure the larger quantity is advisable. A good mixture for green feed is one composed of one bushel of rye and half a bushel of field peas per acre. Superphosphate may be drilled in with the seed at the rate of $\frac{1}{2}$ to 1 cwt. per acre.

Harvesting.

For grain the crop should be allowed to become quite ripe in the paddock before harvesting. For hay for the padding of horse collars, the crop is cut while still green, stoked, and when dry, stacked. This leaves the straw tough and with a good colour. There is a small local demand for rye straw for collar-making.

Varieties and Disease.

Varieties that can be recommended are:—Black Winter rye (for early winter feed and grain); Emerald (for late fodder); and White (for collar-making), though the area devoted to the last two in this State is very small. Slav is a new and rather promising variety, but so far the Department has no seed for distribution.

Rye is fairly free from diseases and insect pests. The most harmful fungus disease is Ergot (*Claviceps purpurea*). Plants attacked by this disease are affected while in bloom: the ergot increases in size, growing much longer than the grain, and appears as a black, hornlike growth in the ear. The decrease in yield of grain, however, is slight. Ergot, though used medicinally in small quantities, contains a principle that in larger quantities is poisonous to man and animals: it is said to cause abortion in stock. To protect rye from Ergot the best plan is to cut before the ears show up.

MAIZE.*

Maize is the crop next in importance to wheat in New South Wales, which of all the States of Australia has the greatest area of land suitable for its successful cultivation. The expansion of maize-growing is prevented at present, however, partly by the uncertainty as to the price obtainable—the market being essentially a local one—and partly by the greater certainty of regular returns to be made from dairying. Indeed, since the advent of paspalum on the North Coast, rapid progress has been made in the dairying industry to the detriment of maize production; but with the increasing number of bacon factories, the growing impoverishment of the paspalum pastures, and the establishment of industries for the conversion of maize into glucose, starch and alcohol, an increase in the demand for maize and a corresponding extension of the area under the crop is expected in the near future.

It is one of the easiest crops to grow on good land, as is evidenced by the yields still obtained by the crude method of hoeing-in on stumpy or rung alluvial land practised on some of our coastal rivers. Besides giving, on rich bottom lands, yields of over 100 bushels of grain per acre, maize is one of the most valuable crops for producing an abundance of green fodder (of which a yield of 45 tons per acre has been recorded in New South Wales) and extremely succulent silage, for which it is particularly suitable. In some districts also, the "stover" (*i.e.*, the stalks and leaves after removal of the ears) has some value for late autumn or winter feeding. The value of the grain for fattening stock has not yet been as fully realised in Australia as in the United States of America, where over 30 bushels per head of population are produced annually (less than 2 per cent. being exported), as compared with an Australian production of less than 2 bushels per head.

Seeing that over 90 per cent. of the maize of the Commonwealth is produced in New South Wales and Queensland, there is always an appreciable export from these States to the others; but even the requirements of these States we seem unable to supply, as in recent years the net imports into Australia have been over 1,000,000 bushels per annum.

TABLE showing Area under Maize, 1920-21.

District.	Grain.	Green Fodder
	acres.	acres.
North Coast	48,263	3,754
Hunter and Manning	3,496	2,334
Metropolitan—County Cumberland	3,138	792
South Coast	11,642	4,892
Northern Tableland	20,874	283
Central Tableland	7,648	246
Southern Tableland	514	251
North-western Slopes	9,540	89
Central-western Slopes	2,005	97
South-western Slopes	8,500	147
Central Plains and Riverina	571	183
Western Division	4	—
Total	144,105	13,068

* H. Weulolz, B. Sc. (Agr.), Inspector of Agriculture.

Two-thirds of the maize produced in New South Wales is grown on the coast, chiefly along the river flats, and two-fifths of the State total on the North Coast. Apart from the coast, the only districts devoted to maize to any extent are the Northern and Central Tablelands, and the North-western and South-western Slopes. Some is also grown on the Southern Tableland and the Central-western Slopes, but very little elsewhere. The Northern Tableland is a district that is rapidly increasing its area under maize; the results obtained there, though not large, are profitable and dependable. The area in the Inverell district has increased rapidly of late years due to generally better results being obtained with maize than are secured from wheat, particularly on the rich black soils. There is also room for further expansion in the districts of better rainfall, on the Central-western Slopes, and (with the introduction of very early varieties) on the Southern Tableland.

The best development and the highest yields of maize are obtained on the coast with warm, moist, long-growing seasons, and deep, rich soils such as obtain on the alluvial river flats. Frost will injure maize at almost any time in its growth, but more particularly during the flowering and cobbing stages. Young maize has often been observed to withstand frosts of several degrees—especially on the tablelands—apparently the result of acclimatisation.

A good summer rainfall is almost essential; indeed, many districts that have suitable soil are impossible for maize just on this account. A sufficient supply of moisture in the soil is urgently needed at the tasselling and cobbing stages, and if this cannot reasonably be expected, maize-growing is hazardous. Many soils can, however, be considerably improved in their water-holding capacity by the addition of large quantities of stable manure or green crop residues; and in districts of good winter rainfall, methods of cultivation can be adopted to conserve sufficient moisture to enable an early maturing variety sown in spring to produce its crop before the dry summer, with its attendant high rate of evaporation, can affect the result. This is often done on the western slopes. Another alternative is to plant in midsummer and depend on the monsoonal rains during the late summer and autumn. This practice is resorted to on the Murrumbidgee Irrigation Area, with the exception that irrigation takes the place of rainfall. It is found that pollination is not interfered with when tasselling takes place during February, whereas the hot scorching winds of midsummer "blast" the tassels and kill the pollen—preventing fertilisation and the formation of grain.

Excess of rainfall is injurious, especially on heavy or badly-drained soils, for maize will not stand "wet feet," especially also if the ground is cold.

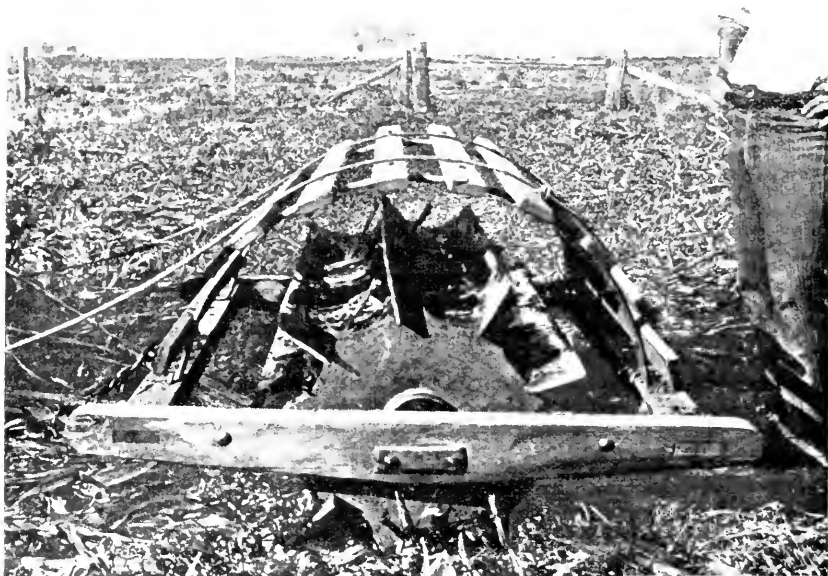
A free, deep, well-drained loam, well provided with organic matter, is the ideal soil for maize, and these conditions are best satisfied on the alluvial flats of the coastal and of some of our inland rivers and creeks. Deep volcanic soils of basaltic or basic character grow excellent crops, both on the coast and tablelands, and even the lighter granitic soils on the Northern Tablelands are extensively used for growing profitable, though not heavy crops.

Preparation of the Soil.

Maize, being comparatively shallow-rooted, especially in the later stages of its growth, requires a thorough and deep working of the soil, for it is mainly in this depth of worked soil that the roots are distributed and on which they depend almost wholly for the nourishment of the plant during later growth.

The ground should therefore be deeply ploughed—as deeply as possible (even up to 12 inches or more) without turning over an undue amount of subsoil. This ploughing should be given in the autumn or early winter, and the ground allowed to lie in the rough state and to mellow down under the action of frosts and winter rains.

In the moister districts on the coast, winter cover-crops, like wheat or oats and field peas or vetches, may be grown on part of the land for green feed or green manure as required. Shallow soils which have been ploughed for a number of years to the depth of the subsoil should not be suddenly deep-ploughed; it is better to deepen the ploughing by an inch or so every year, until a sufficient depth is attained, and then to come back for one year to the shallow ploughing. This method also prevents the formation of a hard or plough-pan in shallow soils with a heavy subsoil.



The Chopping Roller, used for cutting old Maize Stalks prior to ploughing.

On heavy soils which are inclined to run together after rain, the mould-board plough is the best to use, as it leaves the land rough and open for the reception of the winter rains. The disc plough pulverises the soil more, and a heavy soil runs together quickly after its use. The disc plough is therefore not the best for a first ploughing on heavy soil, especially where the winter rainfall is high. The disc plough is, however, a valuable implement for turning under old stalks, weeds, or other rubbish. Where the mould-board plough is used for this purpose, it should be preceded by a chopping roller or by a smooth roller and disc harrow.

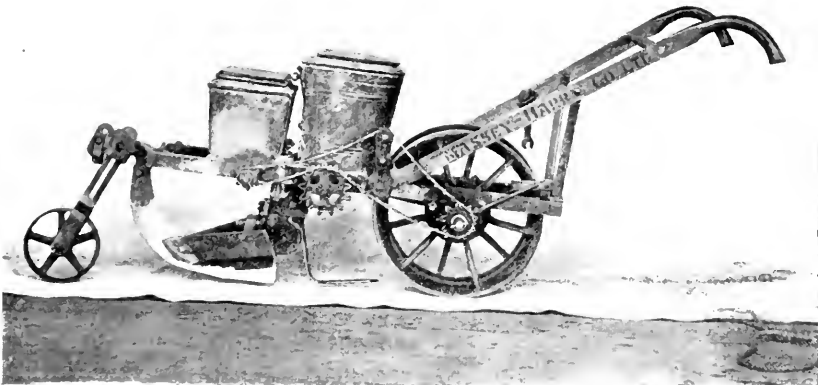
Too many of our maize-growers still allow their land to lie under the old stalks during the winter, and are content with a spring ploughing to prepare the land for the next crop. It is estimated that this practice is one of the biggest factors in lowering the acre yield all over the State.

In early spring the land should be given a second ploughing (preferably a cross ploughing), so as to destroy all weeds and make a good clean seed-bed. This second ploughing should not be deep if it immediately precedes planting, as the seed-bed requires a certain amount of firmness. The spring ploughing should be followed immediately by harrowing to conserve moisture, as evaporation is becoming more active at this time of the year. If a green crop or much weed growth is being turned under in the course of the spring ploughing, the furrow can be made a little deeper than would otherwise be advisable, and the work should be completed at least a month or six weeks before sowing. As soon as the top of the ground is sufficiently dry, the roller should be used to consolidate the soil, and ensure that the buried vegetable matter comes into firm contact with moist ground, thus facilitating its rapid decomposition. If this is not done, large air spaces will be formed, which are particularly injurious to the succeeding crop during a dry season. This rolling should, of course, always be followed by harrowing. Rolling is also sometimes found necessary to produce a proper seed-bed from cloddy land, but the judicious use of the harrow on such land at the right time after rain is better than the roller. The disc harrow is coming into great favour of late years on the coast for preparing a seed-bed for maize, and it has been found possible to dispense with a second ploughing in some instances by the use of this implement.

The importance of a thorough preparation of the soil for maize cannot be too strongly stressed, as it seems to be a prevailing idea with many that a well-prepared soil is not so necessary owing to the large size of the seed of maize. No greater mistake can be made, for no amount of after-cultivation can make up for insufficient preparation of the soil for this crop.

Time of Sowing.

On the far North Coast sowing may commence with early varieties towards the beginning of August, in order to catch the higher price which usually prevails in January and February. These crops are, however, often light (sometimes failures) owing to the dry springs usually experienced, and only small areas and light seedings are recommended.



Maize Drill, with Fertiliser Attachment.

On the Clarence and Richmond Rivers the main crops should be late varieties, sown in November and December. Such crops nearly always yield well owing to the monsoonal rains of February and March being fairly dependable. Further south, on the Macleay and Manning rivers, and along the lower North Coast, sowing usually commences at the beginning of September and continues till November. Later sowings than this usually take leaf blight badly.

On the South Coast October is the best month, and this month also sees the bulk of the sowing complete on the Northern Tableland, in the North-west (Inverell district), and the South-west (Tumut district). In the western district, the bulk of the maize should be sown either towards the end of September or in December, in order that tasselling or flowering shall not fall during the hottest part of the summer. On the Murrumbidgee Irrigation Area a December sowing stands the biggest chance of success.

For green fodder or silage, maize can usually be sown a month or six weeks later than the latest safe time for sowing grain.

Methods of Sowing.

1. *Ploughing-in.*—This is a method which is largely used in some districts, but which cannot be recommended except when the land has been well prepared, and is in good tilth and not weedy. There may be some justification also for using this method when the land is of a heavy nature, and has been beaten down by rain. Either single or multiple ploughs are used, the latter, of course, ploughing the whole ground, and the seed being dropped by hand behind the plough in every fourth or fifth furrow. If the ground is scarcely moist enough to germinate the grain, sowing should be followed by a rolling, and subsequently by a harrowing. The ploughing should only be shallow, especially on heavy ground, or during early spring, so as not to turn too much covering on the seed.

2. *The Maize Drill.*—The maize drill is easily the most satisfactory method of sowing. Single- or double-row drills may be used, and the depth of sowing regulated by raising or lowering the runner wheel. The rate of seeding can be accurately regulated by the use of plates, with various sizes and numbers of holes, and a heavy press-wheel behind the planter box presses the soil round the seed, and ensures immediate germination if the soil is moist. Drills can be had with fertiliser attachment, and a scribe or marker for marking the position of the next row. Some double-row drills are also fitted with check wire for sowing in "squares" or "checks," dropping from two to four grains per hill. This method can only be used in rectangular paddocks, and where the ground does not slope badly. It is, perhaps, an advantage in weedy ground, in that cultivation may be given in two directions. A disadvantage of most double-row drills is that the distance between the drills is fixed, and they cannot be used where a greater width is required.

Sometimes a home-made marker is used for marking the rows, five or six rows being marked at a time. Using marked sticks of equal length at the ends of the field is also a handy way of getting straight rows of any desired width with the single-row drill. A small lister furrow-opener on the front of the drill is very useful on trashy ground. Deeper listing may be obtained by ploughing furrows, and then planting in these furrows with the drill.

This is an invaluable method in dry districts or hot climates, where the top soil dries up quickly. It is especially recommended for late spring and early summer plantings on the North Coast, as the young weeds which come up in the furrows with the maize can be easily smothered as the furrows are filled in by cultivation.

3. *The Wheat Drill.*—This implement may be used in sowing maize for fodder. There is some difficulty in getting it to sow a crop thinly enough for grain. With a 13-tube drill every tube but two should be plugged. This will give rows about $3\frac{1}{2}$ feet apart.

4. *Broadcasting followed by Harrowing.*—This method is only permissible when maize is being grown for green feed or ensilage in good districts, and then is only to be recommended where the ground is unevenly shaped, as on the edge of a creek or river bank. Under most circumstances better results will be obtained by sowing in drills, although there may be some justification for broadcasting on newly broken paspalum sod, where cultivation is difficult.

Width between Drills and Distance between Plants.

Sunlight is essential for the proper fertilisation and development of the ears, and if the rows are planted too closely, especially in a cool, cloudy season, the crop does not "cob" properly. Dry spells also seriously interfere with proper "cobbing" if the rows are too close, owing to moisture limitations or lack of available plant-food material. With late tall-growing varieties on the North Coast, the rows should not be planted closer than $4\frac{1}{2}$ feet apart. In the North-west, Central Tableland, and Central-western Slopes, the same distance, or even 5 feet, should be observed, not on account of the tall growth, but because of the limitation of moisture.

The plants can average from 10 to 18 inches apart in the rows, according to the fertility of the soil, the closer planting being adopted on richer soil. In cooler districts, and where moisture is not so likely to be a limiting factor, e.g., the South Coast, Northern Tablelands, South-western Slopes, or under irrigation in the west, the rows may be $3\frac{1}{2}$ to 4 feet apart, and the plants from 12 to 15 inches apart in the rows. These distances might also apply to the earlier varieties on the North Coast. On rich soils, or under conditions in which varieties of maize sucker freely, it is better to sow three grains every $2\frac{1}{2}$ to $3\frac{1}{2}$ feet apart in the rows, as this "hill" sowing inhibits the formation of suckers to some extent.

For green feed or ensilage the rows may be $2\frac{1}{2}$ to 3 feet apart, and the plants average from 6 to 9 inches apart in the rows.

Quantity of Seed per acre.

The foregoing recommendations cannot be exactly translated into a given quantity of seed per acre, as this depends largely on the variety of maize, and the number of grains required to weigh a pound. The following figures can therefore only be regarded as approximations. For late varieties on the coast, from 8 to 10 lb. will be required; for earlier varieties, 10 to 12 lb. In the drier districts in the west, from 4 to 6 lb. is sufficient.

For green feed and ensilage from 2 to $2\frac{1}{2}$ times as much seed as is used for a grain crop has given the best yields.

For broadcasting, from $\frac{3}{4}$ to $1\frac{1}{2}$ bushels per acre are required.

Varieties Recommended.

Varieties of maize differ chiefly in maturity and growth, average size of ear, size of grain (particularly breadth and length), colour of grain, and general character of dent. Some latitude must be allowed in the description of a variety, because of the many different types of which a variety is composed. The recognition of varieties is a matter of some importance to farmers, on account of the recommendations which have been made by the Department as to the most suitable varieties for particular districts as the result of several years' experiments.

Classification of Maize Districts.

The maize districts of the State are classified as follows for the purpose of these recommendations :—

1. Upper North Coast, comprising the Tweed, Richmond, Clarence, Bellinger, and Nambucca Rivers.
2. Middle North Coast, comprising,—(a) Macleay and Hastings Rivers, and (b) Manning River.
3. North Coast Tablelands, comprising Dorrigo and Comboyne districts.
4. Central Coast, comprising county of Cumberland, and Hunter and Hawkesbury River districts.
5. South Coast comprising—(a) Illawarra, Shoalhaven, and Milton districts, (b) Moruya and Tilba districts, (c) Bega district.
6. Northern Tableland, comprising Tenterfield, Glen Innes, and Armidale districts.
7. Central Tableland, comprising Bathurst district.
8. Southern Tableland, comprising Moss Vale district.
9. North-western Slopes, comprising—(a) Inverell district. (b) Tamworth and Upper Hunter districts.
10. Central-western Slopes, comprising Molong, Murrumbidgee, Mudgee, Canowindra, and Coonabarabran districts.
11. South-western Slopes, comprising Tumut district.
12. Murrumbidgee Irrigation Areas.

Approximate Order of Maturity of Varieties Recommended.

Very Early.—Sundown (formerly North-western Dent), Early Morn (formerly U.S. 133), Golden Glow.

Early.—Wellingrove (formerly Early Yellow Dent), Golden Superb, Iowa Silvermine, Funk's Yellow Dent, Goldmine, Craig Mitchell.

Midseason.—Hickory King, Boone County White, Leaming, Manning Silvermine, Golden Nugget, Early Clarence, Manning White or Macleay White, Golden Beauty.

Late.—Yellow Hogan, Yellow Mastodon, Fitzroy (formerly Improved Yellow Dent), Large Red Hogan, Yellow Moruya, Ulmarra Whitecap.

Varieties Recommended for Grain.

UPPER NORTH COAST.

Early crop—Leaming.

Main crop—Fitzroy, Umarra Whitecap.

Second-class soils—Hickory King, Leaming, Golden Nugget.

MIDDLE NORTH COAST.

(a) *Macleay and Hastings Rivers.*

Early crop—Golden Superb.

Main crop—Fitzroy, Large Red Hogan, Yellow Hogan.

Second-class soils—Hickory King, Macleay White, Golden Nugget.

Blight-resistant varieties for November and December sowing—Fitzroy, Golden Nugget.

(b) *Manning River.*

Early crop—Funk's Yellow Dent, Craig Mitchell.

Main crop—*Lower Manning*: Large Red Hogan, Manning Silvermine, Fitzroy, Umarra Whitecap.

Main crop—*Upper Manning*: Golden Beauty, Fitzroy, Manning White, Leaming.

Second-class soils—Hickory King.

Blight-resistant variety for November and December sowing—Fitzroy.

NORTH COAST TABLELAND.

Leaming, Golden Superb, Golden Nugget.

CENTRAL COAST.

Early crop—Funk's Yellow Dent, Iowa Silvermine, Craig Mitchell.

Main crop—Fitzroy, Umarra Whitecap, Large Red Hogan.

SOUTH COAST.

(a) *Illawarra, Shoalhaven, and Milton Districts.*

Early crop—Funk's Yellow Dent, Goldmine.

Main crop—Funk's Yellow Dent, Leaming, Fitzroy, Large Red Hogan, Boone County White.

Second class soils—Hickory King.

(b) *Moruya and Tilba Districts.*

Early crop—Funk's Yellow Dent.

Main crop—Boone County White, Large Red Hogan, Yellow Moruya.

Second-class soils—Hickory King.

(c) *Bega District.*

Early crop—Iowa Silvermine, Goldmine, Funk's Yellow Dent.

Main crop—Fitzroy, Large Red Hogan, Boone County White, Yellow Mastodon.

Second-class soils—Hickory King.

NORTHERN TABLELAND.

Wellingrove, Funk's Yellow Dent, Golden Glow.

For colder portion of the Tableland (Black Mountain to Ben Lomond)—
Early Morn, and Sundown.

CENTRAL TABLELAND.

Alluvial soils—Funk's Yellow Dent, Iowa Silvermine.

Upland soils—Wellingrove, Funk's Yellow Dent, Iowa Silvermine.

Colder districts—Early Morn.

SOUTHERN TABLELAND.

Early Morn, Golden Glow.

NORTH-WESTERN SLOPES.

(a) Lucerell District.

Main crop—Funk's Yellow Dent, Iowa Silvermine.

Later sowing—Wellingrove.

(b) Tamworth and Upper Hunter Districts.

Alluvial soils—Funk's Yellow Dent.

Upland soils—Early Morn.

CENTRAL-WESTERN SLOPES.

Alluvial soils—Funk's Yellow Dent, Iowa Silvermine, Early Clarence.

Upland soils (September or December sowing recommended)—Funk's
Yellow Dent, Iowa Silvermine, Early Morn.

SOUTH-WESTERN SLOPES.

Alluvial soils—Early Clarence, Funk's Yellow Dent.

MURRUMBIDGEE IRRIGATION AREAS.

Iowa Silvermine, Funk's Yellow Dent (December sowing recommended).

Varieties Recommended for Green Fodder.

COASTAL DISTRICTS.

Early varieties—Hickory King, Leaming.

Late variety—Fitzroy.

TABLELAND DISTRICTS.

For warmer portions—Fitzroy.

For cooler parts—Hickory King, Leaming.

For coldest portions—Wellingrove.

WESTERN SLOPES AND MURRUMBIDGEE IRRIGATION AREAS.

Fitzroy.

Descriptions of Varieties.

The varieties recommended by the Department can be described as follows :—

Boone County White.

This is a variety which does best on rich soils, but also does comparatively well on poorer soils well supplied with moisture. It does not seem to stand too hot a climate, and is therefore not suited to the North Coast. It matures in about five months on the South Coast. The stalks are not tall, but rather coarse. They do not sucker much, and under good conditions the ears, which are mostly borne singly, grow to a large size. The ears droop at maturity, and the husk covering is fairly good.

The ears are cylindrical in shape, 9 to 11 inches long, and 7 to 7½ inches in circumference. The rows vary from sixteen to twenty, and are usually very straight and regular, with a medium to small furrow between them.

The grain is fairly thick, moderately broad, pearl white in colour. The cores are of medium large size, but chaffy and comparatively light in weight.

Craig Mitchell.

This is a comparatively new variety which originated in Victoria—possibly a selection from Boone County White, which it resembles in some respects. It is, however, somewhat earlier maturing and has thicker grain with a much smoother dent. On good land this variety has done extremely well, producing very heavy yields of very large cobs. It must be sown early on the coast for good results.

Early Clarence.

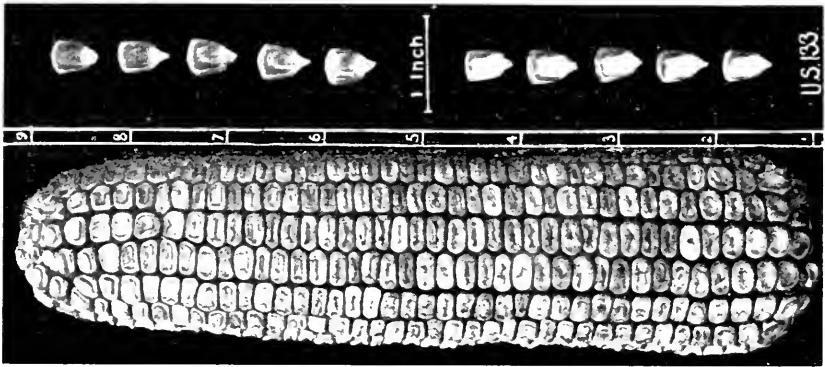
This is a local yellow variety which has been acclimatised to the Tunnah district. It matures in about 5½ months. The stalks are stout and not very tall. The ear is large, with a large core. The dent is fairly rough, and the rows, which vary in number from sixteen to twenty, are fairly straight, with a medium to small furrow between them. The grain is thick, fairly broad, and not very deep. It is of excellent colour and quality.

Early Morn.

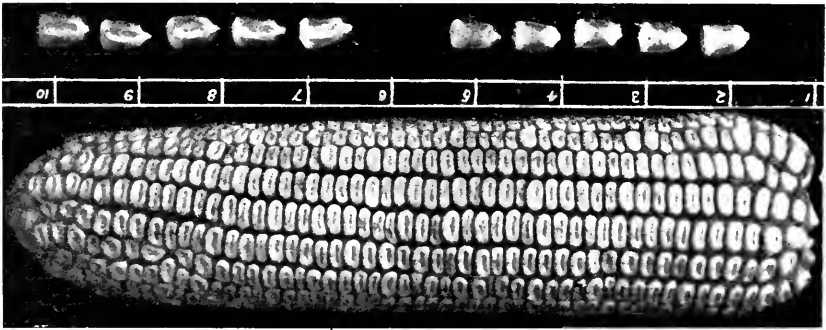
An exceptionally early variety of dent maize, formerly known as U.S. 133, which is only recommended for very cold districts, and for hot, dry districts where an early variety is essential. The growth is only about 5 or 6 feet as a rule, with small cobs 6 or 7 inches long, of short, fairly thick grain of good, bright-yellow colour with a smooth to medium dent.

Fitzroy.

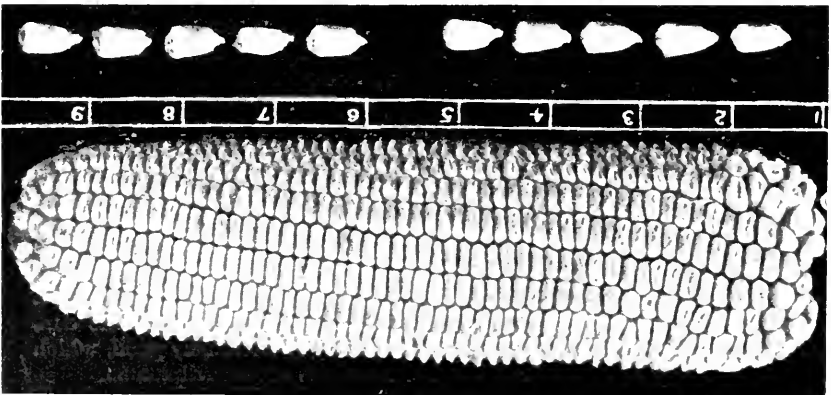
This variety (formerly known as Improved Yellow Dent) has been extremely popular on the North Coast for many years, and of late years is being largely grown also on the South Coast. On the North Coast it takes about six months to mature and is, in addition to being a good yielder of grain, the most popular variety throughout almost the whole State for green fodder or silage on account of its heavy yields and fine succulent stalks. It attains a height of 12 to 15 feet or more on the North Coast, and though the ears mostly remain erect at maturity, the husk covering is extremely good, which makes the cobs very resistant to the weather and also to weevil attack.



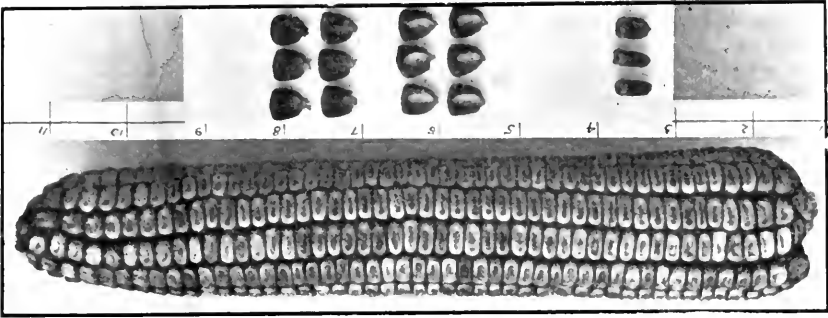
Early Morning



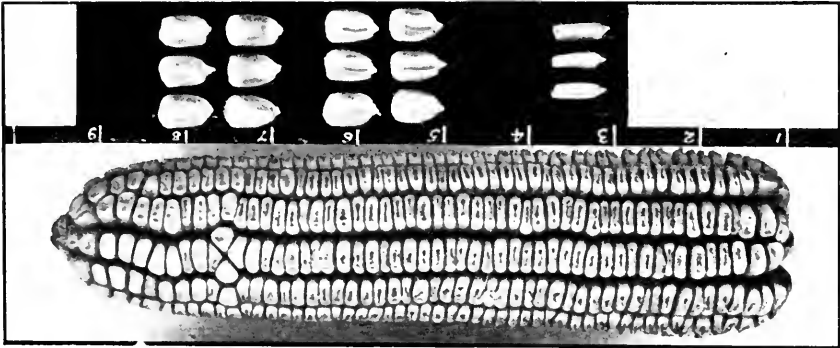
Craig Mitchell



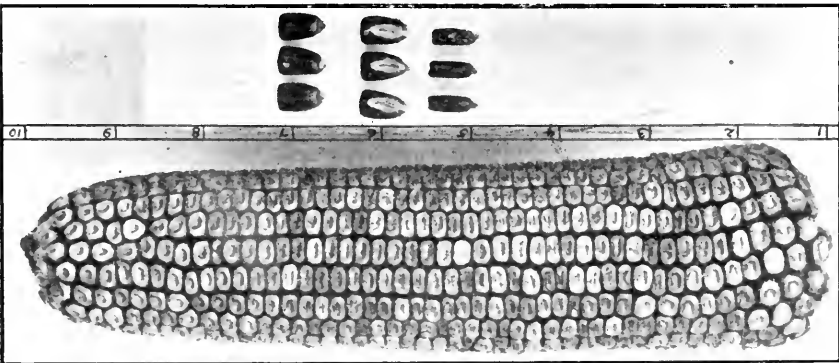
Boone County White



Golden Beauty.



Giant White.



Funk's Yellow Dent.

The ear is cylindrical in shape, 9 to 10 inches in length, and $7\frac{1}{2}$ or 8 inches in circumference. The dent is medium to rough, and the rows vary from fourteen to eighteen in number, with a furrow of medium width between them.

The grain is moderately thick, broad, and deep, and of a bright amber colour, which makes it sell well on the market.

Funk's Yellow Dent.

This variety has been evolved from Reid's Yellow Dent by the selection of a different type, and it is important to note that this selection has fitted the resultant variety for conditions under which the original Reid's Yellow Dent would not grow successfully. Funk's Yellow Dent is gaining rapidly in popularity on the Northern and Central Tablelands, North-western Slopes, Central-western Slopes, the Murrumbidgee Irrigation Area, and the South Coast, on account of its ability to beat other varieties under dry conditions. It has a poor husk covering, but this defect is not of any great account in these districts.

The ears are cylindrical, 9 to 11 inches long and about 7 inches in circumference. The rows number from sixteen to twenty-two, straight, and with a medium wide furrow between them.

The grain is very tight on the cob, thick, medium broad and medium deep. It is thicker and shallower than Reid's Yellow Dent, and the dent is smooth to slightly rough. The colour is dark amber, with a small bright yellow cap.

Reid's Yellow Dent has a softer grain, deeper, and with a rougher dent than Funk's Yellow Dent, but the general experience with it has been that it requires rich soil and very good conditions to do well. Owing to the greater hardness of Funk's Yellow Dent, Reid's has passed from the list of the Department's recommendations.

Golden Beauty.

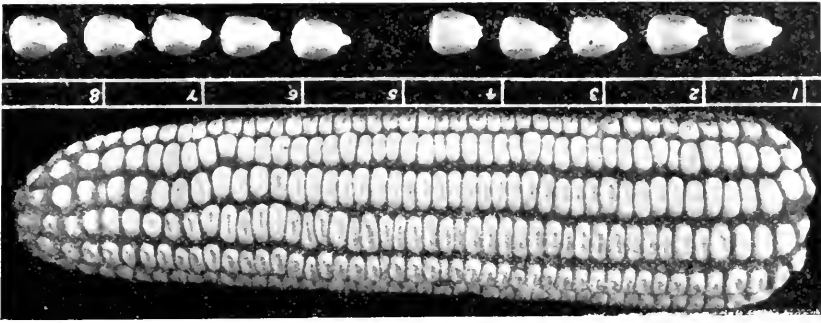
A type of maize easy to identify on account of its long narrow cobs of about 12 rows of fairly broad, yellow, medium hard grain of pale golden colour and medium smooth dent. This maize reaches its best development on the Upper Manning, where it is largely grown; the cobs often reach a length of 12 or 13 inches.

Golden Glow.

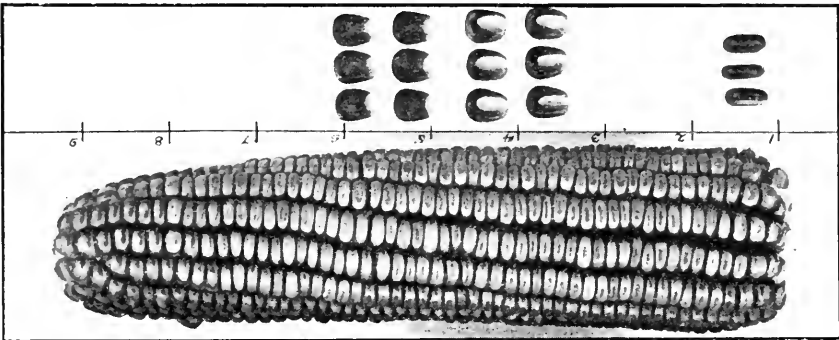
An early variety which is proving a good yielder in some of the cooler tableland districts. It is somewhat similar to Early Morn, but has slightly larger cobs with more closely packed rows of grain with a rougher dent, and is a paler yellow colour than that variety.

Golden Nugget.

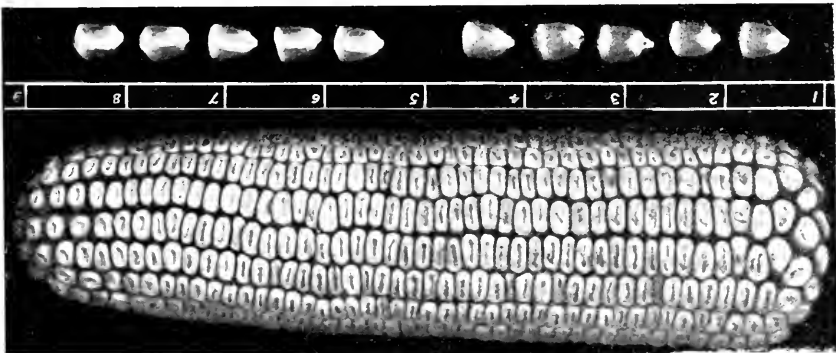
A very useful variety which has given good results on land of only moderate fertility, and which is also useful for late sowing on the coast on account of its resistance to leaf blight, which occurs most abundantly in late sown maize. The cobs are usually well covered with husk, which character enables it to withstand the attacks of weevil in the field and also ensures absence from damage in wet seasons. The cobs are not usually long, averaging 8 or 9 inches, with about 14 rows with medium wide furrows between them. The grain has a tendency to become rounded on the sides, or at least narrowing off to a small, smooth, very shallow dent. The grain is hard, a very bright yellow colour, with a small bright yellow cap.



Golden Superb.



Golden Nugget.



Golden Glow.

Golden Superb.

An early variety of maize very popular on the Macleay River for first sowing to get the early market. For this purpose it is valuable both on account of its earliness and because of its hardness of grain which makes for a good sample. On the Manning River where kiln-drying plants are in operation this quality of hardness is somewhat against it as the kiln-drying makes it too hard.

The ears are slightly tapering, 7 or 8 inches long, with about fourteen rows of moderately broad and fairly thick grain with a shallow smooth dent. The colour of the grain is dark amber often with a reddish tendency, while the cap colour is very pale yellow, almost white.

Goldmine.

This variety has given good results as an early variety on parts of the South Coast. It is somewhat similar to Iowa Silvermine in growth and type of ear, but it has a yellow grain with a significant beak on the upper edge of the dent.

Hickory King.

This is a popular variety on account of its large attractive grain. It is, however, one of our poorest yielding varieties on good land. It matures in about the same time as Boone County, and has established a reputation for doing well on the highlands for fodder. The stalks are rather fine, and the variety suckers freely. The ears are borne on long thick shanks, and they mostly droop at maturity. The husk covering is not good, and many ears are spoilt when the weather is wet during ripening.

The ears are cylindrical in shape, 8 to 10 inches long, and 6 to 6½ inches in circumference. The dent is smooth to slightly rough, and the number of rows eight to ten and sometimes twelve, with a medium to wide furrow between them; and there is a great tendency to irregularity in shape of grain.

The grain is thick, broad, and of average depth. It is pearl white in colour.

Iowa Silvermine.

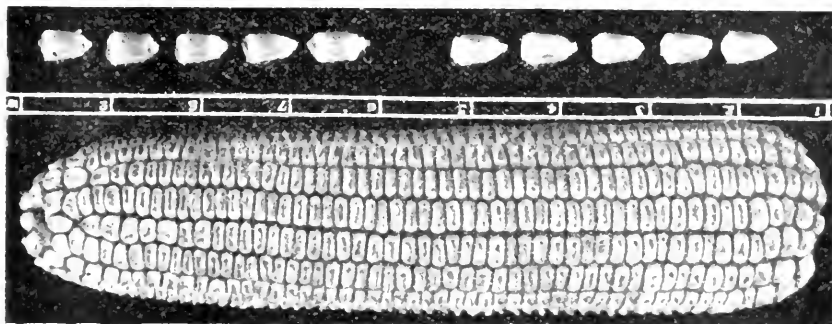
This is a small, white variety which is popular on the Northern Tableland and Western Slopes on account of its earliness and drought resistance. It is also becoming popular now on the Murrumbidgee Irrigation Area and on the South Coast. It will mature in four and a half months on the coast, and grows a very short stalk compared with most other varieties. The ears are carried on long shanks, and readily droop at maturity.

The ears are cylindrical in shape, 8 to 9½ inches long, and about 6½ to 7 inches in circumference. The dent is rough, and mostly pinched, with the upper end drawn out into a projecting beak or spur. The rows are straight and regular, with narrow furrows between them. The cores are small and very light in weight. The number of rows varies from sixteen to twenty.

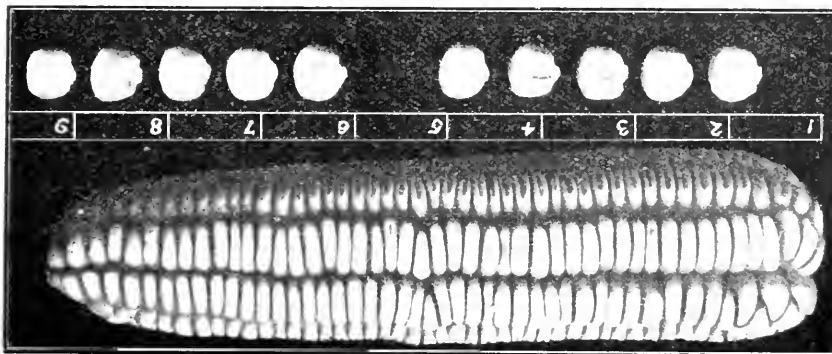
The grain is rather thin, narrow, and of moderate depth when grown under dry conditions, but very deep under good conditions.

Large Red Hogan.

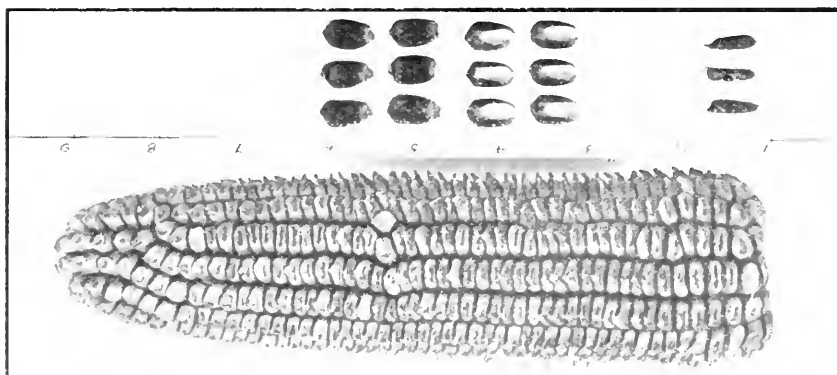
This is one of the latest varieties of maize grown in the State, being extremely popular on the Hawkesbury River Flats and on the Lower Hunter, where it takes about six or six and a half months to mature. The stalk is stout, and grows to about 10 or 12 feet. It does not sucker



Iowa Silvermine.



Hickory King.



Goldmine.

much. The ears are borne somewhat high on the stalk, but the stoutness of the stalk usually resists the force of strong wind. The ears are often held erect owing to the short thick shank, but they are mostly resistant to the weather owing to the good husk covering.

The ears are cylindrical in shape, 9 to 11 inches long and $7\frac{1}{2}$ to 8 inches in circumference. The dent is medium to rough. The rows number usually fourteen or sixteen, with a medium furrow between them.

The grain is fairly thick, broad, and deep, of bright medium red colour.

Leaming.

This is one of the most popular varieties in the State. It takes about five months to mature on the North Coast, where it is largely grown for early planting. It has a fine stalk, which grows about 8 to 10 feet high on the North Coast. The ears are borne on moderately long shanks, which cause the ears to droop at maturity.

The ears are 8 to 9 inches long and $6\frac{1}{2}$ to $7\frac{1}{2}$ inches in circumference, mostly somewhat tapering, with a smooth to slightly rough dent. The number of rows varies from eighteen to twenty-four, and curving or dropping of the rows is not uncommon. The rows are usually irregular at the tip. There is a medium to small furrow between the rows, and the grain is very tight on the cob.

The grain is rather thick, narrow, and deep, with a dark amber colour and a small bright yellow cap.

Manning or Macleay White.

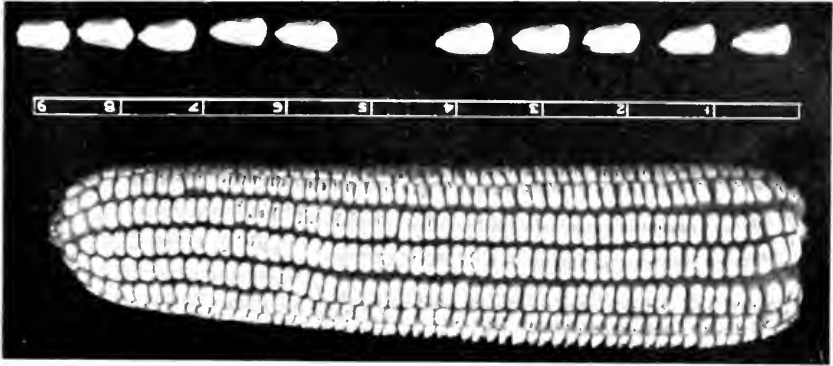
This variety, which is synonymous with Giant White, is a fairly large-grained, white sort that produces characteristically short cobs with about 12 rows of grain and with a fairly open space between the rows. It has earned a reputation for doing well under the somewhat drier conditions on the Upper Manning and Upper Macleay Rivers.

Manning Silvermine.

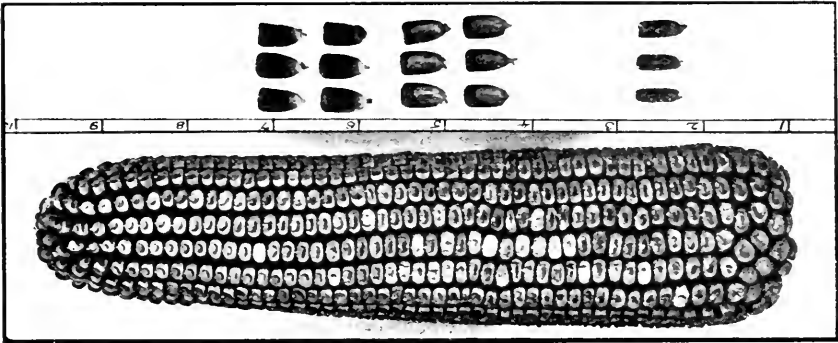
This is a variety of midseason maturity which has come into prominence as the result of yield contests on the Manning River. Its origin is unknown, but its characters place it almost definitely as a cross between Iowa Silvermine and Manning White. The ears are of fair length, averaging 9 inches or more, with about fourteen rows of grain well separated by fairly wide furrows. It differs in this respect from Iowa Silvermine, which has a larger number of rows with narrower furrows. The grain is fairly narrow, like Iowa Silvermine, and very deep, being well over half an inch, and has a rough, pinched dent, with a tendency to "beak." It does not appear to have yielded well so far outside the Manning River. The maturity is about the same as Manning White, about three weeks later than the true Iowa Silvermine.

Ulmarra Whitecap.

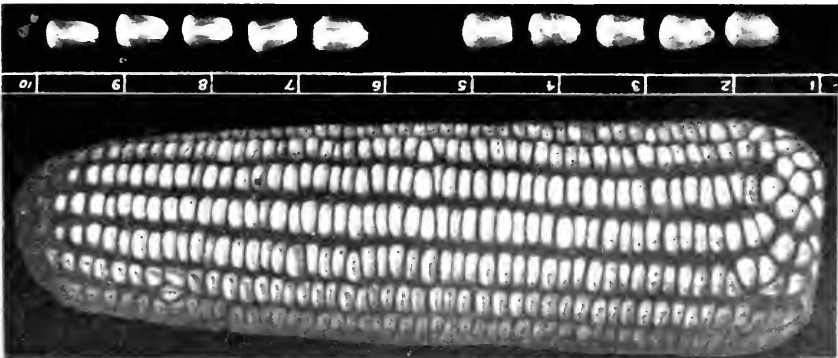
A local variety largely grown on the Clarence River, particularly round Ulmarra. As the name implies it is a maize of crossbred origin not yet fixed as to colour, having mostly a yellow grain with a pale white cap. It is a very late tall growing maize with large cobs. The grain is very deep, of generally pale yellow colour (though it is being improved in this respect to a brighter yellow), rather soft and starchy, with a rough pinched dent. It has been yielding well also on other parts of the North Coast.



Manning Silvernote.



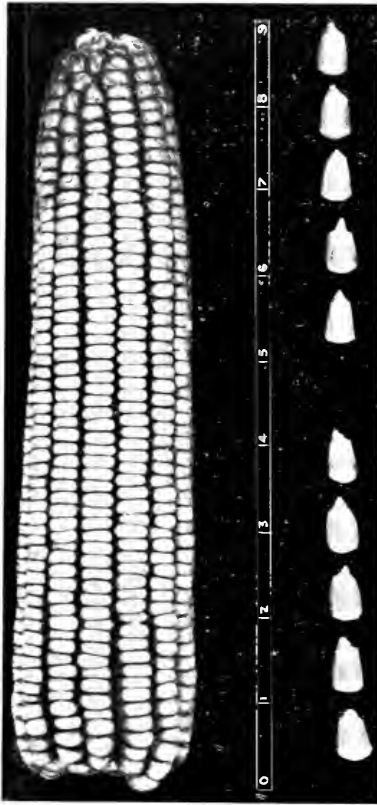
Leaming.



Large Red Hogan.

Wellingrove.

This variety (formerly known as Early Yellow Dent) is extensively grown on the New England Tableland, where it can be depended on to mature before frost, as well as to give very profitable yields. It is not a suitable variety for the coast, but is sometimes sown on the Western Slopes on account of its earliness. The stalk is short and thick at the base, and the ear mostly stands erect at maturity on a short thick shank.



Yellow Hogan.

The ears are tapering, 8 to 9 inches long, and $6\frac{1}{2}$ to 7 inches in circumference. The dent is smooth, and the rows number from fourteen to eighteen. The space between the rows is medium to large, and the grain is tight on the cob.

The grain is fairly thick, moderately broad, and not deep. It is a pale-amber colour, with little variation in shade from that of the cap.

Yellow Hogan.

A late variety, which is grown to a large extent on the Macleay River, where it is highly successful. The cobs are not very long, usually only about 8 or 9 inches, with about fourteen rows of grain and somewhat open furrows between the rows. The grain is only

of medium depth, with a smooth, shallow dent and a very bright colour. The grain is very heavy and is reckoned to be the best selling variety which comes on to the Sydney market.

Yellow Mastodon.

A variety with large cobs and medium sized thick grain which has given good results on parts of the South Coast, particularly in the Bega district.

Yellow Moruya.

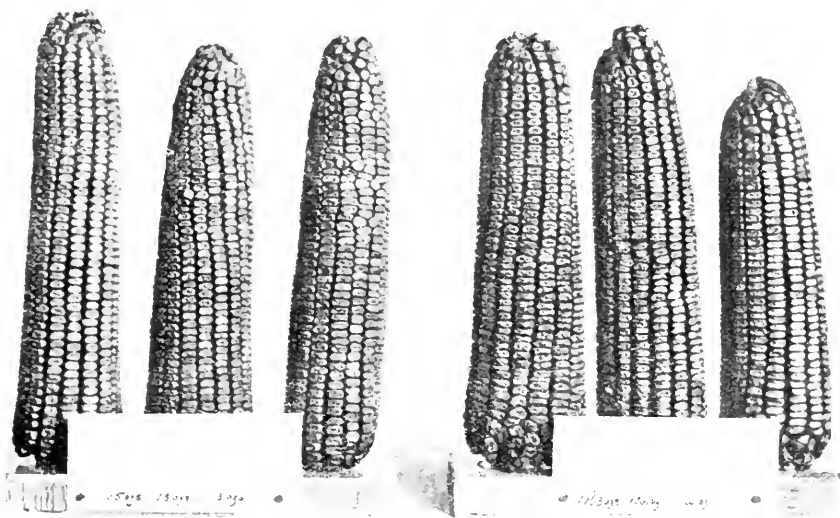
A local variety, with large cobs and large thick grain, which has been evolved in the Moruya district (South Coast). It is probably the result of a cross between Golden King and some other variety.

Selecting the Seed.

There should be no excuse for any maize-grower who neglects to save his own seed maize. The effect of acclimatisation is so marked that one should never go outside the district for seed maize. In spite of the argument sometimes heard, that seed maize is run out and that a change of seed is required, there is abundant evidence to show that by proper selection of seed the yield of a variety can not only be maintained but greatly increased. It is surprising that more selection of seed is not done by farmers, because the comparatively large size of the ears, the large number of grains they contain, the few ears it is necessary to select in order to plant an acre, together with the easily observable types and characters of the different ears, all make the selection of seed maize an interesting and easy operation.

Selection in the Barn.

There are certain fundamental points in the selection of seed ears of any variety of maize, the observance of which makes for continuous improvement. The chief of these points are desirable features in weight and percentage of grain per ear, shape, length and circumference of ear, uniformity, depth and shape of grain, and space between the rows and grain on the ear. Combined with greater attention to field characters and to uniformity in the main characters that define a variety of maize, it is possible to effect



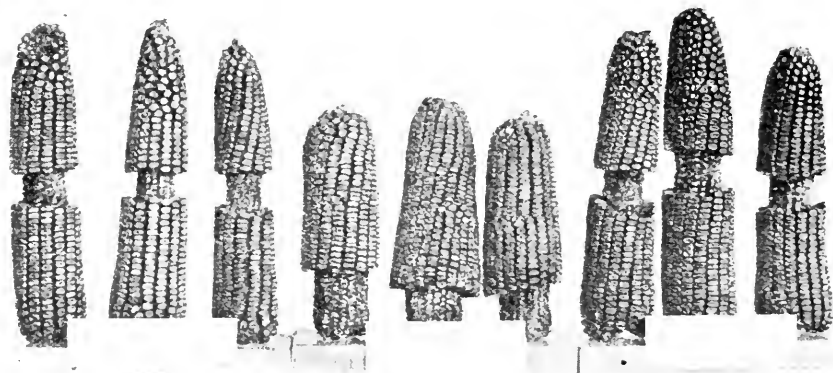
The weights of these ears reading from left to right are 15 oz., 13 oz., 13 oz., 1 lb. 3 oz., 1 lb. 1 oz., 1 lb. 1 oz., respectively. The three on the left are too light in weight in proportion to their size, a fact which is readily discovered on handling the ears.

fairly rapid improvement, especially by the establishment of special seed plots in which cross-fertilisation takes place only between the more desirable types.

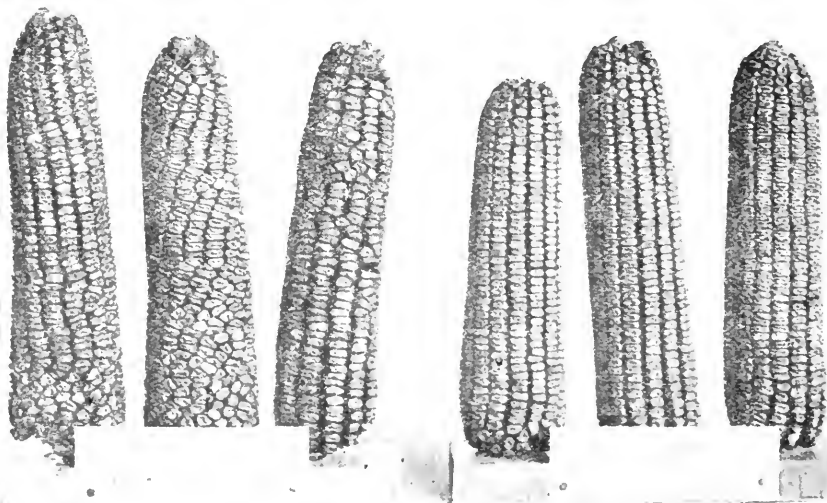
One of the most important points in the selection of seed ears is the choice of those of average size which, when dry, are heavy in proportion to their size. Practical farmers are not asked to weigh their ears on a balance or on scales to get their exact weight; it is easy after a little practice to select the

heavy ears by a rough estimation of weight in the hand. One who keeps this in mind will find several ears of good size and appearance in the reject heap at the end of the day's work. The outside appearance of the ear is sometimes deceptive, but the rough estimation of the weight is found to be a very reliable guide in selecting ears with good solid weighty grain.

The shape of the ear varies from nearly cylindrical to very tapering. As a general rule, the cylindrical ear is the more desirable type for selection, because it not only carries more grain than a tapering ear but also grain of more uniform size, shape, and depth. Straight rows and regular grain are also desirable features. As to the size of the core, it is well to remember that the larger the core the more grain it can carry, and there is no objection



The three ears on the left have too small a core and circumference of ear for their length. It will readily be observed that they will not shell as much grain as the ears with cores of moderate size on the right. The three centre ears have too thick a core and too large a circumference for their length.



The ears on the right show straight regular rows of uniform grain, while those on the left have irregular rows and grain, and are undesirable for seed.

to a core of moderate size for this reason. It is possible, however, to err on the side of excessive thickness of core. Such cores take a considerable time to dry out, and in moist districts constitute a menace in the storage heap because they become mouldy so easily. The ideal of many farmers in selecting seed ears is to get deep grain with a small core. Under conditions of good rainfall and soil, such as exist in most maize districts, the best yielding types seem to be those with a core of moderate size, and it appears that in these districts, at least, there is a big loss in yield by selecting for small cores. There is, however, apparently a correlation between small cores and drought resistance, and this is worthy of note in the drier maize districts.

Ears should have no large amount of space between the grains on the cob, either at the tip of the grain next to the cob or at the crown or dent end of the grain. Ears of good external appearance sometimes have a wide space between the tip of the grains which, when shelled, are seen to be pinched and of poor weight and colour.

A wide furrow between the rows of grain also means a lower weight of shelled grain from the ear, but when the furrow is almost absent the grain is not only of poor shape and colour, but mostly also shallow and pointed, with weak germs. Ears with grain tight on the cob are always to be preferred to those with loose grain.

A mistake is often made by farmers in saying that ears with a rough dent have pinched grain. The roughness of the dent is usually an indication of a higher soft starch content, but also a rough dent is usually indicative of deep grain. Pinched grain is best indicated at the tip end, not at the dent end, and the moderately rough-dent type of grain is usually the best yielding type in a late variety on the North Coast.

In the selection of seed ears, more attention should be paid to uniformity in the appearance of the ears, and also in the size and shape of the grain, than is usually done. Ears that are uniform in size, shape, appearance and character of dent, indicate greater purity of variety. This means greater uniformity in maturing and more uniformity in time of flowering.

Owing to the manner in which a maize plant in the field depends on its neighbours for the fertilisation of its flowers and the formation of its grain, this uniformity in time of flowering is very important. Those plants in a field of maize which flower much later than their neighbours have little chance of being fertilised, and barren stalks are the result.

The more uniform it is possible to get the sample of grain for planting, the more uniform will be the dropping or sowing from the maize drill, and the better will be the yield. Uniformity in colour of grain is also important, as grain of mixed colour brings a lower price on the market.

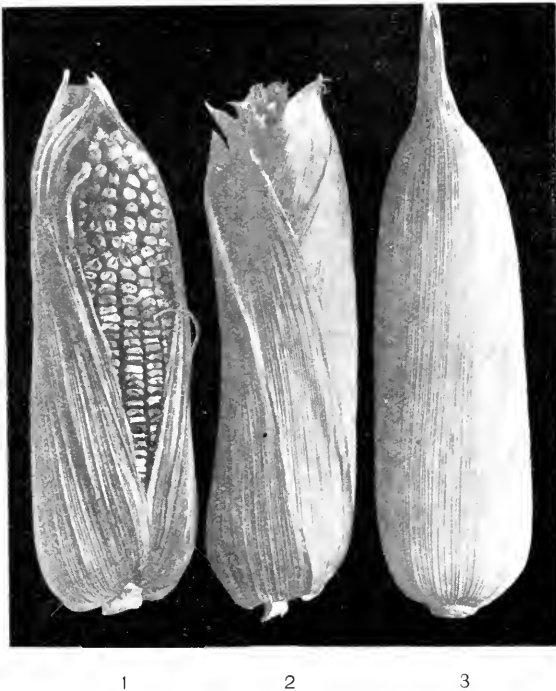
Selection in the Field.

Although in the preceding pages we have closely observed the characters visible in the seed ears, we have as yet taken no cognisance of the field characters of the mother plants from which the ears have been selected. In the first place, a large ear may be due to the fact that its stalk had an advantage while it was growing in the field. It may have had a greater space, or a richer bit of soil, or more abundant moisture. Any of these conditions will enable a plant to produce a larger ear. Such an ear cannot be expected to yield well, unless it has similar advantageous conditions

when it is sown in the following season. The best ears to select in the field are those of good or moderate size, which have been produced under normal or even adverse conditions in the field.

Plants which produce a large ear in comparison with the size of stalk constitute a valuable basis for the improvement of the grain yield of any variety.

Selection for two or more ears per stalk is not likely to give increased yields, unless the first ear is up to normal size; otherwise there is the danger of merely increasing the number of ears per stalk and reducing the average size of the ears.



Types of Ears, showing—1, husk open and much of the ear exposed to insect and fungus attack; 2, tip exposed; 3, a well-covered ear.

Stalks with one or two suckers have been regarded, curiously enough, as undesirable in field selection, but our experience shows that they should not always be rejected. Some varieties sucker more freely than others, and in some cases, especially on rich soils, it might be difficult to select ears only from suckerless stalks. There is no reason why stalks bearing good ears should not be selected, even though they have suckers.

In tall-growing, late varieties on the coast, where the stalks are sometimes 12 feet or more in height, ears should be selected that are growing at a moderate height from the ground, as high ears render harvesting more difficult and induce lodging, both of which result in an increase in the cost of harvesting, while the latter also diminishes the yield.

In those districts where the autumn or winter is wet a large amount of maize is spoilt in those ears which stand erect at maturity, being held so by a short thick supporting shank, especially if the husk covering is deficient. In these districts it is desirable to select ears which turn down at maturity. On the North Coast, where such insect pests as weevil and grain moth are abundant, much damage is done where the husk does not completely cover the tip of the ear, for in those ears which are completely and tightly covered no trace of weevil can be found. By increasing the number of such ears by selection it is possible to keep the crop longer in the field, and the unhusked ears longer in storage.

Field selection may be done during the ordinary process of harvesting, a small box being attached to the dray or waggon in which the selected ears are placed, to be kept separate in the barn from the bulk, and there subjected to a further scrutiny and selection, as in the case of ordinary barn selection already mentioned.

Apart from the improvement in field characters which can be effected by selection in the field, the yield can also be increased by this method. Increases of up to 7 bushels per acre have been obtained from field-selected over barn-selected seed, but for the best results both field and barn selection should be practised.

Improvement of Yield by Ear-row Tests.

Having considered all the visible factors in selection, both in the ear itself and in the mother plant in the field, it might be thought that no further progress can be made in improvement by selection. Such, however, is not the case. It is only within recent years that a method was discovered in America by which the yield and the quality of maize can be still further and more rapidly improved. This method, which easily surpasses all others in obtaining results, is known as improvement by the "ear-to-row" test. This is simply a test in separate rows of equal length planted with grain from individual selected ears. Ears are selected to the best of the farmer's ability, as far as hand and eye can judge, but when compared in an actual test of yielding capacity by the ear-row test remarkable differences are obtained.

A typical test plot has given such differences between individual rows that the highest and lowest weights harvested from two separate rows of equal length, sown with different ears, were 225 lb. and 85 lb. respectively. To plant these rows, which were about 4 chains in length, only half the seed from each ear is used, the other half being kept until the following year. By marking these ear residues with a number corresponding to the row in which the fellow grain has been sown, we are able to say, when the results of the test are known, which are the high-yielding and which the low-yielding ears. The residues of the best five or six out of the forty or fifty ears so tested are planted in a plot isolated from, or planted later or earlier than other adjacent maize to prevent cross-pollination: we thus have in this plot all the high-yielding strains freely intercrossing, but no others, so that the low-yielding strains have been eliminated. Seed from this plot constitutes an improved yielding strain, which is used for planting larger areas. Tests of this improved seed have shown an increase of 11 bushels per acre at Hawkesbury Agricultural College and 10 bushels per acre at Grafton Experiment Farm, over seed selected from the barn in the ordinary manner practised by most farmers.

Manuring.

Maize is one of those crops that make great demands on the plant-food in the soil. It has been estimated that a 50-bushel crop of maize removes from the soil approximately 75 lb. of nitrogen, 30 lb. of phosphoric acid, and 50 lb. of potash. On very heavily manured fields of small area in the United States of America, yields of up to 255 bushels per acre have been produced. This is rather valuable evidence that it is impossible to have the soil too rich for maize—a remark that cannot be made of many other crops. Although good cultivation to a large extent unlocks the store of plant-food present in the soil, we are beginning to see, on our well cultivated alluvial soils, increasing evidence of diminishing maize yields compared with those of twenty years ago. This is surely a sign of failing fertility. We have only to consider how the yields of maize are suddenly increased on “worn-out” land which has been sown to pasture for a few years, and how comparatively good crops are produced on some virgin soils for only a year or two, to realise what is lacking. Undoubtedly it is humus, or decayed organic matter, without which the soil richest in mineral constituents may become quite poor. The retention of moisture by the addition of humus to the soil, together with good cultivation, will do much to explode the idea that maize must have rain at the tasselling stage in order to produce a successful crop. In America, where the conditions necessitate the housing of cattle in the winter, organic matter can be supplied to the soil in a cheap and excellent form, in the shape of farmyard manure. Wherever it is possible to obtain farmyard manure by any means under our conditions it should most certainly be applied. To supply that valuable ingredient, humus, it will be found necessary, under most conditions here, to resort to ploughing-in or feeding off green crops, particularly legumes. The most suitable for our maize districts are velvet beans, cowpeas, field peas, vetches, and the clovers. Besides supplying humus, such crops as these gather nitrogen from a cheap source—the atmosphere—and fix it in the soil. This element is removed by the maize crop from the soil in large amounts, and is the most expensive element purchased in the form of chemical fertilisers. Indeed, it seems that the application of readily-soluble nitrogenous fertilisers to maize is likely to have the effect of promoting a soft and sappy growth, to which a dry spell in the later stages is particularly injurious.

Experiments with fertilisers have been carried out for several years by the Department on all classes of maize soils in different districts, and the results point conclusively to the decided profitableness of artificial fertilisers in certain quantities and mixtures for different districts even on some of the best soils where high yields are still obtained. For instance, on the coastal alluvial soils, in several cases yields of 80 or 90 bushels per acre without fertilisers have been increased another 10 bushels or so by the use of a moderate quantity of fertiliser of the right kind.

The question of what kind of fertiliser or which mixture is a very important one, as in some cases fertilisers have been found to diminish the yields. For instance, on the coast the application of a mixture containing easily soluble nitrogenous fertilisers, such as sulphate of ammonia or nitrate of soda, has been found to decrease the yield by 2 or 3 bushels per acre, which, with the cost of the fertiliser, has resulted in a loss of about 30s. per acre. On the other hand, on the coast the application of 2 cwt. per acre of a mixture, consisting of equal parts of superphosphate and bonedust, has given an average increase of 9 bushels per acre, thus showing a profit of about 30s. per acre after the cost of the fertiliser has been allowed for.

This instance shows how valuable to the farmer are the results of properly conducted fertiliser tests, and the information to be had from the Department on this question is vitally important to maize-growers throughout the State. Unfortunately, too many farmers who have been converted to the use of fertilisers at present take no account of the kind of fertiliser they apply, mostly leaving it to the nearest store or the fertiliser merchant to supply them with a good fertiliser for maize.

On the Northern Tableland $\frac{1}{2}$ cwt. superphosphate has given an average increase of 5 bushels maize per acre, showing a profit of over 20s. per acre. In the Tumut district the best increase has been made from a mixture consisting of 1 to 2 cwt. superphosphate and about $\frac{1}{2}$ cwt. sulphate of ammonia.

Experiments are being continued with potash fertilisers for maize in different districts to determine whether at present prices (which are much higher than pre-war rates) this ingredient can be profitably included in mixtures.

The use of fertilisers for fodder maize is a question that must be considered apart from that of fertilising a grain crop. On the North Coast an average increase of 4 $\frac{1}{2}$ tons green fodder has been obtained from the application of 2 cwt. superphosphate per acre, giving a profit of over 50s. per acre. It is likely that small quantities in addition of sulphate of ammonia or nitrate of soda would also be profitable. On the South Coast a profit of 30s. per acre from an increase of nearly 2 $\frac{1}{2}$ tons fodder has been secured by the application of 1 cwt. superphosphate per acre. On the Southern Tableland an increase of 4 tons per acre has been made from an application of 2 cwt. superphosphate, thus showing a profit of over 50s. per acre.

The Growing Crop.

Important though a thorough preparation of the soil for maize has been made to appear, it is no more important than a thorough after-cultivation. The cultivation of maize should begin almost from the day the crop is planted, and the first operation should be a light harrowing. This harrowing may be left with advantage until four or five days after planting, as it then becomes almost imperative if rain falls soon after sowing, especially on heavy land. Under such circumstances, this harrowing will make all the difference between a poor and a good germination. The advantage of this harrowing also lies in the fact that it kills a heavy crop of young weeds, and aerates and warms the soil. The use of the harrow should be continued until the maize is about 6 inches high. The single-horse cultivator is an implement that is used far too early in the cultivation of the crop by many farmers. Many cannot yet reconcile themselves to the use of the harrow on the growing crop, but the practice is growing rapidly, for it is a case of "once tried, always used." There are, however, two words of caution to be remembered when harrowing growing corn: the first is to select a bright day for the work, as the plants are soft and brittle on a cloudy, cool day, or in the early morning, but quite tough and supple in the heat of the day: the second is to keep the harrow free from clogging rubbish, as this is the cause of many plants being torn out. The use of the harrow on young maize saves a very large amount of more expensive cultivation and hand-hoeing later on, as it destroys a big crop of young weeds and grass which later becomes troublesome. A light lever harrow is the best type of implement for this purpose.

The next cultivation should be done with a riding implement which straddles the rows—either a spring-tooth or rigid-tooth cultivator, or a disc cultivator. The last-named is an implement which has rapidly gained favour in the maize districts on account of the good clean work done by it. It can be made to throw as much hill to the rows as is desired by altering the set or cut of the discs, and it is a considerable improvement on the objectionable practice of hilling with the plough. The rigid-tooth cultivator is a better implement than the spring-tooth for tearing out summer grass, couch or paspalum, which threatens to obtain a hold, and which is not so easily dealt with by the disc cultivator.

When the maize becomes too high to “straddle” with a two-horse cultivator, recourse must be had to a single-horse implement, the use of which should be continued for as long as practicable up to the tasselling stage.

The depth of the cultivation should be regulated according to the height of the crop, it being borne in mind that as the crop grows in height its roots more nearly approach the surface. During the early stage of growth, cultivation may be given to a depth of 4 or 5 inches, but, later, this must be reduced to 2 or 3 inches, or a large number of valuable feeding roots will be destroyed.

Hilling.

For this reason the practice of hilling with the plough is not recommended, as, when the maize is 18 inches or 2 feet high, a large number of roots are cut through by ploughing close to the rows. If hilling is thought necessary at this stage, it should be done with a disc cultivator, or with mould-board sweeps on the single-horse cultivator. It is thought, however, that hilling is a practice for which, in many cases, no good reason can be given. In some instances, where hilling has been done to prevent the stalks being lodged by wind it has been observed that the stalks were snapped on account of their too great rigidity. Where young maize “goes over” with the wind, it usually “picks up” again readily of its own accord, and hilling is not necessary for this reason alone. The only justification for hilling with the plough is in a wet season when a heavy weed growth or grass has obtained a good hold in the rows, and requires early smothering to kill or check it. But this condition can be avoided in most seasons by a thorough preparation of the soil before planting, and by harrowing after planting both before and after the maize is up.

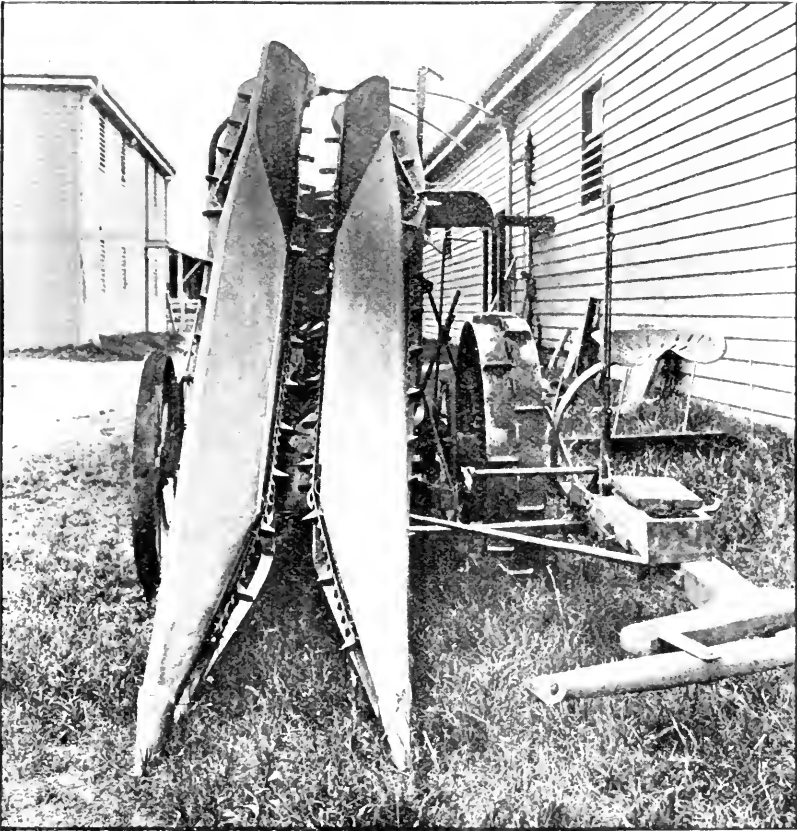
Harvesting and Other Problems.

(1) *For Silage*.—As the maize plant matures it increases in water-free substance, feeding value, and digestibility. Although this is the case right up to maturity, it has been found advisable to cut for silage while the crop is fairly green and contains a fair amount of moisture, as otherwise it does not pack well in the silo; air spaces are left and mould develops. The best stage to cut for silage has been found to be when many, but not all, of the ears are dented or “glazed,” a portion of the husks dry, and the upper leaves still green. If maize is cut before or after this stage, the loss in the silo is the greater. It is, of course, possible to ensile maize beyond this stage of maturity when other green material, such as lucerne, is chaffed together with the maize, or even when water alone is added. Too immature or succulent a growth is apt to cause an over-acid condition in the silage.

(2) *For Fodder*.—The best stage for fodder is slightly more mature than that recommended for silage, and the grain should be fully glazed or dented. Maize is, however, often cut in the milk or “roasting ear” stage for fodder

of high palatability, and sometimes even in the silk or only in the tassel when a continuous supply is required, though in these cases the feeding value is seriously reduced. In the glazed or dented stage it possesses the advantage of being in a suitable condition to "stook" in the field without danger of mould.

Green maize fodder is harvested either by a special maize harvester, which cuts and binds the stalks in bundles, and is capable of harvesting from 6 to 8 acres a day, or it may be done by a home-made implement in the form of a sickle or blade attached to a sliding platform. The ordinary cane-knife is used for cutting maize by hand.



Front View of Maize Harvester.

(3) *For Grain and Stover.*—Where the stover is required to be of as much feeding value as possible while the grain is also needed, it will be necessary to harvest the whole stalk before the grain is mature, and to cure the stover in the field for another month or two in "stooks" containing from 200 to 300 stalks. The best stage of cutting for this purpose is when the ears are nearly all dented or glazed and the husks dry,



A Stook of Maize in the Dough Stage at Glen Innes Experiment Farm.

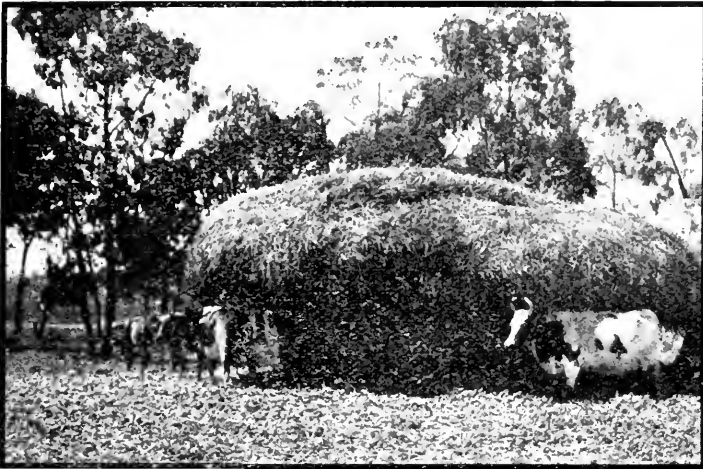


Side View of Harvester.

though the upper leaves and stem are still green. After curing, the ears are husked from the shocks and the stover fed to stock or stored for future use. It may be stored either (a) by cutting up into silage at once with other green material, and well sprinkled with water if required, or (b) by drying the fodder and stacking it.

This method of harvesting is mostly applicable to cold districts—more especially those which as a rule do not have particularly wet winters. The Tableland districts could profitably adopt this practice.

At Glen Innes Experiment Farm a husking and shredding machine deals with the whole of the stalk, husking and shelling the cobs, shredding the stalks, and elevating the shredded fodder into a stack. Such a stack is an extremely valuable and palatable form of roughage for the winter, especially for dry cattle, which should have *ad libitum* access to it from a bush paddock.



Shredded Maize Stover Stack at Glen Innes Experiment Farm.

When the grain is allowed to thoroughly mature on the stalks, the latter are of very little value for feeding purposes.

(4) *For Grain only.*—The ears are snapped off by hand with the husks attached when they are properly dry, and carted to the barn, where they are stored for husking. In some districts the ears are husked from the standing stalks and bagged in the field. A crop is usually fit to pull when about 80 per cent. of the stalks are quite yellow.

Yields.

A yield of 45 tons per acre of green fodder has been obtained on the South Coast, and 100-bushel crops of grain are still obtained on the coast in good seasons. The yields vary greatly with the district. On the coast 60 bushels of grain or 20 tons of green fodder are reckoned to be good crops. On the Northern Tablelands, a 30-bushel crop is profitable, although 45 bushels per acre and over have been obtained. On the Central Tableland and Central-western Slopes 30-bushel crops are obtained on upland soil in a good season, but often not more than 10 or 15 bushels per acre. Under irrigation in these

districts 60 or 70 bushel crops should be possible. In the north-west (Inverell district), a yield of 60 bushels per acre is often obtained in a good season. In the south-west (Tumut district) 80-bushel crops are not uncommon.



A good "three stalk" hill of Fitzroy Maize.

Storage.

Satisfactory methods of storage on a large scale have not yet been evolved to enable the grower on the coast to dispose of his maize at his own pleasure, owing to the presence of weevils and grain moth, which soon reduce sound maize to a riddled condition, especially on the warm North Coast. Apparently the best that can be done with maize in the husk is to store in well-ventilated barns, with sides of open battens or round timber. A certain measure of success is believed to have been obtained in Queensland in "tanking" the shelled grain, but care must be taken in this method to get the grain down to a sufficiently low moisture content to prevent it becoming mouldy in the tank. Mechanical driers will have to be resorted to for this purpose.

In saving a small quantity of maize for seed, it should, after thorough drying, be stored in the ear in air-tight bins with $\frac{1}{4}$ lb. naphthalene flakes or balls for every 20 to 25 cubic feet of space. Before being put away, however, the ears must be kept freed from weevil by fumigating in an air-tight receptacle

with carbon bisulphide, using about 1 oz. or more of the liquid to 16 cubic feet of space, and placing it in a shallow lid or vessel on top of the pile of ears. After fumigation for twenty-four hours, the ears should be taken out and well aired to get rid of the fumes. Care must be taken to have no naked light near the fumigating bin, but further reference is made to this subject where the control of the grain weevil is dealt with a few pages further on.

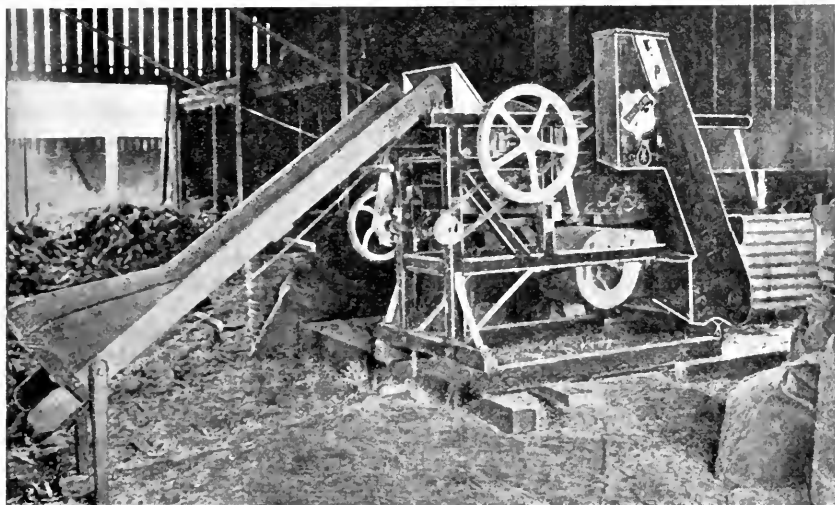
Husking and Shelling.

If the grain is to be used for pig-feed, the husking may be left to the pigs, or the pigs may be allowed to "hog down" the ripe corn in the field. This is done by temporarily fencing off small areas in the paddock and running about 20 to 40 pigs to the acre, or at any rate as many as will clean up the area in two or three weeks. In this way little will be wasted.

Pulling and husking, if done by contract, costs from 10s. to 15s. per acre, according to the crop. A good man should be able to husk about 5 or 6 bushels per hour of ordinary sized corn.

Shelling machines range in size from small hand-machines, with a capacity of 2 bushels per hour, up to power-machines with a capacity of 50 bushels per hour. Shelling costs about 1d. per bushel when done by contract.

Combined huskers and shellers are now on the market, which turn out from 40 to 200 bushels per hour. The saving has been calculated to be about 8s. an acre on a crop of 50 bushels.



Maize Husker and Sheller, in use at Grafton Experiment Farm.

Cost of Production.

The cost of preparing the land, planting, and cultivation on the coast has been estimated at about £2 per acre, and the total cost of production for a 40-bushel crop, including rent, about £6 per acre. This means the cost of producing a bushel would be about 3s. The profit per acre on the yield quoted here would have been about £3 per acre. The winner of the Clarence Pastoral and Agricultural Association acre-yield competition in 1915 was estimated to have made a net profit of £11 per acre from his 77-bushel crop.

At Glen Innes a profit of £6 per acre has been made on a 43-bushel crop.

Sweet Corn.

Though the culture of sweet corn is chiefly confined at present to small patches in a few market gardens and to a few stalks in home vegetable plots, its use as a green vegetable is slowly gaining ground in New South Wales, and seed of many varieties can now be obtained from local seedsmen. Apart from the small local market for this product, it is possible that it will be profitable to export to America during our summer and autumn, which is their "off" season. The local canning of the product might also develop into a profitable industry, as we at present import the whole of our canned sweet corn from the United States and Canada.

Sweet corn differs markedly from field maize not only in its better flavour—due to a higher sugar content—but also in the appearance of the seed and the growth of the plant. Hickory King—a well-known white field variety—is often put on the market as sweet corn; but there is a great difference in flavour between it and good sweet corn. The seed of the latter is translucent, of waxy appearance, and wrinkled over its whole surface. Sweet corn does not grow very tall, and, besides suckering profusely often bears two or more ears per stalk, which seldom attain the size of the hardy dent or field maize.

It is even more imperative than for the field crop that sweet corn should be grown on rich soil well supplied with organic matter and humus to retain the moisture in the soil during growth. The addition of stable manure is the best way of increasing the humus content, and this needs to be supplemented by 1 to 2 cwt. of superphosphate to supply the phosphoric acid in which stable manure is deficient. A top-dressing of $\frac{1}{2}$ to $\frac{3}{4}$ cwt. of nitrate of soda about six weeks after planting will hasten the growth, especially where nitrogen is deficient in the soil.

Sweet corn should not be planted too early, as the seed rots more quickly in cold soil than field maize, and the young plants are also more sensitive to the cold. In order to have sweet corn during the whole of the season, successive plantings should be made about every three weeks. At least two (better three) rows should be sown at one time, as with single rows the cobs are not properly filled with grain, the result of poor fertilisation at flowering time. It is best to sow the corn in "hills" 3 feet or $3\frac{1}{2}$ feet apart each way; and better results will always be obtained by sowing about six grains per hill and thinning out to two or three plants per hill when they have attained a height of 6 or 8 inches. In this way the strongest-looking plants can be left in each hill and the weakest removed. In the Sydney district, planting can commence towards the end of September and continue until February.

The cultivator should be kept going between the rows to conserve the moisture in the soil, but this cultivation should never be deeper than 3 inches, especially when the plants are well up, otherwise a lot of valuable feeding roots will be destroyed.

The usual practice is to remove the suckers, but this should not be done too early. It is better left until after flowering has finished.

The correct stage to harvest is only recognised after some practice. If pulled too young and before being fully developed the quality is poor, and the elapse of two or three days after the proper stage renders the corn too hard and flavourless. The proper stage is when the grains are in

full milk and just about to turn to dough. Outside indications are when the ear is plump, the silk changing from brown to black in colour, and the tassel brown or changing from brown to white.

As sweet corn rapidly loses its flavour after picking, especially in hot weather, it is advisable to leave the harvesting until as late as possible before marketing, cooking or canning; a few hours makes an appreciable difference in the quality.

As a rule, the late varieties, like Stowell's Evergreen, Country Gentleman, and White Evergreen give the largest and the greatest percentage of marketable ears, but some of the early varieties like Golden Bantam and White Cory are suitable for the home garden on account of their excellent flavour.

A fair yield is from 300 to 500 dozen marketable ears per acre, and the market price is usually about 3s. per half bushel case or crate, which generally holds just over two dozen cobs.

In saving seed the corn should be allowed to thoroughly ripen on the stalk, and it should be husked and harvested from the stalk in the field on a warm, dry day, as it moulds very easily. The husked ears should be left in small piles in the sun for an hour or so, and then hung in a well-ventilated barn to cure thoroughly.

The ear-worm is the worst pest the grower of this crop has to contend with, and no methods have been devised to deal with it on a large scale, although in the home garden a lot of damage can be prevented by hand-picking the grubs and destroying them.

Sweet corn may be eaten fresh or cooked in the ordinary manner as a vegetable. One of the most appetising forms in which it can be served is by boiling it on the cob with corned meat. If it is desired to remove the grain from the cob, it should be given a preliminary boiling for ten or fifteen minutes, then dipped suddenly into cold water, and the grain scraped from the cob with a sharp knife. With the removal from the cob before proper cooking, however, it appears that much of the flavour is lost.

There are many districts in this State that are too early to mature ordinary maize where sweet corn can be successfully grown. It grows well wherever field maize is grown, and is becoming more popular in the home vegetable gardens in the cities.

Pop Corn.

Pop corn is another distinct type of maize which has recently come into prominence in this State owing to the failure of supplies from America and to the greater demand which is apparently springing up for the manufactured article in the confectionery trade.

There are two varieties most favoured by the manufacturers—White Rice and Black Beauty, the latter being slightly the better for confectioners' purposes.

The districts which produce the best samples of pop corn for manufacturing purposes are the tablelands; good crops of White Rice have been grown in the Bathurst district, and of Black Beauty (which is about three or four weeks earlier in maturing) in the Tenterfield district.

The yields obtained are usually about one-third or half that of ordinary dent maize.

Fungus Diseases of Maize.*

Ear-rot of Maize (*Diplodia zeæ*, Schw., Lév.).

This fungus, producing Dry Rot or Ear-rot of maize, was first found producing its spores on the dead stalks, and was looked upon as a saprophyte, but it is now well known upon the living corn cobs. The disease is a serious one, and appears to be spreading.

The mycelium produced by the fungal threads is white in colour, and much branched. The slender threads penetrate the young tissues of the grains, cob, and husks. After the cob has become entirely involved, or the growth of the parasite has been checked by the maturing of the corn, the fungus enters upon its reproductive stage. The fructifications consist of small black bodies (pycnidia), which develop in the husks, cobs, and more rarely in the grains themselves. These pycnidia contain large numbers of brown two-celled spores, and appear as minute black points slightly elevated above the surface. They frequently become particularly well developed upon the scales which surround the inner ends of the grains, and may be clearly seen when the maize cob is broken across. On the husks they usually occur singly, but, on the cob, under favourable conditions, they may be grouped together in masses. Diseased cobs, if left in the field under natural conditions, may develop a black appearance.

It is from the fungus when living upon dead tissue—the saprophytic stage—that infection chiefly occurs, innumerable pycnidia crowded with spores developing upon dead parts of the stem and cobs left in the field. The spores, carried by the wind, lodge upon the developing cobs of the new crop, and, if conditions are suitable, germinate and infect them. The conditions most favourable to infection are a warm temperature and a certain amount of moisture. The first of these conditions is usually present on the North Coast, and the amount of moisture necessary must have a wide range, as the rot has been prevalent in a dry as well as a wet season. Apparently, therefore, the requisite conditions for the propagation of this disease may be said to be always present there. The variations in its extent may be due to the variability of the wind at the time when the cobs are in the most susceptible stage, to the amount of spores available from old crops, and to the power of resistance of the variety of maize grown.

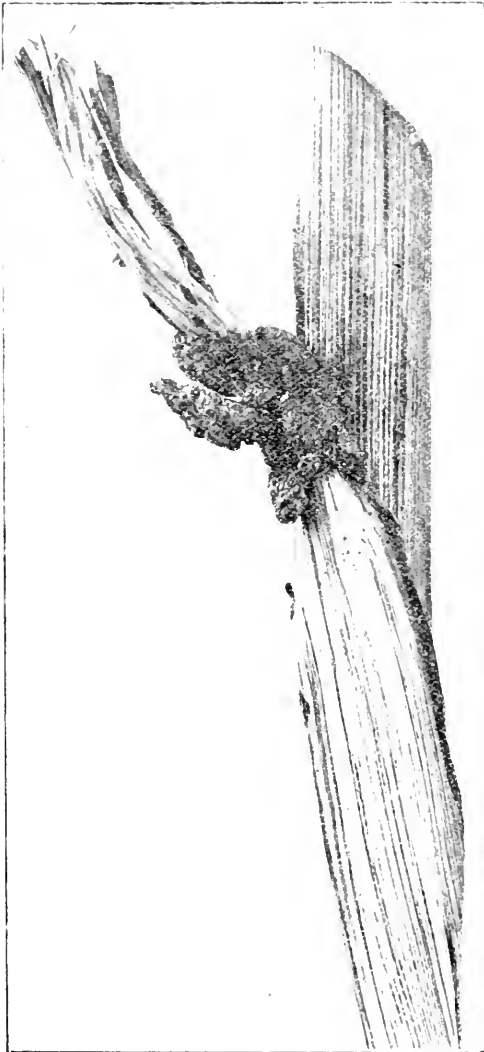
Treatment of the seed by pickling is of no avail as a preventive of the disease. The source of infection must be attacked.

- (a) Old stems, old leaves, and maize stubble must, if the cobs have been found to be infected, be gathered and burnt. Ploughing-in does not destroy the spores, and corn planted on the same land may be infected the following year.
- (b) Since Dry Rot is one of those diseases that can be carried by the seed itself, it is of the utmost importance to secure seed free from disease. As has been pointed out, infected cobs, if broken sharply across, will disclose small black spots, particularly on the scales at the base of the seed.
- (c) Rotation of crops is strongly recommended.
- (d) Varieties of maize which are specially resistant to the disease are not at the present time known, but possibly the most hopeful method of combating disease lies in the selection of resistant varieties.

* Compiled by Officers of the Biological Branch.

American Maize Smut (*Ustilago zea*, Beckm., Ung.).

This is not a common smut on maize in New South Wales. The first specimen was received from Bathurst Experiment Farm, the variety infected being an American one, viz., Funk's Yellow Dent. One of the specimens examined showed two large smut boils present on the stem just above the ground level. On other specimens the boils were present in the heads and tassels, and on the stem and leaf bases. Where the heads were affected there was much greater swelling and destruction than in the case of the ordinary Head Smut.



American Maize Smut (*Ustilago zea*).

Smut Boils on Maize due to American Maize Smut
(*Ustilago zea*).

The destruction of the smut boil or smut gall by cutting it out and burning it is the method to be adopted in coping with this pest, as it deprives the spores of the opportunity to infect other plants or other parts of the same plant. Moisture is necessary for infection, and hence damp weather is most favourable to the spread of the disease. Stevens and Hall state that the only practical way of dealing with this smut is to go through the maize-field at regular short intervals and cut out, collect, and destroy the galls before they have a chance to liberate their spores. It is unwise to feed the diseased plants to stock, as many of the spores pass through the animal uninjured, and are able to develop to a certain degree in the manure, which may thus become a fresh centre of infection.

Head Smut of Maize (*Sorosporium zeilanicum*, Kühn, McAlp.).

Until comparatively recently this was the only smut of maize known in Australia. In districts where maize is largely grown the disease is spreading. It attacks the cobs and tassels, and is usually confined to them, but, in exceptional cases, a few patches of smut may appear on the upper leaves and leaf sheaths. The smut is enclosed at first in a pinkish membrane,

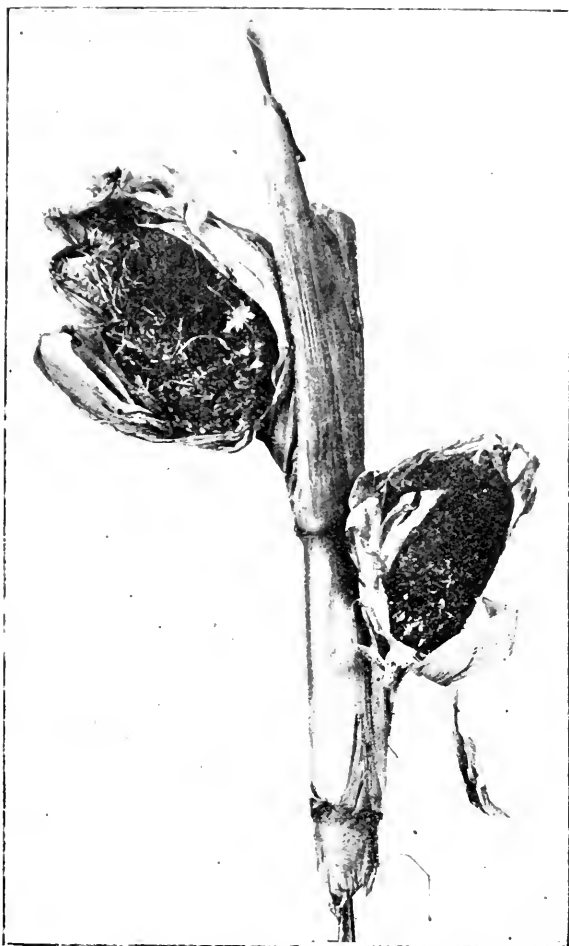


Showing the effect of Smut infestation.

which soon ruptures in order to allow the escape of the spores. It is distinguished from American Corn Smut by not enlarging the ears and forming large smut boils, by generally confining itself to the inflorescence, and not attacking the leaves and stems.

The spores of the fungus are very abundant and drop from the smutted heads to the soil where infection of young germinating maize seedlings subsequently occurs. The life-history is still incompletely known. While to a certain extent the disease is spread mechanically on seed maize—the

spread from a single infected plant contaminating the soil in the vicinity is probably far more important. Areas where the disease has appeared consistently year after year may increase in size. The percentage of infection on lands where Head Smut is prevalent varies greatly, and is probably influenced by soil moisture conditions.



Head Smut of Maize (*Sorosporium reilittum*).

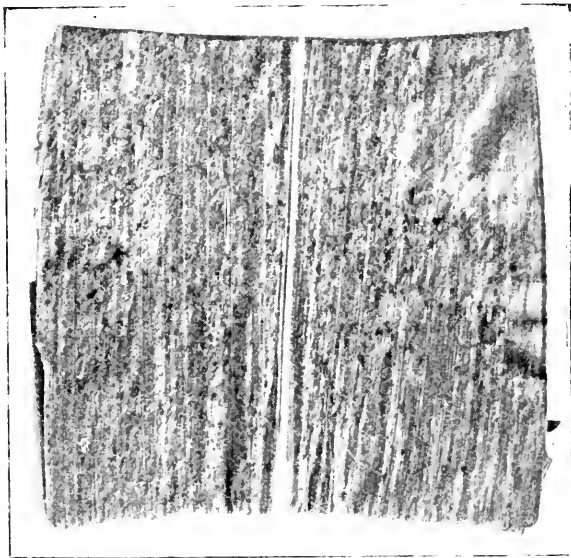
Control.—The methods of control recommended are :—

1. Obtain seed from uncontaminated cobs.
2. Do not grow maize continuously on the same land. Sorghum is liable to attack, and is not to be regarded as a suitable rotation crop. The spores probably persist in the soil for some years, so that, on infected land, the rotation should not include maize and sorghum too frequently.
3. Early removal of smutted heads before they have burst and scattered their spores widely. They should be collected in a tin or similar receptacle and burnt. If more care were taken in small maize crops in the collection of smutted heads, a great deal of smut could be eliminated.

Maize Rust (*Puccinia maydis* Bereng).

This rust is not of great economic importance, being rarely known to give rise to epidemic damage, but in selecting maize for seed purposes, badly rusted samples are undesirable. The rust produces three kinds of spores, viz. :—uredospores, teleutospores, and mesospores.

The uredospore is primarily a spore for the rapid reproduction of the species. As a rule it is produced in immense numbers ; it is provided with a thin wall, having projections of some sort to act as a holdfast, and it generally infests the leaf or sheath, through which it breaks in longitudinal fissures.



Rust (*Puccinia maydis*) on Maize Leaf.

The teleutospores are generally formed towards the end of the active vegetative period of the host plant, and are often called “winter spores,” in contrast with the uredo or “summer spores.” They are specially adapted and equipped for continuing the species over periods of drought, or damp, or cold, or seasons of scarcity.

Mesospores simply represent imperfectly developed or abortive teleutospores. They may, however, in certain cases, perform the function of a fully developed teleutospore.

A fourth form of spore is produced when the teleutospores are germinated on species of *Oxalis*, plants of this genus being intermediate hosts for the rust. These spores (acidiospores) are capable of reinfecting the maize plant.

Formerly the rust occurring upon sorghum was thought to be the same as that occurring on maize, but the two are now regarded as distinct species.

The prevention of rust is to be sought by the selection and cultivation of the most rust-resisting plants, and by the adoption of the best agricultural methods, clean cultivation, judicious rotation, and suitable manuring and fallowing.

Maize Leaf Stripe (*Helminthosporium turcicum* Pass.).

This disease, which often injures maize, has been recorded from Southern Europe, Australia, and the United States.

Small pale patches appear on the leaves, and continue to increase in size, and run into each other, forming large elongate patches, until finally the greater portion of the leaf is covered, the mid-rib alone remaining rigid. The spots finally change to a light brown, often surrounded by a lighter border, and at this stage are more or less covered with a very delicate dusky mould. In some cases the blotches become much elongated, and do not run into each other. The attack varies with climatic conditions and varieties.

This is a difficult disease to check. Burning the stubble when practicable after the corn has been harvested will, to a certain extent, prevent future infection. Rotation of crops is a preventive. Some varieties such as Fitzroy are very resistant to this disease, while others are disease liable. The selection of a resistant variety is perhaps the most practical solution which can be offered to a farmer troubled with the disease. Mr. H. Wenholz states, "There are no immune varieties, but the following are resistant:—Fitzroy, Golden Nugget, Hickory King, and Golden Superb."

Moulds.

Upon maize which has been allowed to become and to remain damp, various moulds speedily develop, the most commonly found genera being *Mucor*, *Penicillium*, *Aspergillus*, and *Fusarium*. All of these rapidly develop innumerable spores, and they may give rise to disease in animals or birds in two ways—either (a) by direct infection from spores, or (b) by setting up disturbances of the digestive or nervous systems when eaten. Direct infection from spores is not very common, but birds may become infected by the spores of *Aspergillus fumigatus*, the symptoms being listlessness, moping, and disinclination to follow the rest of the flock. When made to run they soon become exhausted and fall, and have great difficulty in breathing. There is great thirst and a diminution of appetite. The birds become rapidly emaciated, comb and wattles become quite pale, and there is intense diarrhœa. Very little can be done in the way of treatment in the case of birds. To prevent the disease, do not feed mouldy grain.

It must be admitted that experiments carried out by feeding animals with mouldy maize have given contradictory results; nevertheless, there can be little doubt that feeding mouldy maize may, and frequently does, give rise to disturbances of the digestive or nervous system more or less serious in their nature, and that mouldy maize as feed for horses, cattle, or fowls is to be avoided.

Insect Pests of Maize.*

Some twenty-eight species of insects have so far been recorded as attacking maize in New South Wales, and of these, some twelve (notably weevils and moths) do their worst damage to the stored grain, while sixteen attack the crop in the field.

The chief damage to maize by insects naturally occurs in summer months. The seedlings or the roots may be attacked by wire worms and white grubs, especially crops planted in newly-turned grass land. The principal pests of the foliage are "cut-worms" and other caterpillars, chiefly the Army Worm, in addition to the leaf and silk eating Yellow *Monolepta* beetles. Then the cobs and silk are subjected to the concentrated attack of the Ear-worm, Army Worm, *Monolepta*, Yellow Maize Moth, Pink Corn-worm, and finally weevil and moth.

*W. B. Gurney, F.E.S., Assistant Entomologist.

INSECTS THAT ATTACK MAIZE IN STORE.

The following are the insects that attack maize in store :—

Grain Weevil (*Calandra oryzae* Linn.).

Angoumois Grain Moth (*Sitotroga cerealella* Oliv.).

Red Flour and Grain Beetle (*Tribolium ferrugineum*).

Broad-horned Flour and Grain Beetle (*Gnathocerus* [*Echocerus*] *cornutus* Fab.).

Lesser Grain Borer (*Rhizopertha dominica* Fab.).

Saw-toothed Grain Beetle (*Silvanus surinamensis* Linn.).

Flat Grain Beetle (*Leamophlaeus* sp.).

Meal-worm Beetle (*Tenebrio molitor* Linn.).

Cadelle Beetle (*Tenebroides mauritanicus* Linn.).

Carpophilus hemipterus.

Cryptophagus sp.

Typhae fumata Linn.

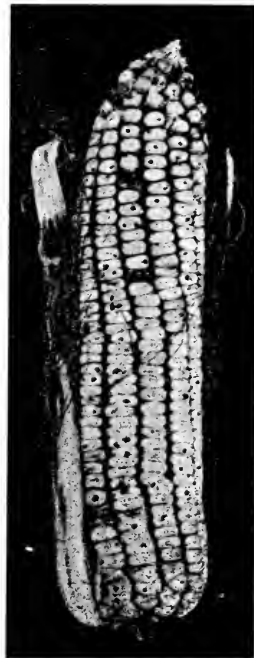
Mites.

Grain Weevil (*Calandra oryzae*).

This insect is a most serious pest of both wheat and maize, and is a small black beetle about one-sixth of an inch long. The female beetle punctures the grain with her snout, and then turns round and deposits her eggs. Each egg hatches into a tiny white legless grub. These grubs eat out the centre of the grain, eventually change into pupæ, and finally, still within



Common Grain Weevil (*Calandra oryzae*).

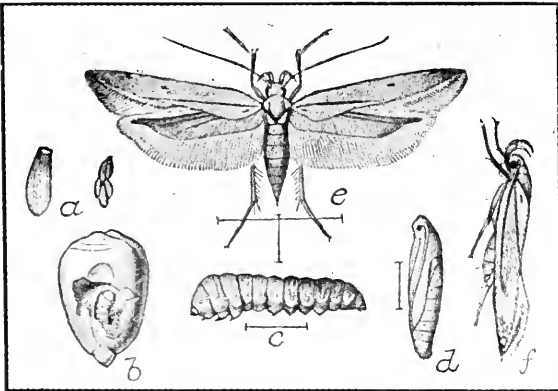


Typical damage due to Grain Weevil (*Calandra oryzae*).

the grain, to adult beetles, when they emerge and spread the infestation. A single grain of maize may develop up to four weevils. Development from egg stage to adult stage occupies about six weeks. The adult beetles live for several weeks, feeding and laying eggs.

Angoumois Grain Moth (*Sitotroga cerealella*).

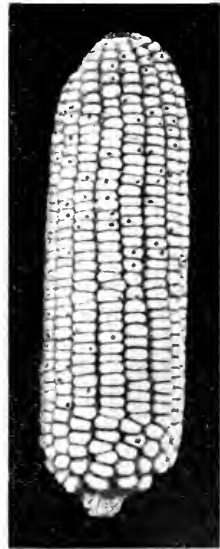
This is a small buff-coloured moth, resembling the clothes moth; when its wings are folded it measures about one-third of an inch in length. It lays its eggs on the grain (of wheat as well as maize), and about sixty eggs may be laid by a single female. The eggs hatch in a week, and the young caterpillar (which, unlike the weevil grub, has legs) crawls and bores into the grain, eating out the interior. While still in the grain it changes into a chrysalis, and thence into an adult (moth), in which form it emerges. This development occupies about four weeks. To the small hole made by the moth in exit there is often attached a perceptible circular lid.



Angoumois Grain Moth (*Sitotroga cerealella*).

a, eggs; *b*, larval case; *c*, larva, side view; *d*, pupa; *e*, moth; *f*, same, side view.

(After Chittenden.)



Typical damage due to Angoumois Grain Moth.

METHOD OF TREATMENT.

To ensure that maize may remain free from insect infestation over a period it may be treated in one of three ways: it may be fumigated with liquid carbon bisulphide; it may be fumigated with carbon dioxide gas, or (if for seed) it may be treated with flaked naphthaline. Treatment with lime, kerosene, &c., is of less value, and not to be recommended.

Which of the methods mentioned will be the most economical will depend in a measure upon the grower's circumstances, the quantity of grain to be dealt with, and so on. For instance, for a small quantity of seed maize the naphthaline treatment would be satisfactory, while for the treatment of grain in bulk, fumigation would be the better.

Fumigation with Liquid Carbon Bisulphide.—Perhaps of the two methods of fumigation particularised above, treatment with carbon bisulphide is the cheaper and easier. The gas given off by carbon bisulphide is very inflammable, and care should be taken that no fires, lights, or lighted pipes or cigarettes are near when handling the liquid or fumigating, but the substance may be used with perfect safety if proper precautions are observed. Neither carbon bisulphide nor carbon dioxide, if used as directed, will affect the quality of the maize for seed or food.

The maize may be fumigated in bags under a tarpaulin in lots of twelve to twenty bags at a time, and this method is quite effective, but if an empty galvanised iron water tank is available for use as a receptacle, so much the better. If the grain is to be fumigated in bags, place about fifteen bags side by side on a tarpaulin or canvas sheet, and into the top of each bag pour one to two fluid ounces of the liquid carbon bisulphide. Fold the sides of the sheet over the bags tightly and so as to overlap, and cover the whole with bags or another tarpaulin to further help keep in the fumes. A "trier" (sampler) serves as a useful funnel for running in the liquid, the heavy fumes of which sink down through the grain. Each lot of bags should be exposed to the fumes for not longer than twenty-four hours.

Fumigation should be carried out, if possible, on a warm day—say with a temperature of 70 deg. Fah., as at a temperature below 60 deg. Fah. the fumes become less effective. The bulk of the weevils will be killed by this process, but the bags should be inspected every two months, and if they show signs of reinfestation they should be given further treatment.

The advantage of using an empty water tank as a receptacle for the maize is that it can be made to hold in the fumes far more effectively than a tarpaulin cover, as the lid can be closed very tightly if a ring of rubber tubing or a bag is placed under it and weights placed on top. For this reason less of the liquid may be used. One ounce to every four bags of maize (that is, to about every fifteen cubic feet of space in the tank) will be sufficient. After twenty-four hours' treatment remove the lid temporarily to allow the fumes to escape.

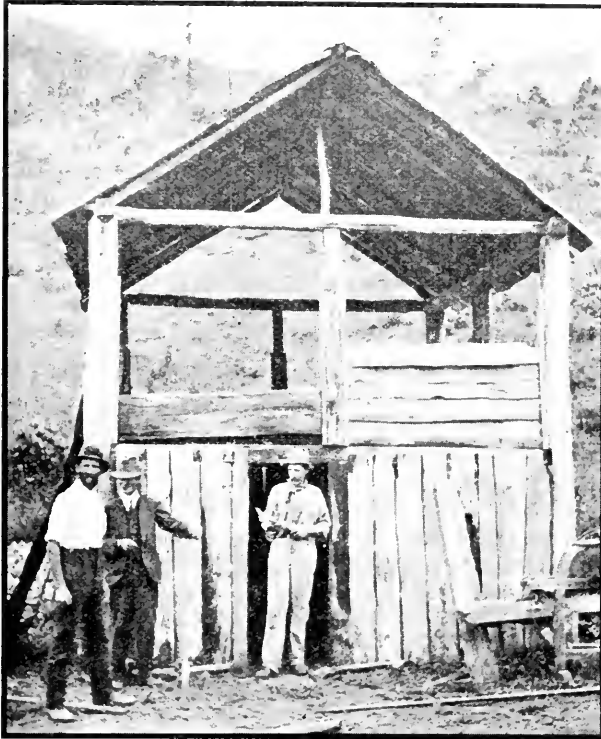
Commercial carbon bisulphide costs 1s. 6d. per lb. if purchased in small quantities, but it may be purchased more cheaply in 1-gallon tins, and more cheaply still if a number of such tins are bought at a time. One gallon will be easily sufficient to fumigate all the maize grown on the average farm in a season.

Fumigation with Carbon Dioxide Gas.—If it is desired to fumigate maize by means of carbon dioxide gas it is essential that a galvanised iron tank be used as a container. The gas is passed slowly in through the top of the tank by means of a rubber tube connected with an ordinary cylinder of the gas, such as is easily procurable from various firms. The cylinder should be placed on a weighing machine, and the weight noted, and then 1 lb. of gas allowed to flow into the tank for every 12 bushels of grain. The contents of the tank can be estimated at 12 bushels of grain to 100-gallons capacity, so that a 500-gallon tank will hold twenty bags (60 bushels) of shelled maize, and therefore (whether full or not) should have 5 lb. of gas. The lid of the tank can be left off, as the carbon dioxide gas is heavier than air, and if it is admitted slowly (at the rate of 1 lb. in three minutes) it will push the air up and out of the orifice as it sinks to the bottom. A lighted candle held in the tank above the grain should go out for lack of oxygen. When

sufficient gas has been admitted the tube should be withdrawn, and the tank lid put in place, with a rubber ring or a sack under it to prevent the gas from escaping. Any weevils or grubs present will die within about seven days.

The maize may be kept in these fumes for over a year without being affected for either seed or food and without developing weevils. At Grafton Experiment Farm maize has been so stored and kept sound for two years at a cost of only 1d. per bushel for gas. The gas is quite harmless and non-explosive, and costs 6d. per lb.

Naphthaline for Seed Maize. Of the substances which have been tried for the treatment of maize to be stored, there may be mentioned lime, kerosene, sulphur, naphthaline, and the weed known as "Stinking Roger." Departmental tests have found "Stinking Roger" and sulphur of no value. Lime,



Drying Kiln at Mt. George, on the Manning River.

The platform on which the maize is placed is just above the heads of the figures, and the log fire is lit in the middle of the earthen floor below.

if used at the rate of weight for weight certainly protects the maize, but the process is expensive and (necessitating as it does the subsequent cleaning of the maize) laborious. Kerosene, used at the rate of 1 pint per 3 bushels, affords protection, but only for two or three months. Incomplete tests indicate that treatment with kerosene affects the germinating power in only a slight degree. Of the deterrents tested, naphthaline has proved the most

effective, and treatment with this substance can be recommended for seed maize. Naphthaline, used at the rate of 1 per cent. by weight, that is, at the rate of $4\frac{1}{2}$ oz. per bushel of maize, has given immunity for a period of about four months in almost open bins, a larger percentage of naphthaline keeping the maize free from infestation for more than five months.

Conditioning Maize for Storage.—Before maize can be stored safely in silos or sealed up in tanks or other air-tight receptacles, the moisture content must be reduced to about 14 per cent. The danger of tanked maize sweating is well known to farmers, and the excess moisture which is responsible for such sweating also encourages mould and decay, and favours the rapid development of weevil and moth. Green maize cannot even be bagged, let alone sealed up in vessels or silos, with the certainty that it will not sweat.

The alternative to drying maize by natural means, which is a process occupying weeks or months, is to dry the grain artificially, either (1) in special conditioning machines, provided with hot-air blasts to reduce the moisture content rapidly, or (2) in kilns. A home-made kiln can be erected with wood and other material usually available on the farm, at a cost, perhaps, of £5 to £15, while firing only amounts to about four or five logs per day.

Various types of kiln have been inspected by the Department, but one built to the following dimensions is recommended as most satisfactory :—

Platform.—17 feet long, 12 feet wide, 7 feet above the ground, maize on platform, $2\frac{1}{2}$ feet deep.

Fireplace.—8 feet long, 3 feet wide, and scooped out to a depth of 9 inches. This leaves 4 feet 6 inches between the fire and the walls on all sides. The hollow prevents logs spilling or rolling.

These dimensions would allow sixty-five to sixty-eight bags (about 200 bushels) to be treated at a time. The time required in the kiln would be about three or four days according to the greenness or moisture of the maize under treatment. Preferably four days should be allowed, as implying a slow fire and more even heating.

Summary.—The following are the Department's recommendations in brief for the safe storage of maize :—

1. Clean up all barns and sheds, raking or sweeping up all rubbish and scattered grain from on or under the floors, and burning it. Dust with a mixture of one part flaked naphthaline to 20 parts lime. Carry out this work not only before putting the new season's grain into the barn, but before the grain has begun to ripen in the field. Weevil from the barns may otherwise infest the growing crop.
2. To condition maize quickly, whether for immediate dispatch to the early market or for fumigation and storage in tanks or silos, utilise the kiln-drying or machine drying method.
3. Treat small quantities of seed maize with flaked naphthaline.
4. To fumigate maize in bulk, whether for seed or food, treat with either liquid carbon bisulphide or carbon dioxide gas as described.
5. Foster the idea of co-operation among maize-growers in your district. Co-operation will make the use of silos and conditioning machines feasible even for the small grower, and centrally-situated co-operative plants and co-operative methods of marketing are capable of making our maize industry vastly more profitable.

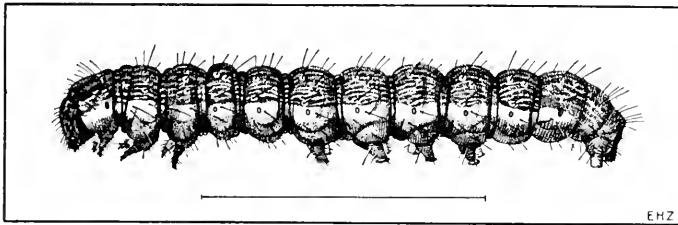
INSECTS THAT ATTACK MAIZE IN THE FIELD.

The following are the insects that attack maize in the field :—

Corn Ear-worm (<i>Chloridea</i> [<i>Heliothis</i>] <i>obsoleta</i> Fab.).	Underground Maize Beetle (<i>Pentodom</i> <i>australis</i> Blackb.).
Yellow Maize Moth (<i>Dichocrocis</i> <i>punctiferalis</i> Gn.).	Slender Seed-corn Beetle (<i>Clivina</i> sp.).
Army Worm (<i>Cirphis</i> [<i>Leucania</i>] <i>unipuncta</i> Haw.).	Corn-leaf Aphis (<i>Aphis maidis</i> Fitch).
Cutworm {	Sugar-cane Borer Moth (<i>Phragma-</i> <i>tiphila</i> [<i>Yonagria</i>] <i>truncata</i> Walk.).
	Coccids (<i>Diacylopius</i> sp.).
Pink Corn-worm (<i>Batrachodra rileyi</i> Wals.).	Wireworms.
	White Grubs.
Yellow Monolepta Beetle (<i>Monolepta</i> <i>rose</i> Blackb.).	Rutherglen Bug (<i>Nysius vinitor</i> Berg.).
	Various Grasshoppers (<i>Cyrtacantha-</i> <i>cris</i> , &c.).

Maize or Corn Ear-worm.—(*Chloridea* [*Heliothis*] *obsoleta* Fab.).

This moth is common and wide-spread throughout this State, and (while more common along the coastal districts) is found inland, and even in the New England and the Tumut districts. Both the moth and the caterpillars vary very much in colouring. The caterpillars vary so much that it is difficult to realise that they develop into the same species of moth. Some are pale green or pale yellow to dark green in general ground colour, with



Maize or Corn Ear-worm (*Chloridea obsoleta*) (side view).

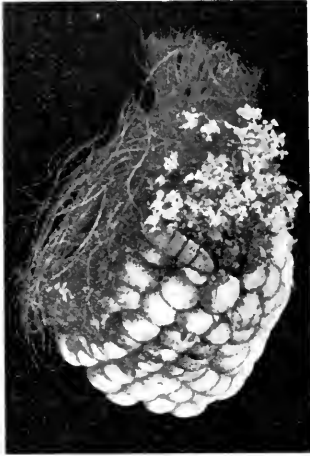
Showing legs, dorsal markings, and the arrangement of hairs on the segments.

little or much black marking dorsally ; others are pale yellow with brownish markings ; others are buff-coloured with broad brown striping dorsally and laterally.

The caterpillars of the Ear-worm moth, as the name infers, most frequently attack the cobs and the ear. Commonly the point of attack is the tip of the cob, or a small round hole in the green sheath may mark the insect's

entrance or exit. This damage permits the entrance of moisture and growth of mould. It also attacks the silks and tassels. Odd Ear-worms may be found in the maize crop as late as the commencement of June.

The eggs are frequently to be noted as minute round whitish bodies, less than the size of a pin-head, attached to the silks, or scattered on the leaves or the sheath of the cob. From two or three up to a dozen or more may be seen on the silks of a single cob. These eggs hatch in a few days, and the young caterpillars feed on the silks, and as they grow older burrow down through the silks to the ear, or eat out a circular opening through the corn husk direct to the ear. After some fourteen days or more the grubs crawl out of the cob and bury themselves in the soil, where they change to the brown quiescent pupal stage. About fourteen days later the adult moth emerges, pushes its way to the surface. It seems probable that at least three or four broods occur, but they overlap; the pest may be found in all stages of caterpillar and adult growth on the same day.



Tip of cob showing an Ear-worm
in situ.

Yellow Maize (or Peach) Moth (*Dichocrois punctiferalis* Gn.).

The body and wings of this moth are bright yellow in colour, and dotted with brown, giving a definite speckled appearance to the insect. In maize the grubs are found infesting the cobs mainly, but will also bore in the stems. When infesting cobs they usually line the bore with silk, and this silken tube may extend as a pipe up through the silk and tip of the sheath to open externally. The core, the grains themselves, and the sheath and silk are eaten and damaged by this pest, which however is not as prevalent nor as serious a pest as the Maize Ear-worm.

The larva is narrower than that of cut-worms, and in colour is palest buff or slaty-white, with pale brown spots marking the position of scattered, fine, indistinct hairs. The head and dorsal surface of segment behind head are brown in colour. The full-grown larva is just under an inch in length.

The pupa or chrysalis is relatively long and narrow and of dark chocolate brown colour, and not so shiny as the Ear-moth or Cutworm pupa.

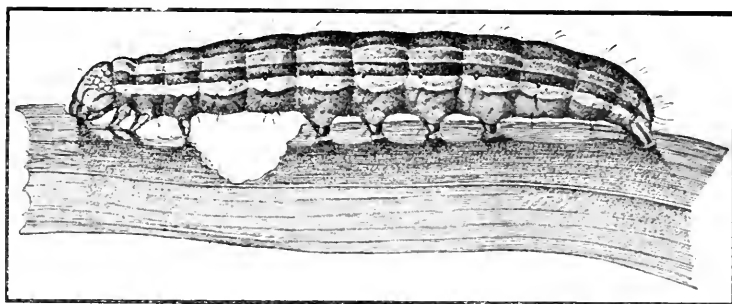


Tip of cob showing work of Yellow
Maize Moth larva with pupa *in situ*

Cutworms.

Cutworms are the caterpillars of a family called the Noctuidæ, which includes many species of small moths. The caterpillars usually feed at night and hide by day, and when attacking young seedlings are capable of readily eating through the stems, thus cutting off the tops; hence the name "cutworm." Later, when the plants are older, thicker-stemmed and tougher, the caterpillars may succeed in only gnawing the stems and destroying the leaves, and thus stunting the growth of the plants without eating them right down. When the pest is in evidence in swarms, however, well-grown crops may be stripped bare of foliage, and even their stalks eaten down.

Army Worm (Cirphis [Leucania] unipuncta Haw)—The Army Worm is among the cutworms that attack maize. It does serious damage to foliage, sheath, and silk. The eggs (which in summer hatch in eight to ten days) are laid by the moths in rows against the bases of the leaf blades, and up to 700 eggs have been recorded as having been laid by a single female. When numerous, the caterpillars may move in irregular swarms or armies from field to field. The tiny, newly-hatched ones may be of palest brown or dirty white, sometimes with greenish tinge, and longitudinal stripes on the back. The older caterpillars are darker and sometimes more definitely striped, but vary considerably to a dark brown or smoky black colour all over, with the

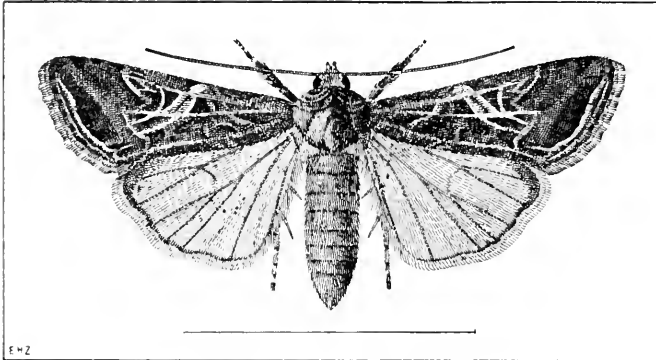


The Army Worm—the destructive larval stage of the introduced *Cirphis (Leucania) unipuncta*. Feeds on maize plants and other crops.

(After Walton. Farmers' Bulletin 731, U.S.A. Dept. Agr.)

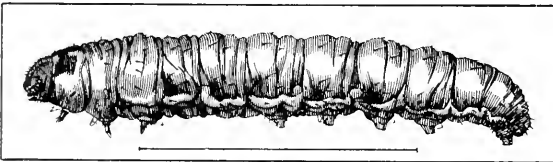
characteristic dorsal longitudinal stripes scarcely showing. They become full grown in three or four weeks, attain a length of $1\frac{1}{2}$ inches, and curl up when disturbed. The pupa or chrysalis is reddish brown, oval and smooth, just under $\frac{3}{4}$ inch long. It is usually found an inch or two below the soil surface, where the full-grown caterpillar has buried itself to change to the pupal or resting stage in which it remains for about two weeks in summer. The adult moth is buff coloured, or very light brown, with a single whitish spot with a dark surrounding patch or one or two distinct spots placed in the centre of the fore-wing; the hind-wing paler, sometimes greyish or smoky on the outer half.

Prodenia litura Fab. [Syn. *Hadena littoralis*]—Another species of cutworm that attacks maize. The adult has brown fore-wings with distinct white blotches; its hind-wings are white, with smoky brown tips and thin brown streak, parallel with most of the outer margin. The caterpillar is dark brown, with series of yellow and black spots along each side of its body.

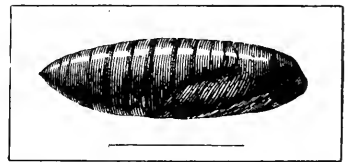


A Cutworm Moth (*Prodenia litura*).

Agrotis radians Guen. [Syn. *Agrotis munda*].—The adult of this species has brown fore-wings and hind-wings smoky white, and in this stage the insect is harmless. The caterpillar (cutworm) is brown to smoky-black in colour.



A Cutworm of Seedling Maize (*Agrotis radians*).



Pupa of Cutworm (*Agrotis radians*).

Control of Cutworms.—For the control of cutworms both bran and Paris green, and bran and arsenic have been used as mash baits. Especially good results have been obtained by using baits made to the formulæ below, spread along the rows of seedling maize in handfuls, as a damp crumbly mash, over 75 per cent. of the cutworms being killed in one night.

Paris green, 1 lb.

Bran, 24 lb.

Water, 3 quarts, with 3 oz. salt dissolved in it.

or

Paris green, 1 lb.

Bran, 24 lb.

Water, 3 quarts, with 6 oz. treacle dissolved in it.

It has been found that white arsenic when used at the same strength as Paris green is much less attractive and effective; this may be due to the fact that the arsenic contains nearly twice as much arsenious acid as the other.

The bait is made by mixing the bran and Paris green together while dry, and then adding the salt water, 1 pint to every 4 lb. bran, which makes a slightly damp crumbly mash. Too wet mash is lumpy and wasteful of material when spreading the bait. With this bait in a sack, or kerosene tin slung over the shoulder, a man can walk up and down the rows, throwing a

small handful at the base of each cluster of two or three seedlings. The salt keeps the bait moister than when water sweetened with treacle or sugar is used. The bait is best scattered late in the afternoon.

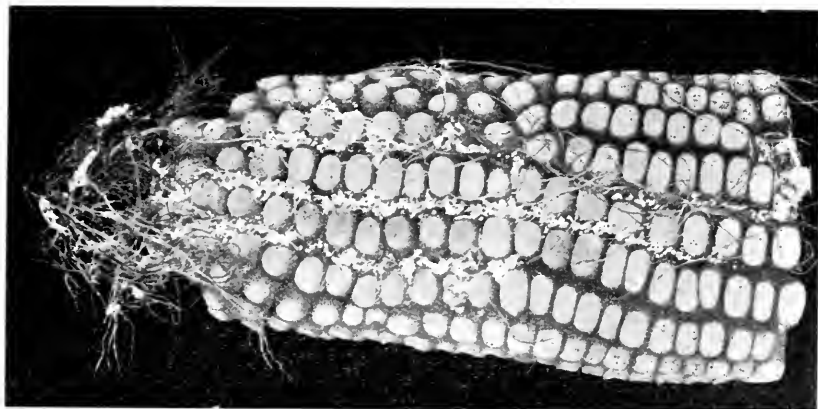
It has been found elsewhere that a few lemons or oranges, finally chopped up and added to the water when mixing the mash, render the above baits more attractive to the cutworms. Success has also been attained by using foliage such as maize tops, potato haulms, turnip tops, &c, chopped up and stirred for about five minutes in Paris green water (1 lb. to 50 gallons). The green bait is thus poisoned, and is then scattered as in the case of bran baits.

In most cases the use of poisoned baits mentioned above is invaluable in controlling these pests. Spraying grass or weeds or a narrow strip of the crop with Paris green or arsenate of lead in front of advancing swarms of cutworms is a method sometimes effective in checking the pest (especially the Army Worm), the sprayed strip being afterwards cut and burned. Trenching a deep furrow in front of their advance, and spraying or crushing the caterpillars, which accumulate in thousands in the steep-sided furrow, is also a useful method.

Pink Corn-worm (*Batrachedra rileyi* Wals.).

This pest damages maize by eating out the grains, and also feeds on the core, husks, and silk of the cobs. It attacks the ears in the field and in store, but is not serious in shelled and bagged grain. It also feeds on sugarcane, bananas, lantana and sorghum.

The eggs are minute and pearly white and are laid on the cobs. The caterpillar is small (up to $\frac{3}{8}$ of an inch) and of characteristic pink colour.



Cob damaged by the Pink Corn-worm.

Note the streaks of fine granules of excrement (smaller than those of the excrement of the Ear-worm or of the Yellow Maize Moth).

The pupa or chrysalis is small and brown, and is found in light silk cocoons in the husks and silks, and among the grains.

The adult moth is light greyish brown, slender, small (smaller than the common grain moth) and inconspicuous.

In late summer this insect is common on the ears attacking the grain and top of the ear. The danger seems to be to the ripe maize grains in the field and stored cobs in the last three months of summer, but this insect has not so far been termed a serious pest.

Yellow Monolepta Beetle (*Monolepta rosæ* Blackb.).

This is not an introduced pest, but a native of our North Coast river districts. The little beetle is about $\frac{1}{4}$ inch only in length, with yellow body and legs, and with a bright cerise patch on each shoulder, as well as a single cerise spot near the middle of each elytron.

This pest attacks the silks and the tassels of maize. It is also a serious pest of the orchard, attacking blossoms and foliage of citrus, stone, and pip fruits indiscriminately. The beetles also swarm on certain species of wattle. The pepper tree (introduced) is also a favourite food both in winter and summer.

Careful observation of the dates of the appearance of this beetle indicates what it has a very lengthy adult life. It is its habit of infesting fruit, wattle, and pepper trees that enables it to survive through the winter. Its absence from early October to early January indicates that the beetles are then hidden in the larval stage, probably feeding in the scrub.

In view of the above facts, to attack the beetles when on fruit trees, pepper trees or wattles, suggests itself as a logical if indirect method of controlling the pest in the maize crop. Unfortunately, owing both to their hardiness and their extreme activity on the wing (for they rise in clouds with almost the speed of flies on being disturbed), the beetles are not readily killed. Good results have been obtained by the use of certain sprays, applied under strong pressure, care being taken to apply them also to the ground upon which the beetles which have been brought down have fallen. If the beetles are attacked on pepper trees or on fruit trees not in bloom, kero-sene and soap emulsion (1 part kerosene to eleven water) or resin and soda (1 lb. resin and $\frac{1}{2}$ lb. washing soda to 8 gallons water) are perhaps the best sprays to use. For fruit trees in blossom a benzine and soap emulsion (1 part in, say, 40 water) is the safest. Perhaps the best method of control, however, is dusting with arsenate of lead powder mixed with lime dust (1 lb. powdered arsenate of lead to 20 lb. lime). Such treatments are especially effective if they are used at night or in the early morning, for it is at these times that the beetles are least active.

Underground Maize Beetle (*Pentodon australis* Blackb.).

The adult beetle damages maize by eating the germinating seeds and also seedlings.

Slender Seed-corn Beetle (*Chivina* sp.).

The adult beetle of this species is occasionally reported as damaging the crop in a similar manner.

Aphis.

Aphides suck the sap of leaves, stem, and cob sheaths. Spraying with a nicotine extract wash will kill them, but such a measure is not generally considered to be profitable. The aphides are usually controlled by the useful aphid-eating ladybird beetles, and only in some seasons appear in destructive numbers.

Sugar cane Borer Moth (*Phragmatiphila* [*Nonagrina*] *truncata* Walk.).

This species bores into the maize stems, but is more serious as a pest of the crop which gives it its name.

Coccids (*Dactylopius* sp.).

A species of mealy bug is found occasionally at the bases of leaves and cob sheaths, where they suck the sap. They are attended frequently by a small ant.

Wireworms.

These are hard-bodied, smooth, yellowish-white grubs, common in the soil, and varying in sizes up to $1\frac{1}{2}$ inches in length. These active, wiry, quick-moving grubs or wireworms are the larvæ of the common brownish beetles known as "click" or "skip-jack" beetles (*Elaterida*). They feed on roots of maize, wheat, and other grains, and also on the freshly-planted maize grains. The grubs remain at work feeding and growing in the soil for from three to five years, when, like the white grubs, they construct a small cell to pupate in, and then appear as the common brown beetles mentioned.

As they resemble "white grubs" in food and habits, similar methods are recommended. Ploughing and harrowing in the autumn destroys numbers of the cells and pupæ. Rotation of crops is also recommended.

Laboratory experiments have shown that wireworms are destroyed by feeding on bran poisoned with Paris green, mixed as recommended for cutworms. It therefore seems possible that over limited patches where wireworms are at work, if a sprinkling of bran so poisoned were turned into the soil just prior to sowing or during that operation, it might prove of value. The absence of vegetation for two or three weeks before the seed is sown or before it germinates would probably force the wireworms to try the poisoned bait, and thus save the seed.

White Grubs.

These are the thick, white, curved grubs so common in the soil, and often turned up by the plough. They are the larval or grub state of the common "King" or "Christmas" beetles, and their allies, the "chafers," and vary much in size, according to the age or the species, but are all very similar in appearance. These grubs remain feeding in the soil on grass and crop roots for two years or more before becoming full-grown, when they construct a soft rounded earthen cocoon, pupate therein, and thus pass their last winter in the soil, to appear the following summer as adult beetles, which feed on foliage.

Where these grubs appear in maize or wheat crops, rotation is recommended, such as clover following wheat or maize, or potatoes in newly turned-up grass land found to be infested. The change crop in each case is not so seriously infested, and return can afterwards be made to the original crop. Deep ploughing in late autumn is recommended, as it destroys numbers of those which have pupated, by breaking their earthen cells and exposing the helpless pupæ to other insects, birds, and frost. Treatment of the soil with lime, apterite, &c., has not been found to give satisfactory results.

Rutherglen Bug (*Nysius vinitor*).

This pest is dealt with under the heading of potatoes (see page 491).

Grasshoppers.

There are three species of grasshoppers in New South Wales which appear in such swarms as to be a plague where they occur. They are "The Larger Plague Locust" (*Chortioictes terminifera*), "The Smaller Plague Locust" (*C. pusilla*), and the "Coastal Locust" (*Ætalæus senegalensis*). They attack grass, crops, fruit-trees, vegetables, and garden plants.

Normally the first grasshopper swarms hatch in September from eggs laid the previous March and April; they grow gradually, and become winged in November and December. These winged swarms lay eggs in the ground. The eggs hatch in three weeks, and the second hopper swarms appear during December, January, and February, and become winged flying swarms during March and April. These second winged swarms lay eggs which remain in the ground unhatched until spring (September).

Egg-laying is effected by the swarms in comparatively limited patches of ground, varying from a few square yards up to thousands of square yards, according to the size of the swarm. The swarms when laying usually mass together for a day or two on some bare or thinly-grassed lands, and deposit their eggs one to two inches below the surface. By noting the position of the egg-bed areas it is possible to spray the tiny young hoppers immediately they emerge and before they grow and spread. By organising and spraying these patches of young hoppers within the first three weeks after emerging from the ground the majority of hoppers can be killed before they do any appreciable damage, and the pest can be thus be controlled.



A.—Stage when spraying most effective.



B.—Stage rather too old for best results from spraying.

Spraying with arsenite of soda is recommended, and is perfectly harmless to stock under practical field conditions. The formula recommended is:—

Arsenite of soda, 1 lb.
Treacle, 4 lb.
Water, 16 gallons.

An important point in mixing is to dissolve the arsenite of soda in a kerosene-tin or more of hot water, and to dissolve the treacle in a separate quantity of hot water, allowing both mixtures to cool before bringing them together, when the whole can be made up to the 16 gallons.

The spray should be applied to a strip of grass about 30 feet wide around each swarm, as well as directly on to the hoppers themselves. The spray kills both by direct contact with the bodies of the grasshoppers and by poisoning the grass on which they first feed.

The spray mixture can be carried to the swarms in petrol-tins, two in a case, with a hole in the top of each tin sufficiently big to admit the foot of the pump; a large number of tins can thus be carried on a spring-cart from which the infested ground can be sprayed. Spraying may be light, but it should be done thoroughly, and the spray applied in a fine mist. For this purpose a small bucket pump will be found satisfactory. Twenty-eight pounds of arsenite of soda and 1 cwt. of treacle will make a sufficient quantity of spray to treat 6 acres actually massed with hoppers.

United action is essential for success in grasshopper control. The coping with an invasion is a community problem, and should be taken up as such. The best results can be obtained only when every landholder is on the lookout for trouble, and is prepared to combat it. The best time to destroy the grasshoppers is before they reach maturity, and particularly during the first two or three weeks after hatching. For this reason landowners should watch their fields for the appearance of the insects, and spray the hoppers while they are in the massed state.

SORGHUM.*

ALL sorghums were at first supposed to be derived from a wild species of grass, namely, *Andropogon halepensis*, of which Johnson grass is a typical representative. The underground creeping rootstocks of Johnson grass, however, and its perennial character, make it extremely difficult to reconcile it with our annual sorghums. Sudan grass, which is really half a grass and half a sorghum, appears more closely related to the sorghums; and it seems more feasible to believe that the sorghums have been derived from a wild species of grass, such as Sudan grass, than from such a plant as Johnson grass.

Sorghums have been known and cultivated almost from time immemorial, and Egyptian records of this class of fodder plants have been discovered dating as far back as 2500 B.C. At the present time they are grown for one of three purposes—for forage, for grain, or for brush. The principal groups may be divided as follows:—

- (1) The sweet or saccharine group, the members of which are distinctly sweet.
- (2) The grain or non-saccharine group, the varieties of which have large heads of nutritive grain. The stems contain no sweet juice, and are sometimes more or less pithy.
- (3) The broom-corn group, which has varieties with long branching heads, and which are valuable only for broom-making. (*See* Broom Millet, page .)
- (4) The grass-sorghum group, embracing Sudan grass and the less important Tunis grass.

THE SWEET OR SACCHARINE SORGHUMS.

The qualifications of these sorghums render them exceedingly valuable members of the list of crops available to the dairy-farmer, pig-raiser, or sheepowner in most parts of this State. Perhaps no other crop has the same range of adaptability to soil or climate, and at the same time produces such a large quantity of excellent feed.

The essential requirements of a forage crop are that it can be cheaply produced and easily handled, the yield must be fairly large and the feed must be nutritious and relished by stock. We find these conditions in the highest degree in maize, and where that crop can be satisfactorily grown, the sphere of usefulness of sorghum is much restricted. Unless maize, however, is grown under congenial circumstances it does not give good results, and then sorghum profitably takes its place. It will thrive on poorer soil, when mature will stand more frost, and has greater power of withstanding drought. This latter quality renders it of exceptional merit as a fodder crop in the drier districts of the State.

Breeding ewes require green feed during the lambing period to maintain the flow of milk, and where irrigation cannot be practised, no other crop is so fitted to supply it as sorghum.

The spread of dairying into the drier districts has further created a demand for suitable green crops, and sorghum—with its powers of growing under a low rainfall, or of withstanding without harmful effects long periods of

* A. H. E. McDonald, Chief Inspector of Agriculture, and E. Breakwell, B.A., B.Sc.

drought—fully meets the requirements. Its capacity for thriving under dry conditions is remarkable, and renders it one of the most valuable fodder plants for dry districts. A few acres of this crop each year would provide an insurance against drought, and make an excellent substitute for chaff and other feeding stuffs which would otherwise have to be purchased. At the same time, the succulent green feed it produces keeps stock in a healthy condition, and counteracts the tendency to colic and other diseases prevalent when only dry feed is available. In more favoured districts it is supplementary to maize rather than a main crop.

Sorghum will stand more frost than maize when mature, and this makes it valuable for preserving a continuance of green feed into winter. Maize is cut off early, but sorghum retains its succulence, and this makes it a favourite crop for autumn feeding.

In America sorghum is highly recommended as a crop for dry regions, and is extensively grown where the conditions are too arid for the staple crop—maize. It is used as green feed, hay and silage, and in some States the sweet varieties are used for the production of syrup, though owing to the cheapness of cane sugar it has not been used here for the latter purpose.

The Soil.

The following figures, based on an analysis of green fodder taken from Henry's "Feeds and Feeding," show the quantities of plant-food absorbed from the soil per acre by a crop of 15 tons of sorghum and maize :—

	Sorghum, 15 tons.	Maize, 15 tons.
Nitrogen	77·2 lb.	137·7 lb.
Phosphoric acid	30·2 „	50·4 „
Potash	77·2 „	110·8 „

They show that sorghum, in comparison with maize, makes small demands upon the soil, and we find when we compare the quantities with those removed by other farm crops, that they are by no means heavy. Sorghum has a vigorous root system which enables it to exploit a considerable area of soil, and utilise to the full its inherent fertility. Added to this, the season of its growth is particularly favourable to the chemical and bacterial agencies which are at work fulfilling their functions of releasing plant-food. This combination of plant capacity to obtain food with rapid increase in the available ingredients through changes in the soil, enables sorghum to thrive on almost all classes of land.

The most suitable soils are the deep sweet loams or alluvial soils, and on these heavy yields are obtained. When such soils are available, little manuring is required, and it is not necessary to enter into expensive tillage operations to secure profitable yields. On many farms, however, areas of poor land are found which are not suitable for most crops. Our experience with sorghum shows that, when proper methods are adopted, such soils can



Varieties of Saccharine Sorghums.

1. Typical Planter's Friend (Imphee); 2. Typical Amber Cane; 3. Saccaline.

be made to give profitable returns when cropped with sorghum. It is an extremely hardy crop, and seems to have the power of drawing upon refractory soils for its requirements. In districts where maize and sorghum can be grown, the system can be satisfactorily adopted of utilising these poorer areas for the growth of sorghum, while the fertile soil is used for the more fastidious maize crop.

Sorghum gives profitable yields on sandy country, and on poor, stiff clay soils. Its cultivation for green feed can be highly recommended on all soils of the Hawkesbury sandstone series, the Wianamatta shale of the county of Cumberland, and, generally speaking, for all soils too poor for the best growth of maize.

Climate.

Practically the only limiting factor in the growth of sorghum is temperature. Frosts kill it if they occur while the crop is young, and in districts with very short summers it cannot be successfully grown. The range of choice in varieties is so wide, however, that it is only in the very coldest districts of the State that it cannot be grown. Broadly, the higher the temperature the greater is its development. The optimum conditions for growth are high temperatures, humid atmosphere, and abundance of moisture. Under such conditions, a crop once sown can be cut several times without resowing.

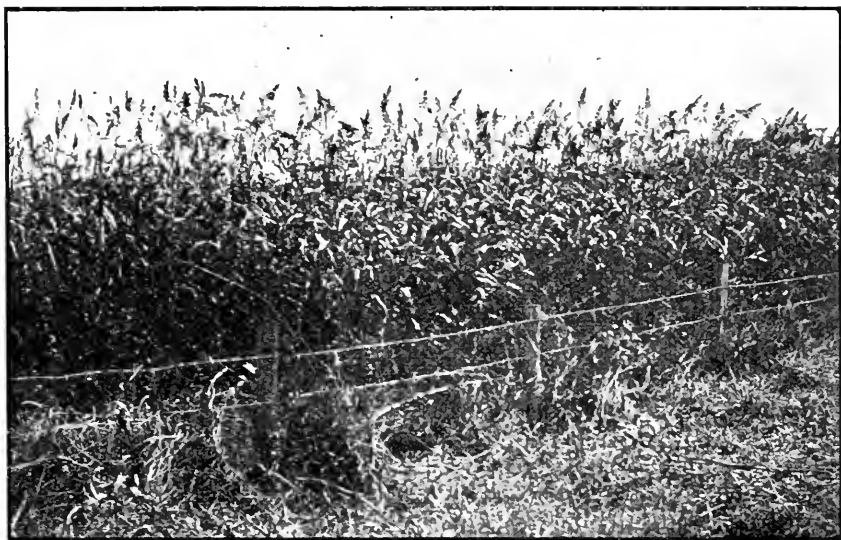
Although sorghum makes its best growth where the rainfall is large, it must not be assumed that such a condition is necessary. The feature which renders this crop so valuable is the capability of withstanding drought, which it possesses in a higher degree than any other crop of such a succulent nature. The young plants are somewhat delicate, and require fairly good conditions, but, when once established, they will go through extremely dry periods without being adversely affected. The crop merely lies dormant, and, when rain falls, immediately makes a vigorous growth. Maize, under such circumstances, becomes stunted, and fails to recover. This renders sorghum one of the most suitable crops for districts where the rainfall is precarious.

Provided the seed germinates well, and the young plants get a good start, a crop is practically assured. A regular rainfall is not required; a good fall or two at any time during the growing season is sufficient to cause a heavy growth.

Sorghum is susceptible to frost whilst growing, but, after it has reached maturity, it is not affected to nearly the same extent as maize. Further growth is prevented by frosting, but the leaves and stems do not lose their succulence, and its valuable nature as feed is maintained for a month or more afterwards. This renders sorghum useful for continuing the supply of green feed into winter. A practice which is largely followed in providing feed for dairy cows, is to sow maize at successive periods, so that it will provide feed until about May, when it is expected that frosts will cut it down and render it practically useless. A supply is then ensured by planting sorghum about January, which will continue the supply from May till the end of June. Where the soil is good and the climate favourable, it is frequently sown earlier and cut so that a second growth will be made for winter feed. By combining sorghum with maize in this way, a continuous supply of green feed is obtained until the autumn-sown cereals are available.

Varieties.

Owing to the readiness with which sorghum varieties hybridise with each other, new sorghums are from time to time put on the market under various names. A satisfactory classification, therefore, according to botanical characteristics, based mainly on the flower, is practically impossible. Certain economic features such as the habit and character of the entire plant, including the sap content, should be taken into account, as well as the general shape and colour of the head.



General View of Saccaline growing at Wollongbar Experiment Farm.

Since practically all the saccharine varieties were grown in America prior to being introduced to Australia, the American classification should be adhered to as closely as possible in order to avoid confusion. This is as follows:—

(1) *Amber Cane group*, represented in Australia by the well-known Amber Cane, and also by *Sorghum saccharatum*. The heads or panicles are large and loose, but usually present a more or less conical shape; that is, broad at the base, and pointed at the top. The stalks are generally more slender than in the other varieties. The seed is comparatively large, brown in colour, with black hairy glumes (chaff). These glumes are not so easily removed from the grain in threshing as in Planter's Friend. Amber Cane is a quicker growing variety than Planter's Friend, and, owing to its superior drought-resisting qualities, is a more suitable variety for the dry western districts, such as on the slopes. Its yield, however, in coastal districts is much lower than that of Planter's Friend, and the latter has been preferred by farmers during the past few years. It will not endure frosts to any extent, and much earlier planting than Planter's Friend is required. Amber Cane is sufficiently mature to cut four months after sowing, and is, therefore, useful for supplying summer green feed. The fine stems also render it a suitable kind for conversion into hay.

Sorghum saccharatum has a head somewhat similar to Amber Cane—open and spreading. The glumes (chaff) are jet black in colour, and encircle the grain to a greater extent than in Amber Cane, and much more persistently during and after threshing. *Sorghum saccharatum* is best adapted to a good rainfall and warm conditions. Under such conditions it produces high yields, but without plenty of moisture it is invariably inferior to the other varieties, while in the dry interior, experiments show it to be practically worthless.

(2) *Orange group*.—In this group the stalks are larger and heavier than in the other groups, while the seed-heads are slightly more compact than those of Amber Cane, being commonly about 3 inches wide and 5 to 7 inches long, varying from an oblong outline to a fan-shaped, with the top of the panicle loose and open.

In all probability the new variety known commercially as Saccaline has been derived from forms (such as the Collier type) of this group. This sorghum was introduced from Victoria, and is undoubtedly an improved strain of sweet sorghum. It has quickly jumped into favour, on both the North and the South Coast, and remarkable yields (up to 20 tons per acre) have been recorded. Its growth in warm weather is so rapid that it can be recommended for cleaning up old paspalam pastures. Saccaline is particularly characterised by sweetness and palatability and by its ratooning (stooling) habits. Ratooning takes place after each cut, and thus many good cuttings may be obtained in a single season.

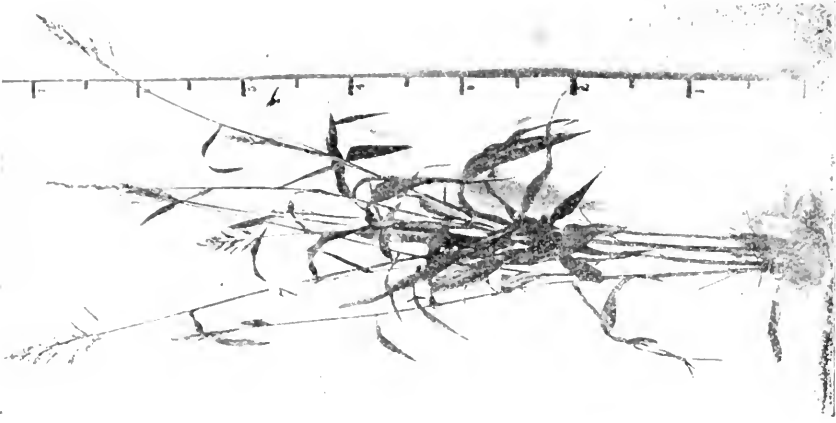
In appearance the growth of Saccaline closely resembles that of the Planter's Friend type, but it shows a more vigorous leaf growth. The seed-head, however, differs from all the other types in being semi-compact in shape and of a brick-red colour. The grain projects almost entirely from the glumes, which are very small, but, as in the other types, black in colour. Under the influence of weathering the grain generally takes on the mottled appearance seen in Planter seed.

(3) *The Sumac or Red Top group*.—This group is well represented in New South Wales by Planter's Friend, one of the Imphee types originally derived from South Africa. This is a stout variety, with large, broad leaves, and the seed heads are thick, cylindrical and erect, 6 to 9 inches long. The side branches are very short and full of seed, which is brown or brownish-red in colour. The glumes are small, much shorter than the seed, hairy and varying from deep red to black in colour. Usually, most of the glumes are separated during the process of threshing.

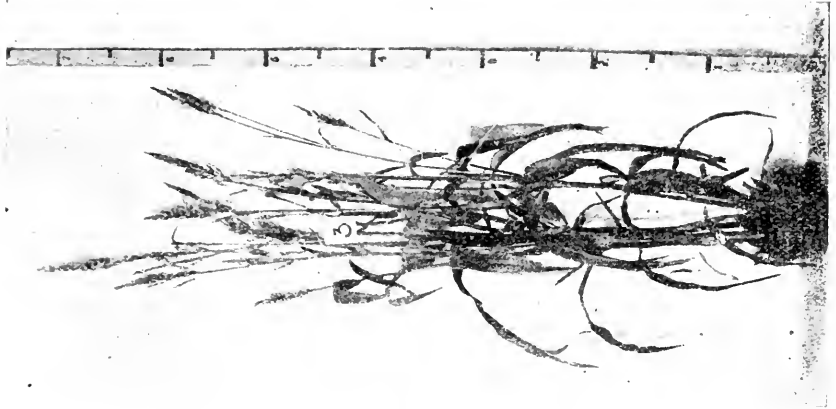
Planter's Friend is about five weeks later than Early Amber Cane, and is a favourite variety for autumn or winter feed. When it reaches maturity it is not so easily affected by frosts as some other varieties, and retains its succulence for some time. After some growth has been made, it develops astonishing powers of withstanding drought, and may lie dormant for two or three months during a dry period, to recover wonderfully when rain falls.

In experiments carried out in coastal districts this variety generally yields higher than Amber Cane or *Sorghum saccharatum*.

(4) *The Goose-neck group*.—As far as is known, this group is not represented in New South Wales amongst the sweet sorghums.

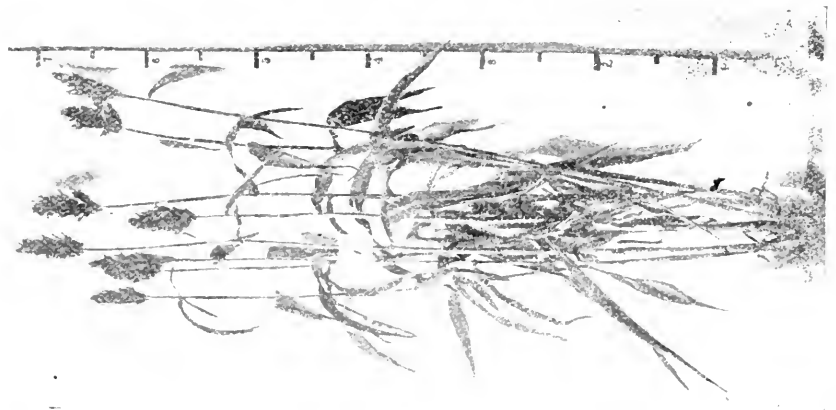


Sorghum saccharatum.



Varieties of Saccharine Sorghums.

Early Amber Case.



Planter's Friend.

Preparation of the Soil.

The preparation is largely determined by the nature of the soil, character of the climate, and the time of sowing. It is primarily intended to bring into action the inert or unavailable plant-food to facilitate the growth of roots, and to place the soil in such a condition that it will absorb the warmth and moisture essential to germination of the seed and to growth.

In all cases deep ploughing should be given to allow the extensive root system to freely develop. The luxuriant growth makes heavy demands upon the soil moisture, and even in districts which normally have a good rainfall it is as well to prepare for possible contingencies by encouraging the roots to extend deeply into the soil.

On the coast, where land is very valuable, fallowing to any extent is not admissible except under special circumstances, and fertility must be maintained by rotation and judicious manuring. The land is usually heavily and continually cropped, and lengthy periods are not available for preparation. The best system to follow is to plough the land deeply immediately it is available, and work it down well with heavy harrows. Allow it to lie idle until it is time to sow, and then cross plough and sow at once. The second ploughing should only be shallow. During the time the land is lying in a worked condition, ameliorating agencies are at work in the surface soil, bringing it into a more fertile and sweetened condition, and it is extremely inadvisable to bury this good soil by deep ploughing. Young sorghum plants, like all others, have not the power of taking up plant food from the soil that old plants have, and their growth must be encouraged by giving them the very best conditions. Apart from this, deep ploughing tends to loosen the soil and increase the loss of moisture by evaporation, and this must be guarded against.

In districts which are normally dry it is necessary to adopt a different system of cultivation. Good crops of sorghum, like good crops of other kinds, can be obtained for many years without any special preparation, but there are years when failures result if such a practice is followed; and when cows or sheep are to be fed chances cannot be taken. A supply of feed must be provided, and this can only be done by timely working of the land. In this, fallowing is an essential process, and although it has its drawbacks, as for instance the loss of the land for some time, the certainty of a crop more than counterbalances them.

It must be remembered, that, to secure a good crop in dry districts, it is necessary to augment the rainfall of the growing season by conserving moisture before the crop is sown. Nearly half the battle is in getting a good germination and a vigorous start. If the rainfall is depended upon this cannot always be obtained, but by good preparation it is assured, and the crop is then in a position to take full advantage of later falls. The moisture which is held in the soil is important, not because of its total quantity, but because of the fact that it is held in such a position that it germinates the seed and starts the crop off well. Sowing can then be done independently of the weather, at the proper time for doing so.

To obtain such a favourable soil condition it is necessary to commence work early. The time varies according to the time the crop is to be sown, but it should be about three or four months previously. A deep ploughing should be given and the soil harrowed at once, or, if dry, immediately sufficient rain falls to soften the hard clods. Harrowing or cultivation is required at periods of about a month, until just before sowing, when the

ground should be given a shallow ploughing and the seed sown immediately. It may appear that the use of the harrow is a mere detail, but it is really a matter of extreme importance and should not be neglected. By keeping the surface loose and broken it checks evaporation and thereby helps to achieve the main purpose of the work.

On poor soils it is necessary to follow very much the same method as that just laid down for dry districts. In this case, although a different object is sought, the means used are similar. It is necessary to release the dormant



Harvesting with Reaper and Binder.

plant food to render the soil sufficiently fertile, and it may be briefly stated that preparation undertaken to conserve moisture is one of the chief ways of doing this also. Green manuring is particularly necessary on this class of land to keep it in good heart.

Manuring.

The soil should be kept in good condition by the application of farmyard manure or by green manuring. Humus is supplied by these means, and it is essential to keep the soil in good friable condition, and to maintain its power of retaining moisture. Farmyard manure is, unfortunately not available, except in rare cases, but its place can be satisfactorily taken by crops which are treated in such a way that a considerable amount of organic matter is returned to the soil. Leguminous crops are preferable, as, besides supplying humus, they materially increase the supply of nitrogen in the soil by drawing upon that in the atmosphere. Good results can be obtained from cowpeas, field peas, vetches, or clover, according to the suitability of the climate and soil for them. Cowpeas thrive on all classes of soil and in wet or dry climates, provided they are warm enough. Field peas, vetches and clovers require good loamy or clay soil and a cool, fairly moist climate. The most satisfactory method of dealing with these crops, to obtain the best results from them, both as feed and as soil renovators, is to feed them off and plough under the residue. By this means the soil is wonderfully improved, and at the same time some monetary return is obtained in milk, meat, or wool.

Where farmyard manure is available, it can be applied broadcast at the rate of 10 tons per acre, and lightly harrowed in.

Green manuring is not sufficient in itself to maintain the fertility of the land; neither is farmyard manure. Artificial manures are also required to make up the deficiencies. As the result of many experiments with fertilisers for sorghum on the North Coast, an application of 2 cwt. superphosphate per acre is recommended where farmyard manure has been applied, or where green manuring has been practised. Where the soil is deficient in decaying organic matter, and consequently in nitrogen, $\frac{1}{2}$ cwt. sulphate of ammonia or nitrate of soda should be added to this superphosphate.

On the South Coast and Southern Tablelands where the yields of fodder are lower than on the North Coast, from 1 to $1\frac{1}{2}$ cwt. superphosphate per acre is recommended.

The manuring depends very largely upon the nature of the soil. On light sandy soils more potash, and possibly more of the nitrogeous manure, are required, while on good clay soils less potash may be used. Superphosphate, or some other form of phosphatic manure, nearly always gives good results on all classes of soils, and should not be omitted.

Superphosphate is particularly valuable in promoting vigorous development of the young growth, especially in the early spring and in cold climates where young sorghum plants are apt to grow slowly, and become choked by weed growth, if they have not the stimulation that is given by this fertiliser.

The artificial manures should always be sown with the seed by using a fertiliser attachment on the drill. If the seed is sown by hand in drills, the manure should be scattered along them first. As good results cannot be expected from manure sown broadcast, as are obtained when it and the seed are put in it together with a drill. The manure is then placed in such a position that it can be utilised immediately by the young plants, and fulfils one of its functions by inducing a vigorous healthy start.

Sowing.

Experiments and a study of climatic conditions have shown that the best results are obtained by drilling, and broadcast sowing is not advocated. Broadcasting may give good results under ideal conditions, but if the soil is inclined to be at all rough, an uneven or poor germination results. Again, if the soil is inclined to be weedy, cultivation cannot be carried out on the young crop to suppress the weeds; whereas, when drilling is followed, cultivation can be carried out between the rows whilst the crop is growing, thus materially assisting growth by checking the loss of moisture from evaporation. The difference effected is often the difference between success and failure. When drilling is followed, a more even germination can be obtained if the surface of the ground is dry, as the seed can be placed in moist soil. In one experiment conducted at the Hawkesbury Agricultural College broadcast seed entirely failed to germinate owing to a dry surface, while drilled seed on the same block germinated perfectly.

In drilling, two methods are followed. The seed is either sown on the flat—that is, no furrow is opened out, or a furrow is made about 4 inches deep, and the seed sown at the bottom with a corn-dropper fitted with a seed-plate of the proper size. The furrow is made by using a special plough fitted with a mouldboard to throw a furrow to each side, or by an ordinary plough with a fairly long low mouldboard. The furrow method is the better where the

surface is dry and the lower ground moist, as the seed can be placed where it will germinate. It is sown on the flat by using a corn-dropper or (for large areas) a wheat drill with some of the holes closed so that the rows are made the proper distance apart. The best distance is about 3 feet (or every fifth drill). For coastal districts 6 to 8 lb. of seed are recommended, but for the interior, where less moisture is available for the plants, only 4 or 5 lb. per acre are required.

Cultivation.

The young plants take from five days to a fortnight to appear, according to the condition of the soil and the variety. Whilst young the plants are tender and susceptible to illtreatment, and whatever cultivation is given must be done carefully. A very narrow-toothed cultivator is useful, as it will not smother the young plants with soil. After a fortnight or three weeks, however, the plants become hardy, and commence to grow rapidly. Cultivation must be consistently carried out from this time until the crop is almost at the flowering stage, with the double object of conserving moisture and of destroying weeds. The frequency depends upon the weather, but usually it is needed about once a month. Moisture is rapidly lost by evaporation when a crust forms on the surface of the soil, and this must be prevented by cultivation. Every fall of rain creates this crust, and cultivation should therefore be given after every shower. Careful cultivation enables a crop to be grown under dry conditions, as a greater proportion of the soil moisture is effectively used in leaf and stem production.

In addition to checking loss of soil moisture, cultivation prevents the growth of weeds. These are of no value to the farmer, and lessen his profits by preventing the proper growth of the crop. They exhaust the moisture in the soil and deplete its fertility, robbing the rightful crop. When weeds become well rooted, it is almost impossible to deal with them, but if attacked at the right time they are comparatively easily destroyed. The best time to kill them is when the seed has just germinated. Timely cultivations do this by disturbing them in their beds, so that even if it is not necessary to cultivate to conserve moisture it should be done, as often as required, to prevent the weeds getting a foothold.

Several kinds of implements suitable for cultivating sorghums are available. On small areas the one-horse cultivators are quite satisfactory, but where large areas are sown a two-horse implement is preferable, owing to the rapidity and cheapness with which the work is done. It straddles the rows, and can be used until the plants are 3 to 4 feet high. After this, cultivation is rarely needed, as the plants protect the soil sufficiently, but should it be required, a single-horse cultivator must be used.

Many of the sorghum roots exist near the surface, and cultivation must be fairly shallow, to avoid injuring them. Generally, about 3 inches is deep enough to be effective, and little harm is done to the roots. It is important that the cultivation be carried out from the commencement of growth. It encourages deep rooting, and no injury will be done by cultivating implements, but if the crop is allowed to grow for a couple of months without cultivation, and it is then given, the crop will be seriously injured. The roots will have formed in the surface soil, and the severance of them by the cultivator tines robs the crop of a large source of supply of plant-food and moisture.

Harvesting.

The crop should not be harvested until the seed has formed in the head, and has reached the milky stage. At this time the greatest yield is obtained and the food is in the most palatable and digestible condition.

It is not advisable to allow the crop to become too mature, for, although the sugar content may be greater and the crude cellulose less in the matured cane, digestion experiments show a much greater digestibility for the carbohydrates, when the crop is in the milky stage.

Several methods of harvesting are followed. A sickle is frequently used, but this method entails considerable labour. Small hoes, with short handles, are more effective, and when the operator has had a little practice, the plants are easily severed with a stroke of one hand, and caught and carried in the hollow of the other arm.

A very useful, inexpensive implement for cutting sorghum or maize can be made by attaching a scythe blade to a small sledge. This is drawn by a horse close to the row, and in a good standing crop does excellent work.

The maize harvester, which cuts and binds the crop, is a splendid machine, and easily the best for handling either maize or sorghum grown in rows, providing the plants are not too short. The handling of the crop is much facilitated by its use, and the stalks are tied in bundles of convenient size.

Harvesting for Seed.

Without special machinery the best method of harvesting the seed is to harvest the whole crop in bundles with the maize harvester or reaper and binder, when, if the crop is uniform, the heads can be easily removed by a few cuts with a sharp chopper from the rest of the bundle. The grain is then best removed by the wheat thresher or header. If the concaves of corn-shellers are set fairly closely, these will also act, or if more pegs are attached to the drum of the broom millet heckler, this, too, should be effective.

Feeding Value.

Analyses of sorghum green fodder have been made in the case of Planter's Friend and Saccaline grown in New South Wales. The results show a very high percentage of carbohydrates, but a very low one of protein. Saccaline has a higher nutritive value than Planter. On account of the greater quantity of food nutrients in maize, it is a superior green feed. A right proportion of protein and carbohydrates is absolutely essential to get the best results from the animal to which the food is fed, and consequently sorghum should be fed in conjunction with other foods—such as lucerne, hay, or bran, which are rich in protein. Palatability is an essential feature in feeds, and sorghum possesses this quality in such a degree that it is greedily eaten by stock. Besides being a valuable food for dairy cows, it can be very satisfactorily used as green feed for pigs.

The yield of greenstuff per acre varies, but under ordinarily favourable conditions, is about 15 tons per acre. Where the rainfall and soil are good, it does not produce as heavy a crop as maize, but under unfavourable conditions the average yield is higher.

Sorghum Silage.

The silage when well preserved is excellent food, and is relished by stock. Owing to the high content of saccharine juice it is slightly more difficult to cure sorghum into sweet silage than maize. During the fermentative processes which occur in the transformation of green material into silage, the

sweet juices are readily attacked and converted into acids. When the crop is cut at the right stage, however, and precautions taken to exclude air, very satisfactory silage results.

The crop should not be cut when too immature, but just after the seeds have begun to harden. At the same time it should not be allowed to become too fully mature, as the proportion of fibre rapidly increases at maturity. There is not as much difference in the protein content of sorghum and maize silage as in the case of the green fodder, and the protein content may be increased by mixing with cowpeas or some other leguminous plant, when the chaffing is being carried out. Cowpeas go through fairly easily if they are fed to the machine on top of a light feed of sorghum.

Excellent stack silage has been made from surplus growth of sorghum at the Hawkesbury Agricultural College, and it was readily eaten by stock.

Sorghum Hay.

Sorghum makes excellent coarse hay. The fine-stemmed sweet varieties are the most suitable, and when properly cured the hay is very palatable to stock of all kinds. Sorghum which is not required for green feed can be effectively conserved as hay when the quantity is not sufficient for conversion into silage. It has been utilised by some farmers in this way, but the practice is not widespread. This is chiefly due to want of knowledge of its value, as in the drier regions of America it is extensively used, especially for fattening steers.

The hay is made by cutting the crop when the seed has formed, and after partially drying, it is gathered into windrows or small cocks, and finally into bunches of about 1,200 lb. It is either allowed to remain in these until required for feed, or after further drying, put into stacks like ordinary hay. The stems will not shed water, and when the stacks are built outside, it is necessary to protect them from rain by thatching or some other covering.

Farmers have also found that sorghum dried and cut into chaff is an excellent substitute for wheaten or oaten chaff.

Improvement by Selection.

It has been definitely established that sorghums can be considerably improved by a process of selection, producing a much greater yield, higher sugar content, immunity from "rust," and quicker maturing qualities. The head-to-row method is the best and quickest for such improvement. Marked plants should have the heads bagged as soon as the flower begins to form: such bagging will be effective in preventing cross pollination. When the pollen of the flowers enclosed by the bags has done its work in fertilising its own seed, and is "dead," the bags should be removed to prevent mouldiness.

In working up a stock of seed from the selected plant, it is often necessary to isolate the row or rows of such seed from other varieties, in order to keep the variety pure. Two or more varieties can be safely sown in contact with each other if the flowering periods are different, or sometimes the difficulty can be removed by sowing equal maturing varieties at different periods.

The best varieties should eventually be narrowed down by the farmer to a best single variety, and further extension is then an easy matter. In working up a stock of seed of a good variety care should be taken to isolate the paddock from other plants with which it is likely to cross, such as Sudan grass or broom millet. Uniformity of crop should be continually aimed at,

and plants of smaller stature, or those differing in any marked respect from the type, should be hoed out before they flower. If neighbouring farmers are growing sorghums or other allied plants, the seed should be harvested only from the centre of the paddock, and the outside rows neglected.

There should be a ready demand for sorghum seed true to type, as most of the seed sold at present produces crops notorious for unevenness, and sometimes containing Planter, Amber cane, and broom millet types. Such crops are not only unsightly, but they are often inferior in sap content and more difficult to harvest.

Sorghum Poisoning.

Cases of death have occurred frequently amongst cattle feeding upon sorghum. The deaths have been attributed by some to the presence of a poisonous substance in the plant, whilst others hold that they are caused by hoven, and the crop is not more likely to cause death than any other green food. The suddenness of death, however, amongst stock after eating only small quantities of the plant seems to indicate that some other cause than the one which results in hoven is at work.

Sorghum poisoning is of fairly common occurrence in Australia, and has also been reported from America and Egypt. The latest investigations in the prussic acid content of sorghum have led to the following conclusions:—

- (1) When sorghum is grown on poor, infertile soil, added nitrogen may slightly increase the amount of hydrocyanic acid in the plant. With a fertile soil and abundant nitrogen, this effect may not be produced.
- (2) During the first three or four weeks of the plant's life the prussic acid is concentrated in the stalks. Then it rapidly decreases and disappears there, but apparently persists in the leaves in decreasing percentages until maturity.
- (3) Climate and variety may be more important factors than soil nitrogen in determining the amount of the acid in the plant.
- (4) Complete hydrolysis of the glucosid is obtained by digesting the macerated tissue for two hours at 40 to 45 deg. Cent.; that is, the steaming of the crushed tissue as stated will remove the effects of the poison.

In feeding sorghum to stock it is only necessary to adopt certain precautions to avoid loss. Experience shows that it is only under some circumstances that it is poisonous. In some cases stock, after feeding on young sorghum, suffer no ill-effects, whilst in others death results. The poisonous substance gradually lessens as the plants get old, and entirely disappears by the time seed is formed. Stock should not be allowed to eat young sorghum, especially if it is wilted through dry, hot weather. Stunted sorghum may also cause death, and immature sorghum which has been frosted is dangerous. The mature sorghum is harmless, and can be fed with perfect safety. Apparently the poisonous properties in immature sorghum are destroyed when it is made into silage.

THE GRAIN SORGHUMS.

In early times the grain sorghums were those principally cultivated. This was probably due to the fact that the seed was one of the chief sources of diet of mankind, just as it is at present among many of the native tribes of Africa. As civilization progressed and social conditions changed, the use of the grain as an article of man's diet diminished, and for a considerable period the cultivation of the grain sorghums was not encouraged. Especially

was this so because the stems were not considered the best form of animal forage, owing to their pithy contents, and much better results could be obtained from the saccharine sorghums. Of late years, however, certain characteristics have been discovered amongst the grain sorghums which are highly important in the economy of farming, particularly in dry areas. These are—(1) their ability to set grain, sometimes in large quantities, under very adverse conditions; (2) the nutritive quality of the grain; and (3) the remarkable drought-resisting properties of the plants.

There are four varieties of grain sorghums of economic importance, namely, Kafir, Milo, Feterita, and Kaoliang.

The History of Several Varieties.

The Kafir grain sorghums were at first thought to be native only to the extreme southern portions of Africa, but of late years indigenous varieties have been discovered as far north as Rhodesia. They have probably been grown and the grain used as feed by the natives (such as Kafirs) from the earliest times. Even at present they furnish a very considerable amount of feed to the African tribes.

Their introduction to the United States of America dates back to about 1875, when the variety known as White Kafir was introduced. Of the three varieties, White, Red, and Black Hull Kafir, the last-named has been proved to be the best, and at present this is the variety which is mostly grown throughout the States. Some 750,000 acres are devoted to Kafir in the State of Kansas alone.

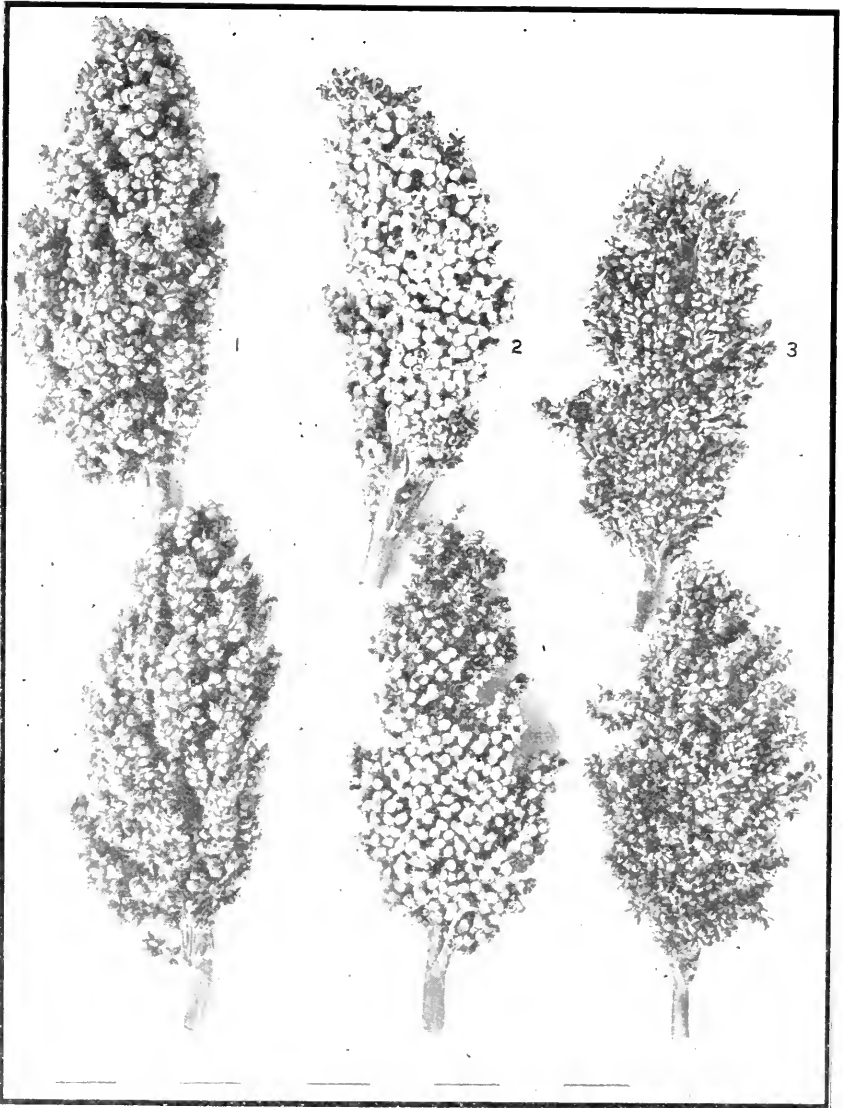
The Kafir type was probably the first grain sorghum to be grown in this State, although the first reference in the *Agricultural Gazette* (1892) was to the Dhurra type (Milo). At the present time Kafir is the grain sorghum best known among farmers.

The origin of Milo is uncertain. It is thought that it came from Africa; but all varieties, as far as South and Central Africa are concerned, are very much unlike Milo. A variety grown in Egypt, however, and known as Yellow Dhurra, is very similar to it. The introduction into America of this sorghum dates back as far as 1885, and it was probably not long after this that it was introduced into Australia. For many years it was grown in this State as Milo maize, sometimes as Yellow Milo maize, although there is no connection whatever between the sorghum and ordinary maize. When seed was obtained from Egypt it was often grown under the same name as in that country, such as Dhurra, Yellow Dhurra, &c. Thus a confusion of terms between Dhurra and Milo has arisen, whereas in many cases the two are identical.

The cultivation of Milo in this country has diminished to a considerable extent. This is probably due to (1) failure to appreciate the nutritive quality of the grain; and (2) the pendent or "goose-neck" seed-heads, a characteristic which has been entirely eliminated during late years as the result of selection and acclimatisation.

Feterita is one of the newest varieties of grain sorghums. It is a white dhurra variety of North Africa, but should not be confused with the old white dhurra type known as Egyptian or Jerusalem corn and native to the Barbary States. Feterita appears to be a native of the Sudan. In that country the seeds are of a greyish tint, but are much whiter when grown in the United States. There is no doubt, however, that the seeds of the plants grown in this State are more greyish than pure white.

In America, Feterita is quite a recent introduction. Although first imported in 1901, it was not particularly noticed until 1912, when, with a rainfall of 15 inches for the year, it yielded in Texas 58 bushels to the acre. Since then it has maintained its reputation as one of the best grain-producing sorghums in dry districts, and on this reputation it has been imported into this State.



Varieties of Grain Sorghum.

1. Milo; 2. Feterita; 3. Kaoliang.

Manchu Kaoliang is probably one of the oldest grain sorghums grown; nevertheless its introduction into European countries is quite recent. A very complete description of this variety was written by Carleton Ball, the American agronomist, in 1913, and much of the following has been culled from his bulletin.

The Kaoliangs, Ball says, comprise a group of grain-producing sorghums only recently introduced into cultivation. They are native to Eastern Asia, and are the only sorghums found there. The Chinese name is "Kaoliang," meaning literally tall millet, and pronounced "kowliang." Among the names applied to this sorghum by Europeans in the East are Tall Millet, Great Millet, Large Millet, Giant Millet, False Millet, and Barbados Millet. It is probable that this group of sorghums was originally brought from China into India; but this introduction took place many centuries ago, and the forms as we find them to-day in China and Manchuria probably vary considerably from the original importations.

Kaoliang sorghum is probably the principal crop grown in Manchuria, but it is also cultivated largely throughout China, and, to a small extent, in Japan. In Manchuria every part of the plant is utilised—the seeds for grain and wine, the stalks for fuel, laths, fences, baskets, &c., the leaves for fodder, and even the roots are used for fuel. In Japan, Kaoliang is principally grown as a windbreak.

The official introduction of Kaoliangs into America commenced in 1898, and many varieties have been tested. Of all the types, Manchu Brown Kaoliang appears to have given the best results, and it was this type which was imported into New South Wales.

Classification of the Grain Sorghums.

The four grain sorghums at present growing in this State may be distinguished from each other in accordance with the following table:—

Variety.	Leaf Growth.	Stems.	Heads.	Seed.	Order in which they mature.
Kafir ...	Abundant	Thick, juicy, and slightly sweet.	Long and fairly large.	White, comparatively small, with black hulls.	4
Feterita ...	Fair ...	Thick, inclined to tiller; juicy in young stages, but becoming pithy on maturity; juice not sweet.	Plump and compact.	Large, greyish	2
Milo ...	Fair ...	Of medium thickness, juicy in young stages, but becoming pithy on maturity.	Compact, very heavy.	Yellowish-brown, large.	
Kaoliang...	Sparse ...	Thin and long; always pithy.	Loose to semi-compact; light.	Brownish ...	1

Where confusion may arise.—In Kafir and Feterita the seeds are whitish in tint. In Kafir, however, the leaf growth is very abundant, the heads are generally long, the seed is small, and the plant retains its sap right to maturity. In Feterita the heads are much more compact, and the stems become slightly pithy as the plant reaches maturity. The seed also is much larger, not so round in shape as Kafir, with a bluish tint, and generally marked with irregular, concentric lines.

In Milo and Kaoliang the seeds are somewhat alike in colour, both being of a brownish tint, but that is as far as the resemblance goes. The plants of Kaoliang are taller and contain much more pith than the Milo, while the heads of the latter are much more compact, and the seeds far heavier than those of Kaoliang. The black hull of the Kaoliang seed, too, is very characteristic.



Feterita at Nyngan Experiment Farm.

Manchu Kaoliang can often be confused with Planter's Friend, as far as outward appearances are concerned. The distinction, of course, is made clear by the saccharine sap of Planter's Friend and the non-saccharine pithy character of Kaoliang. The seeds of Kaoliang also separate much more easily from the hull than do the seeds of the other.

Results of Experiments in New South Wales.

Kafir.—Although Kafir has in the past been the principal grain sorghum grown in this State, few data were available as to yield and habits of growth until comprehensive experiments were conducted by the Department, commencing some years ago. It has been tried at Hawkesbury Agricultural College, and at Cowra, Yanco, Nyngan, and Wagga Experiment Farms. It stands out prominently amongst the grain sorghums for its very leafy growth, and more succulent appearance in general. The seed germinates very satisfactorily under moist conditions: but the growth is comparatively slow throughout the growing period, and in this respect it

is easily left behind by the other sorghams. Kafir possesses good drought-resisting properties, and the leaf growth will remain green for a long period. This characteristic was particularly noted by the Experimentalist at Nyngan in a season which was very dry, when it was reported as retaining its verdure the longest.

Kafir has not succeeded yet, in any season, in setting seed at Cowra and Nyngan Experiment Farms. At Yanco Experiment Farm, under irrigation, however, and at Hawkesbury Agricultural College, with a good rainfall, some high yields of grain have been produced. At Yanco yields as high as 120 bushels per acre can be obtained, while at the College it has yielded 44 bushels against 40 of Milo.

There is very little to choose between the fodder yields of Kafir and those of Feterita and Milo, when grown inland under irrigation or in the coastal districts. Yields at Cowra were 4 tons 13 cwt. against 4 tons 4 cwt. of Milo, while at the College it produced 10 tons 1 cwt. against 9 tons 4 cwt. of Milo.

Kafir is the slowest of all grain sorghams to mature. In the interior it does not even show signs of flower until the others have almost matured their grain, while at the College in 1916-17 the figures given for maturing were—Kafir 112 days, Milo 98 days, Feterita 91 days, Kaoliang 75 days.

Owing to its inability to set grain in the interior, Kafir must be discarded as a grain-producing sorghum for those parts. The increase in fodder yields over those of Milo, Feterita and Kaoliang is also too slight to justify its growth for this purpose alone. Under irrigation it has so far succeeded best of all the grain sorghams in yield of grain, although there are strong indications that Milo, as it is improved in course of time by selection, will outyield it. On the coast, Kafir has proved undoubtedly the most successful of all the grain sorghams up to date. In coastal districts, however, the grain sorghams have maize to contend with from a grain-producing point of view; and it is only in districts where dry summer spells are fairly frequent, such as parts of the South Coast, that it can ever hope to compete with maize. From a fodder point of view much better results are, as a rule, obtained from the saccharine sorghams, such as Planter's Friend or Amber Cane, although the fungus which is rampant in the leaves of the sweet sorghams, and which is absent from Kafir corn, will probably be a matter for consideration in some districts. Some farmers are of the opinion, even now, that it pays, on account of this fungus, to grow Kafir in preference to Planter's Friend.

Milo.—Although Milo has been grown from time to time in this State, few data are available as to its success, and it has never been taken up to any extent. Experiments were carried out on a systematic scale some years ago, and since then selection and acclimatisation have eliminated, to a considerable extent, the objectionable features noticed in the first year's crop, viz., its goose-neck, pendent heads, and the small yield of the seed crop. The Milo, as it is grown to-day at the experiment farms and in farmers' experiment plots, is far different from and superior to the Milo of a few years ago.

Milo has been grown at Nyngan, Cowra, Wagga, Bathurst, and Yanco Experiment Farms, at Hawkesbury Agricultural College, and on farmers' experiment plots.

The germination of Milo seed has always been uniformly good, and it is not as sensitive to cold soils as is Feterita seed. Next to Kaoliang, it is the most rapid grower of all the sorghams. Tillering takes place when the plants are removed some distance apart, and under such conditions the crop sets its seed irregularly. The plant itself is fairly drought-resistant, but

the grain yield is seriously affected by adverse conditions. Unlike Feterita, the heads will not hold out until favourable conditions arise, and if the season is a particularly dry one, the yield is light. No amount of rain after the heads have once formed, appears to increase the yield to any extent. It must be noted, however, that it requires little moisture to produce a good grain crop, and in this respect Milo is one of our best sorghums.

In all cases, with the exception of farmers' experiment plots at Wee Waa and Inverell, Milo has consistently given higher yields than any of the other grain sorghums. The seed is always bright, plump, and heavy, and particularly characterised by the long period it will hold on to the head after maturity. This factor is distinctly advantageous in the harvesting of the crop.

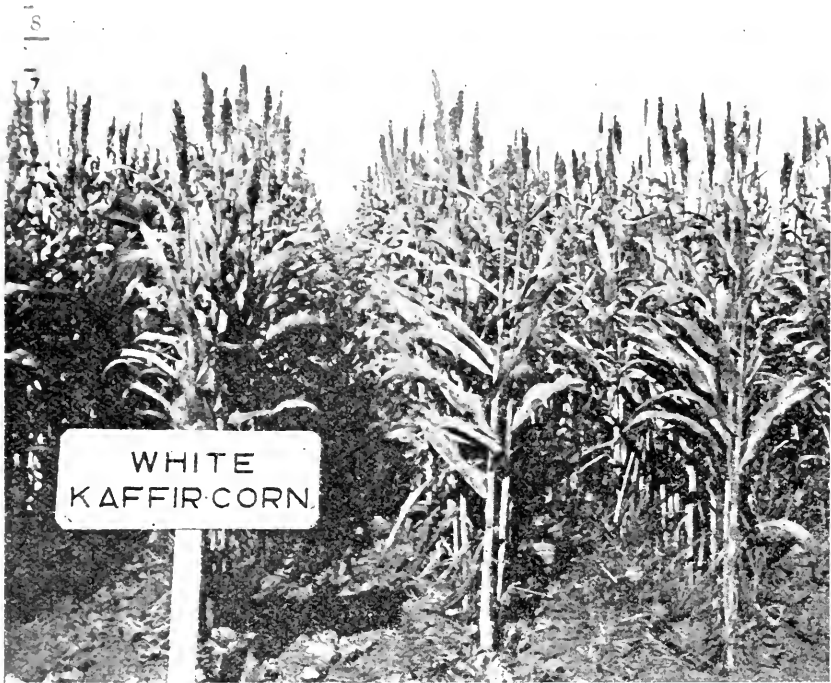
As a rule, Milo produces more fodder than Feterita or Kaoliang, but not so much as Kafir. In the western districts, without irrigation, it will yield up to 4 tons of green fodder per acre, while under irrigation it will reach as high as 9 tons per acre.

Milo, as a rule, matures later than Feterita or Kaoliang; but as earliness in maturity is a desirable factor, selection is being carried out with a view to modifying it in this respect. Up to date Milo is the best grain sorghum growing in the western districts without irrigation, and with the normal rainfall. It may be exceeded in certain seasons by Feterita or even Kaoliang; but its uniformity in growth, its capacity for setting a heavy crop with a small rainfall, and, lastly, the superior nutritive qualities of the grain render it most attractive, and perhaps best adapted to the larger portion of our semi-arid districts.

Feterita.—This sorghum has been grown at Cowra, Nyngan, Bathurst, Wagga, and Yanco Experiment Farms, at Hawkesbury Agricultural College, and on farmers' experiment plots. The seed of Feterita must be sown in warm soil if a good germination is desired. Failures have been recorded by sowing in cool wet soils, and it is the most sensitive in this respect of all the sorghums. Good seed has a high germinating capacity; the 1917-18 seed when tested gave a 98 per cent. vitality, and an excellent stand is therefore assured under favourable conditions. Feterita is rather slow in the first stages of growth, and the plants are inclined to tiller to a considerable extent. Whether this is advantageous or otherwise has not yet been decided. If the crop is desired for both fodder and grain the tillering may be a distinct advantage, but it leads somewhat to irregularity in the maturing of the grain. Although, as a rule, Feterita flowers later than Milo, it matures its seed very quickly, and can generally be harvested before Milo. In farmers' experiment plots at Inverell and Wee Waa it matured its grain even before Kaoliang.

Feterita is an excellent sorghum to tide over dry spells, both the stems and heads holding on remarkably well until favourable conditions arise for the grain to form and mature, which it does very quickly. It matures grain under adverse conditions better than Milo, but not as well as Kaoliang. At Cowra and Nyngan, and also in a farmer's experiment plot at Tallawang, Milo yielded higher than Feterita, but in plots at Wee Waa and Inverell in 1917-18 it outyielded Milo (40 bushels against 30 in the first case and by 24 against 21 in the second). Generally speaking, yields varying from 20 to 30 bushels should be obtainable in most parts of the Riverina. At Nyngan Feterita has yielded less than Milo and more than Kaoliang, and at Cowra less than both. Generally speaking, owing to the limited height of the plant which is much less than Milo and Kaoliang, it can hardly be expected to

produce as much fodder as the other grain sorghums: but it is very quick in maturity, being at least second, and sometimes first, of all the sorghums. This is an important factor in dry-farming districts, and one which is always kept in view in the process of selection. Feterita is one of our most promising grain sorghums for the interior, and its value should be considerable as a summer grain-producing crop. Its ability to set seed under adverse conditions renders it superior to Kafir, and its heavy seed heads make it superior to Kaoliang. It can only be equalled or excelled in most parts by Milo.



White Kafir at Hawkesbury Agricultural College.
Yield—10 tons of fodder and 44 bushels of seed per acre.

Kaoliang.—This sorghum has been tried in the same localities as the others, with the addition of farmers' experiment plots at Casino and Milton, and also at Grafton and Glen Innes Experiment Farms.

Kaoliang is easily the most rapid grower of all the sorghums. Its seed always germinates satisfactorily, even in such cold soils as Glen Innes, and it is always first to appear above ground. As a rule, it grows to a good height, with thin stems and not much leaf. It does not tiller or sucker in any way. Its roots are weak, and strong winds play havoc with the mature crop, levelling it to the ground in all directions. Hilling-up will eliminate this defect to a considerable extent.

Kaoliang is the most drought-resistant of all our sorghums, even more so than Kafir, inasmuch as it will not fail to set seed under the most adverse conditions. At Nyngan in the season 1915-16, which was extremely dry, 35 per cent. of the plants had flowered and set seed before any of the other sorghums showed any tendency to do so.

Up to the present the yields have been extremely small on the coast as well as in the interior (with and without irrigation). The plants set seed very readily, and produce big heads, but the seed is very light, and the yields suffer in consequence. The highest yields have been 15 bushels to the acre at Nyngan and 30 bushels on the coast. These yields are above the average, but there is a strong probability that by selecting for compact heads the seed yields will be considerably increased.

The thin stems and sparse leaves seriously affect the fodder yields of Kaoliang. Nor is that all: the stems are extremely pithy, and practically negligible from a feeding point of view. Yields of 3 tons per acre have been obtained from it in the interior.

Kaoliang is easily the quickest maturing grain sorghum we have. At Hawkesbury Agricultural College it matured in 75 days as against 112 days for Kafir.

This sorghum possesses two characteristics which render it extremely useful under certain conditions. These are (1) its quick maturing habits, and (2) its drought resistance and capacity for setting seed under the most adverse conditions. Another feature, of slightly less importance, is its ability to set seed, even when the season is very wet. The rain does not appear to drown the pollen as in the other sorghums. Under normal conditions it is very inferior to Milo and Feterita; but the presence of such characteristics outlined above, combined with the possibility of considerably increasing the grain yield by selection, may eventually render it of great importance in our semi-arid districts.



Milo (Grain Sorghum) at Hawkesbury Agricultural College.

Yield—3 tons 6 cwt. fodder and 35 bushels seed per acre.

Cultural Methods.

Time of Sowing.—Kaoliang can be sown earlier than the others, owing to the fact that it is not nearly as sensitive to cold conditions. Feterita must have fairly warm soil if a satisfactory stand is required. If it is desired to sow the four varieties at one time, this can be done early in October in the western and north-western districts, while on the Central Slopes and Riverina it would be better to wait until late in that month.

Rates of Sowing.—Just the exact amount of seed to sow per acre in different districts is still under investigation. Two factors must be considered, viz., (1) that the plants must not be too crowded in semi-arid districts if they are to gather sufficient moisture for their development; and (2) that by spacing too far apart in the rows, tillering is encouraged, which results in irregularity in the ripening of the seed—a distinct drawback as far as harvesting is concerned. It has been noticed at Nyngan that any



Manchu Kaoliang (Non-saccharine Sorghum) at Cunningham.

Yield of green fodder, 6 tons 1 cwt. per acre.

space of over 9 inches tends to produce tillering. At present 4 to 6 lb. of seed per acre in rows 3 feet to 3½ feet apart seems to give good results, and for the time being this rate of seeding is recommended, though it is quite possible that as a result of experiments this rate will be modified. Under irrigation a heavier seeding can be given.

Cultivation.—Inter-row cultivation is absolutely essential. It serves two purposes, viz., suppression of weed growth and improvement of the moisture-holding capacity of the soil. Just as in maize-growing, good yields cannot be expected if the cultivation is neglected. All the grain sorghums, with the exception of Kaoliang, are very slow in their early stages of growth, and can easily be smothered by weeds unless cultivation is carried out, which should be deep at first, but less so as the crop grows, or the root system is injured.

When to Harvest.—The right time to harvest depends on the manner in which the crop is to be fed to stock. If it is desired to feed it whole—stem, leaves, and grain—it should be cut when the seed is in the firm dough stage. The flag will remain fairly green and succulent up to this stage; but by the time the grain is quite ripe the stems have become quite pithy, the leaves dry and dropping off, and the feeding value of the green part of the plant considerably lessened. If, however, only the grain of the sorghum is desired, Milo and Feterita can remain some considerable time in the field without much deterioration or shedding of the grain. Kaoliang is the only grain sorghum likely to shed its seed if not harvested shortly after it is mature. Heavy rains, however, appear to seriously affect the colour and possibly the feeding qualities of the grain of Milo when it is quite mature.

Method of Harvesting.—If the cutting of the whole crop is desired it will be found that it is too heavy for the wheat harvester, and a machine like the maize harvester is necessary. Cutting the crop by hand and soiling it like maize or Planter's Friend is neither practicable nor desirable, owing to the habits of the plant.

If the crop is grown for grain only, there are different ways of dealing with it. The heads can be cut or broken by hand, as are the cobs in maize, and afterwards heckled, crushed, or fed whole. The ordinary grain-separator heckles the seed from the heads very readily. One of the best methods, however, of harvesting the heads is by means of the grain header—a machine after the style of the wheat header. If the crop is a uniform one, the wheat header could itself be used with advantage. If the cultivation of the grain sorghums is to be carried out in the future on a scale similar to that of maize, machines like these will become essential.

Feeding to Stock.

Methods of Feeding.—Grain sorghums can be fed in the bundle without threshing the seed, or the grain can be fed alone. If fed whole, it is necessary to cut, bind, and stook in the field. Care should be taken not to place too much in the barn at a time, owing to a tendency to develop mouldiness. The grain is much more digestible when fed cracked than when fed whole. If none of the teeth of the grain-separator are removed, most of the grain can be cracked in the heckling process.

Nutritive Qualities of the Seed.—That the seed of grain sorghums has a high nutritive content has been proved absolutely, both in actual feeding experiments and by chemical analysis. This nutritive value of the grain is increased by feeding with a leguminous plant, such as lucerne. The value of Kafir has been found to be only slightly less than that of maize; while the official analysis of the grain sorghums in this State showed that Milo had a higher feeding value than Kafir.

Where the Grain Sorghums are Valuable.—In those districts where maize-growing is impracticable or is undertaken with a risk, nothing better could be grown than the grain sorghums as a summer crop. Even on the Murrumbidgee Irrigation Area it is quite probable that grain sorghums will yield better and produce better returns than maize, if they were used as they should be. The value of good summer crops to the mixed farmer is of great moment. At the present time late summer and early autumn are generally critical periods for the sheep, and a crop of grain sorghums, whether grown for ensilage, hay, or grain, would be of considerable assistance. Farmers who have tried these sorghums during the past few years all speak well of them; and when minor difficulties, such as methods of harvesting and feeding, are overcome they should become popular and be grown much more extensively than at present.

Improvement by Selection.

Value of Selection and Acclimatisation.—It would be difficult to find a plant that will improve more as the result of selection and acclimatisation than either Milo or Feteria.

There were several objectionable characteristics in Milo when first grown. Amongst these were (1) goose-neck or pendent heads; (2) free stooling; (3) free branching; and (4) absence of uniformity in height and size of the plant. Goose-neck heads are very awkward to harvest, and also ripen more unevenly owing to shading, than erect heads. Free stooling and branching lead to irregular ripening of heads, as they do not all seed at the same time. Absence of uniformity in size of plant renders harvesting difficult, and also makes threshing awkward if the latter is done in the bundle. Now, as the result of selection, the goose-neck or pendent heads have been entirely eliminated in Milo and Feteria at the experiment farms, while free stooling and absence of uniformity have been considerably lessened. Just as in the case of maize, the farmer growing these sorghums can continually enhance the value of his crop by paying attention to desirable characteristics and selecting for the same. To avoid free stooling, the previous remarks concerning wide spacing in the rows should be noted.

Increase in Yield by Selection.—In selecting for increase in yield of grain, compactness and fullness of head should be chosen. The tendency towards “branching” in the head should be severely discouraged. Milo heads will often be found with branches at the base of the head, bearing none or little seed. These should always be discarded. Plants bearing the largest, most compact heads, should be chosen, due regard being paid to the desirability of having the height and size of the plants as uniform as possible.

Fungus Diseases of Sorghum.

Red Stain (*Fusarium* sp.).

In the coastal districts this disease is one of the most serious. Broom millet is badly attacked, the disease affecting the node of the broom, making it brittle, and some of the fodder sorghums are very liable to attack. Sudan grass and Johnson grass are also attacked. The disease appears as broad, reddish blotches on the leaf sheaths, and inside the stems of the plants as reddish strands or as extensive reddish colorations of the vascular tissue. The disease is known to be conveyed from plant to plant in the field. Sometimes the inside of a leaf sheath which holds water, or has been attacked by aphid, may be greatly reddened and diseased by this secondary infection. The disease is also known to be conveyed by seed, and through the soil by reason of the presence of old sorghum “trash” on which it can live.

The methods of control recommended are:—

1. Avoid a succession of sorghum or broom millet crops in the same land by adopting some form of rotation.
2. Use the cleanest seed procurable. No satisfactory seed treatment is known.
3. Select the most resistant and vigorous plants available for seed purposes. While it is very difficult, if not impossible, to get seed free from contamination, it is possible to greatly improve the type of crop with respect to the disease by selecting the best plants in the field. Saccaline, though not immune, resists the disease, and other varieties are being tested.

Head Smut (*Sorosporium reilianum*).

This soil-borne disease attacks sorghum as well as maize. When this disease is present, it is therefore inadvisable to consider sorghum as an entirely satisfactory successor to maize in a rotation, though for one to follow the other is a better practice from the point of view of disease control than continuous cropping with either. (See under Head Smut of maize, page 426).

Grain Smut (*Sphacelotheca sorghi* Lk. Clinton).

This smut can be distinguished from Head Smut by reason of the fact that it does not affect the whole of the panicle. Individual grains become diseased and instead of grain there is found underneath the outer covering membrane a mass of smut. The disease is conveyed to healthy seeds by the wind or by contact with diseased panicles during threshing. Seedlings become infected from spores borne in the seed.

Methods of control recommended are :—

1. Select seed from clean crops.
2. Treat the seed before sowing with bluestone and lime as recommended for Bunt in wheat (see page 336).

Leaf Spot or Anthracnose (*Colletotrichum graminicolum* Ces. Wils.).

This disease causes light-coloured spots outlined with red on the leaves and stems of sorghum, and in the case of broom millet may seriously affect the broom, discolouring it and causing it to become brittle.

No methods of keeping the disease in check have been devised. It is customary to harvest broom millet sufficiently early to prevent damage by this disease, which is able to make its most rapid progress on the tissue of the broom when it is nearly mature, especially under wet conditions. As a disease in the leaves it is of little importance.

Leaf Stripe (*Helminthosporium*).

This disease attacks some varieties of sorghum, e.g., Early Amber Cane, very badly, and is particularly prevalent in wet seasons. The characteristic appearance of the disease is the death of portions of the leaf in spots or in elongated areas, generally reddish or pink at the margin. The dead portions are white or brown in colour.

The disease is perpetuated by the growth of the fungus on old sorghum trash in the soil and by the spread of the spores of the fungus from plant to plant through the air.

To control it, avoid a succession of sorghum crops on the same land, and use a variety which, under the conditions of the district concerned, is normally free from the disease. Saccaline is freer from this disease than Early Amber Cane.

Rust (*Puccinia purpurea* Cke.).

This disease gives rise to reddish or purple spots on the leaves, and on these spots reddish or brown pustules occur and burst, liberating the spores. The disease sometimes reduces the yield of grain and fodder sorghums, and is known to live on Johnson grass and Sudan grass. The selection of a variety relatively resistant to attack is the only practicable method of control.

MILLET.

There are many varieties of this group of forage plants, which belongs to the same natural order as maize and grass, and is very closely allied to the sorghums.

It has been found of service to grow millet as a catch crop. The seed will germinate and thrive well on land recently cropped with wheat, rye, oats, or barley, or where a crop has failed, or between two crops. Millet is a good crop after clover, soy-beans, or other legumes. It is further known that it succeeds best on bare fallow. The cost of cultivation is low,



Crop of White French Millet.

as little is needed once the crop is in. It is found good practice to feed off the first crop, and allow the second to grow for hay. In any case, when fed off, the crop (*i.e.*, the stubble) should be harrowed, to loosen the soil and conserve the moisture. By this means a good second growth, in many instances heavier than the first, can be obtained.

As an example of the value of millet as a catch crop, the following experiment, carried out at Hawkesbury Agricultural College, affords a good instance. A portion of a paddock was prepared and sown in the

autumn for a crop of turnips. One hundredweight each of bone-dust and superphosphate was used as manure. Owing to the failure of the autumn and winter rains the seed did not germinate, and it was decided to test the White French millet on this land as an early summer crop. After cultivation the seed was sown broadcast, 7 lb. to the acre. From the 6th September to the 11th November, or sixty-five days, when the crop matured, there were falls of rain making a total of 5 inches.

The land was poor, sandy loam, and undrained. On 11th November the crop ranged from 3 to 4 feet high. The well-laden seed panicles in their green and succulent stage were very prolific, the broad, leafy foliage was at its fullest development, and the sturdy and juicy stems contributed in no small degree to build up a forage plant eminently suitable at that time of the year for green forage, hay, or ensilage.

By a series of cuts it was estimated that the crop averaged 10 tons of green forage per acre, and provided about 3 tons of coarse hay. It was cut with the reaper and binder, and whilst it was realised that such a crop would test the stability of the machine, yet, in the absence of special machinery, it was the only means of rapidly harvesting it at the most nutritious stage.

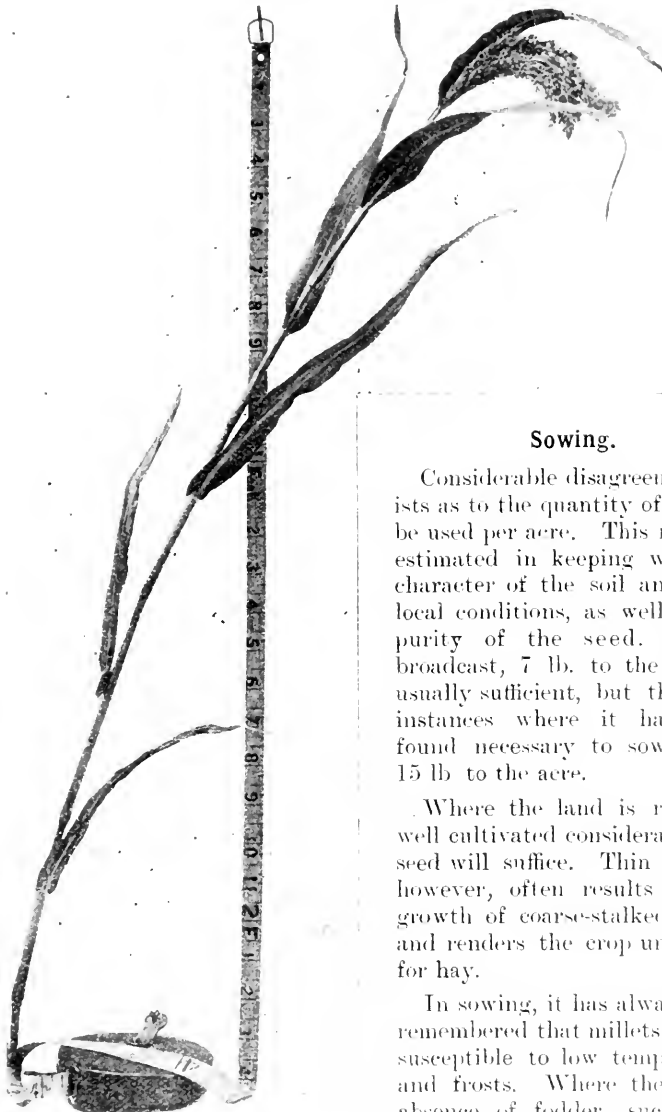
Varieties.

The various millets are recognised by the distinctive colour acquired by the ripened seed, and are grouped as white, yellow, or red. They vary considerably, even under those heads, and possess peculiarities in their growth and colour of foliage. The most useful varieties are Japanese, Hungarian, Manchurian (white and yellow), White French, and Pearl: of these Japanese is by far the most grown. It is perhaps the quickest growing of all plants cultivated on the farm, providing it finds suitable weather conditions. It may be grown for hay, green fodder, or to be fed off by stock—it is useful for feeding to all classes of stock and poultry. Japanese is about the best stooler of all the millets. Hungarian is useful as a hay variety, but is not a good stooler, and will not stand a dry weather pinch like Japanese. Where grain is required the Manchurian varieties will be found the most prolific; as many as 41 bushels of seed per acre have been taken from this class. The yellow variety is the best for seed: the ripened grain may be fed to poultry and pigeons with advantage in conjunction with other grains.

Soil.

The millets are very hardy. They require a medium quantity of moisture, grow luxuriantly on a variety of soils, and endure drought remarkably well. They do best in a mellow soil, rich in humus, but they thrive on a great variety of soils, and loams with a medium admixture of clay and sand answer well. It has to be remembered that this plant secures its nourishment chiefly from the surface soil, and it is good farm practice to stimulate that with readily assimilable fertilisers, or rotted farmyard manure, keeping in view the need for the supply of nitrogen, phosphoric acid, and potash in their most soluble forms. The fertilisers are best harrowed in, and the farmyard manure applied before ploughing.

Owing to its sturdy habits millet has always been found a splendid crop to grow on foul land to get rid of the weeds. It will give good returns on higher and drier soils than most grasses. Poor land will often produce a good crop providing there is a sufficient rainfall or some artificial or farm-yard manure to help.



Stem of White French Millet.

Sowing.

Considerable disagreement exists as to the quantity of seed to be used per acre. This must be estimated in keeping with the character of the soil and other local conditions, as well as the purity of the seed. Sown broadcast, 7 lb. to the acre is usually sufficient, but there are instances where it has been found necessary to sow 12 to 15 lb. to the acre.

Where the land is rich and well cultivated considerably less seed will suffice. Thin seeding, however, often results in the growth of coarse-stalked plants, and renders the crop unsuitable for hay.

In sowing, it has always to be remembered that millets are very susceptible to low temperatures and frosts. Where there is an absence of fodder—such as in periods of drought—it is best to sow continuously every two

or three weeks as long as there is warmth and moisture sufficient to germinate and raise the crop, while avoiding the danger of early frosts.

Occasionally spring-sown crops fail owing to dry weather conditions, and then a crop of millet fills the gap splendidly, as it may be taken off early enough to admit of the ground being prepared for autumn-sown crops. Under such conditions, there being little or no plant growth on the ground, the millet seed may be broadcasted and disced or spring-tooth cultivated in.

Late Sowing.

Millet can be used for forage, hay, or ensilage with equally good results. It may be sown to the end of January, and even later. Some advocate drilling the seed as against the usual method used of broadcasting. It is claimed that less seed need be used, and, further, that if the soil cakes, it

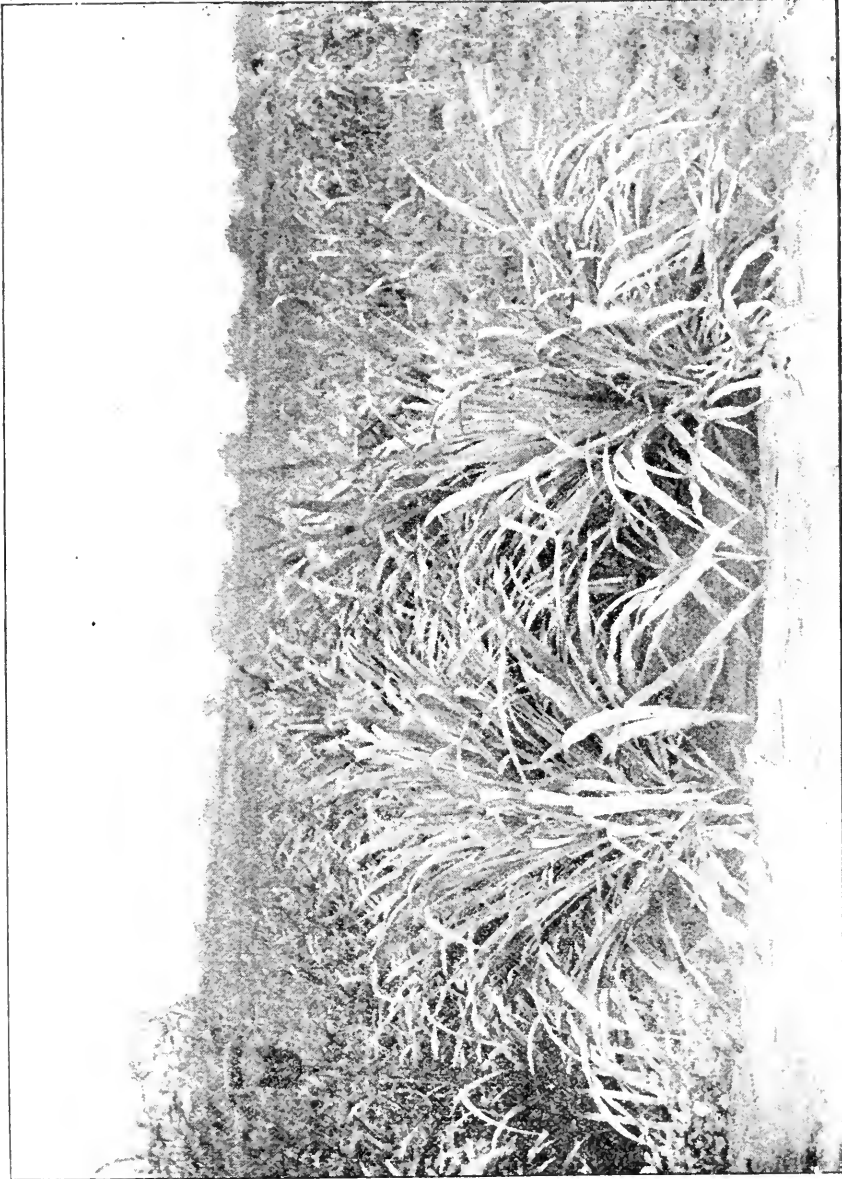


Hungarian Millet.

can be cultivated between the rows to conserve moisture. If for grain production or ensilage then drilling would be advantageous. More seed is required on exhausted soil than on new or rich soils. In all instances sowing should be carried out after rains, or when the soil is moist, in order to give the crop a start.

Harvesting.

The farmer has to exercise keen judgment to decide the time at which the crop is fit to cut for forage. This should be the stage at which it is richest in nutrients, and most palatable and digestible. When cut too green millet is laxative in its effect on stock. Further, it has to be cut before the seed in the panicles commences to ripen. Strict attention must be paid to this.



Pearl Millet, Wagga Experiment Farm.

When the majority of the seed-heads or panicles have formed in the green pendulant stage, then have the whole crop properly cut. It is better to err on the side of greenness. If too ripe there is a possibility of the food becoming unpalatable. The green crop is heavily charged with moisture in both stalks and foliage, and in consequence will take longer to cure than ordinary oaten hay. It should be placed in cocks and allowed sufficient time to



Manchurian Millet (Hsiao-mi White)
Grafton Experiment Farm.



Manchurian Millet (Hsiao-mi, Yellow),
Grafton Experiment Farm.

dry thoroughly. If the crop be intended for ensilage, then it may stand a little longer after heading out, but it must be cut prior to ripening. Unlike other crops, no liberties can be taken at the time of cutting. When converting millet into ensilage it is advisable to add a quantity of clover, lucerne, cowpea, or other legume, to increase the proportion of nitrogenous food.

Fodder Value.

Millet is one of the most nutritious and attractive of green fodders, and it is available at a time when the spring grasses have failed, and green fodders are scarce. It is essentially a summer fodder.

In point of digestibility the millets are similar, owing to their composition being approximately alike. From a variety of analyses we conclude that this class of fodder, either in green food, hay, or ensilage, is very useful for dairy cattle, sheep, and young stock. As pasturage it has been found to be excellent food for sheep and cattle—it is remarkable the amount of grazing a paddock of millet will stand providing it is stocked judiciously. Millets have no poisonous qualities, like sorghum, and may be fed when quite young. It is best not to start feeding off until the crop has attained a height of about 6 inches. After it has been well eaten down the stock should be removed until another growth is made. With suitable weather conditions this should be only a matter of days, as the growth is rapid. Japanese millet is by far the best variety for feeding off.

Effect upon Horses.

Considerable mistrust as to the wisdom of feeding with millet was aroused by the outbreak of an ailment known as millet sickness amongst horses in North Dakota. This was found to arise where the animals were fed exclusively on millet hay, but insufficient grounds were forthcoming to condemn it as a food. The adoption of a rational system of feeding, in which millet hay formed only a portion of a ration, soon dispelled the cause of complaint.

On horses, when the fodder was cut too green, it acted as a laxative, and when too ripe it over-stimulated the kidneys like a strong diuretic. It has also been noted that if the crop is cut on the ripe side the seed awns become harsh, and cause irritation.

It is, however, claimed by prominent stock-raisers and veterinarians, that a judicious diet, in which millet hay forms a chief ingredient, restores healthy functions, and stimulates the vigorous maintenance of vital energy.

SECTION VI.

Root Crops.

THE POTATO.*

THOUGH largely grown in New South Wales, the potato as a crop has not received the attention from farmers that is due to it, and for a number of years this State has had to import largely from Tasmania and Victoria to make up the deficiency in our production, the importations being almost equal to the quantity grown within the boundaries of the State.

The oft-asked question, why potatoes from other States are worth so much more than the local product, is best answered by visits to the wharves in Sydney harbour, where the interstate supplies are unloaded, and to the Alexandria railway yards, where our local produce is sold. The interstate potatoes are well graded, of good shape, free from dirt, and put up in new bags, whereas the local tubers, in the majority of cases, are of all shapes and sizes, and put up in second-hand bags which very often contain a large percentage of dirt. A few of our local growers pay special attention to their potatoes, with the result that their name is soon established, and buyers can purchase with every confidence, and consequently pay higher prices: but the bulk of our produce is marketed in anything but an attractive manner.

Preparation of the Soil.

Although the potato as a pioneer crop may be sometimes relied upon to yield good returns with little cultivation, it is usually found that the crop requires the best of attention in every detail.

On the coastal areas the extensive culture of potatoes during the autumn is not recommended, because the conditions favour Irish blight, and growers should confine their attention during this period of the year to the preparation of the soil for the spring crop by planting a preparation crop. Mr. A. H. Haywood, when Manager of Grafton Experiment Farm, advised farmers to practise fallowing between their maize and potato crops, even though the period was short. When maize is harvested in June the land should be ploughed at once, the stalks being turned under and allowed to decay, forming the humus that is so essential to fertility.

He found at Grafton that whenever the ploughing was left till immediately prior to sowing the succeeding potato crop, there seemed to be more trouble with insects as well as a reduced yield. "We never practise even that short fallow of a couple of months," said Mr. Haywood, "without getting better crops and greater freedom from insect pests."

On the tablelands the preparation of the soil should be commenced during the winter months. There are many advantages attached to early and thorough working of the soil, some of them being direct and others indirect, but all are quite important in relation to the final result.

* A. J. Pinn, Inspector of Agriculture.

The first direct advantage is the exposure of the soil for three or four months to the sweetening influences of sun, air, and frost, and the second the increased capacity of the soil for the absorption and retention of any rain that may fall. If this early ploughing is followed with cultivation by means of the spring-tooth cultivator, the effects are to preserve a surface mulch which conserves moisture, and at the same time to bring sorrel (which infests most of our potato soils) to the surface, so that the roots are exposed to the sun.

The early ploughing should be at least 8 to 10 inches deep, in order to ensure that when the seed is planted it will have a good depth of worked soil beneath it. The practice of many farmers of ploughing only 4 inches deep, and then putting the seed on the hard bottom, is the reason for many of the yields that compare so unfavourably with those obtained where better methods have been employed. Towards the end of the winter the land should be cultivated with the spring-tooth cultivator, and this should be repeated occasionally to conserve the moisture. If heavy rains have occurred during the period of preparation, it will be necessary to plough the land again; but in this case a shallow working will be sufficient. The effect is to open up and aerate the soil which has been hardened down by the rain, to give it a better physical condition, and to turn under any weeds that have grown. The aim in all operations should be to loosen the soil, as any rain which falls after the potatoes are planted will soon compact the seed-bed.

As stated above, one of the greatest advantages of this early and deep working is the absorption and retention of moisture.

The result of this treatment is that the soil is in such good condition when sowing time arrives that it is unnecessary to wait for rain to plant the seed. The farmer can start operations with the knowledge that he is sowing at the right time, and that he can go through with the business to the finish without delay.

Again, the grower can plant cut seed; but it is well known that if cut seed is planted in a dry seed-bed a poor germination and a patchy crop is the result. If, however, preparations have been made in the way advised, there is ample moisture in the soil, and a large area can be sown with cut seed, and no delay for rain be necessary at any stage.

The same reserve of moisture has an important influence on fertilisers, if they have been used. Soil moisture is essential for best results from fertilisers. If the soil is dry at the time of planting, the young plant derives no advantage at the start. It is true that wet weather at a later stage will have an effect upon the fertilisers, and the crop will benefit to some extent then, but one of the greatest advantages of these manures is the vigorous start they may give when first the seed puts forth leaf and root. This is lost if the land is dry at seeding time. Ensure moisture by early working if you want to use fertilisers with confidence as to the results.

Besides the benefits which thus attach to early ploughing and working of the soil, a large amount of plant-food is also released and made available for the needs of the crop. Analysis has shown that the bulk of our soils contain sufficient plant-food to produce potato crops for hundreds of years, but the trouble is that this plant-food is not in an available form, and on continuously cultivated soils it is only by a proper system of cultivation that a sufficiency of plant-food is secured for the crop.

Where potatoes are grown for early market the aim is to plant as early as possible—that is, as soon as danger from frosts is over—provided there is an ample supply of moisture. Nothing will be gained by planting in a soil that is excessively cold and wet. Covering with litter, such as straw, when the plants are breaking above ground, will often ward off the effects of frost. The covering of the land with litter immediately after planting is not recommended, as it reduces the soil temperature, and germination is slower and sometimes hindered.

On the tablelands, potatoes are planted most extensively during October, November, and early December—November being the month of heaviest planting. During October planting is always associated with a certain amount of risk, as the occurrence of frosts during early November is not uncommon. Although the haulms may be cut back by frosts, it is only very heavy frosts which entirely destroy the crop. Usually with late frosts the tops are at the most cut back to the surface of the soil, and fresh shoots are produced from dormant buds lower down the stem.

Seed Potatoes.

On the quality of the seed planted much of the success of the potato crop depends. When selecting seed the utmost care should be taken to see that the variety is true to type and perfectly free from disease. Always make it a point to obtain seed from a reputable seed merchant or some reliable grower. For main crops one or two varieties of sorts that have been tested, and are known to do well in the particular district on similar soil, should be selected.



A good whole Tuber Set,
about 3 oz. in weight.

In the tableland districts during past years seed potatoes have been picked in a haphazard manner, and have generally consisted of the grade between the "pig" and marketable sizes; in fact, anything that was left at the end of the season after all marketable tubers had been sold. With all other varieties of crops the seed is carefully selected from the best available, and it is apparent that some change should be made in the selection of seed potatoes. If growers object to planting large

potatoes, a system such as the following could be adopted:—

Each grower should select and mark in some way those plants that have the most healthy and generally attractive appearance. At digging time these plants should be subjected to a further process of selection, tubers being kept for seed from those that have borne in greatest measure potatoes of good type. This seed should be reserved for a special plot the following year, and should yield a considerable quantity of potatoes, all of which can be used as seed the next season.

It is only by selection that desirable types and high-yielding strains of potatoes can be retained, more especially since the advent of such diseases as Leaf Roll (see page 509), which so largely contribute to the degeneration of this crop. A system of continual selection on these lines would result very largely in the elimination of run-out or diseased plants.

The main trouble with our potato soils is the lack of organic matter. In new land there is always a good supply of humus, and the land when broken up is in good physical condition, but after a few years of cultivation all the organic matter becomes exhausted, and unless additional supplies are returned to the soil, either in the form of farmyard or green manure, the soil soon becomes compacted and consequently cannot produce a maximum crop.

The presence of humus in the soil improves its texture, lightening and loosening it, and preventing the compaction of the surface, so that it is of special value in the preparation of potato soils. The humus in the soil is the ingredient which is most subject to alteration and destruction, and under dry conditions it is more or less rapidly destroyed. As soon as it has lost its moisture and become dry, it is rapidly burnt out by the combined action of sun and air. As its presence is most essential where it is most liable to destruction, the necessity for renewing it is apparent.

In order to maintain this supply of humus, the following rotation is recommended:—

- (1) Potatoes.
- (2) Oats or wheat.
- (3) Field peas or rape.

The cultivation of the potato crop prepares the soil for the cereal crop, which in potato districts is usually oats for hay. After the hay crop is harvested the land should be ploughed as soon as possible so as to participate in the usual February rainfall, after which rape (February sowing) or field peas (March sowing) should be planted. Of the two, field peas are recommended. These crops can be utilised as sheep-feed during the winter, but they should not be completely eaten off, and care should be taken that the soil is not trampled out of condition by grazing heavily during wet weather. The crop residues should be turned under during late winter, and not later than August, the ploughing being fairly deep. The soil should occasionally be harrowed to conserve moisture, and should be in a fit condition for planting with potatoes during November.

Seasons of Growth.

For the purposes of this crop the State is divided into two sections as regards season, viz., coastal and tableland, the time of planting varying in different parts of the State, and growers must be guided largely by local conditions.

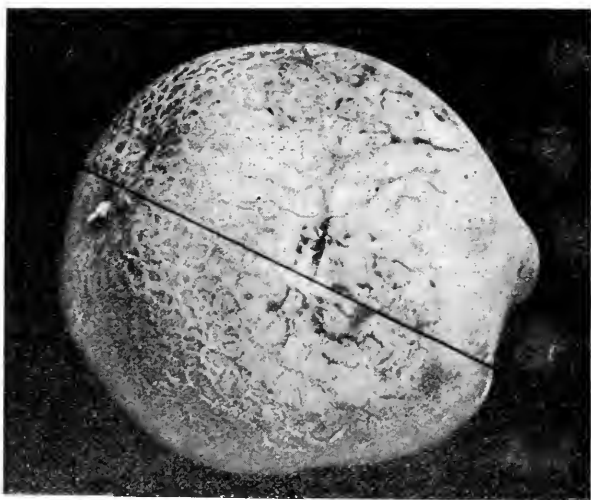
In the warm coastal districts two crops of potatoes can be grown each season. The first crop is planted in July or August, and is called the "spring crop"; the second, in January or February, is designated the "autumn crop."

The weather conditions generally prevailing throughout the growth of the spring crop are such as to be unfavourable to the development of Irish blight, and consequently damage is very rarely caused. This crop usually meets with a big demand, owing to the market being bare, and it realises

high prices. The autumn crop meets with conditions favourable to the rapid spread of the blight fungus, and in addition the tubers are marketed at a time when potatoes from the tableland districts are available, and prices are consequently low. The growing of the autumn crop on the coastal area is only recommended on a small scale sufficient to meet local requirements.

There is considerable diversity of opinion as to which is the best size of tuber to use as seed. Small potatoes can be divided into two classes—(1) the late-formed tubers of a strong, robust plant; (2) the produce of a plant of low vitality. The former would probably yield as well as its parent, but the latter could only be expected to produce a crop of poor quality. When small potatoes, selected from the pit, are used year after year, reduction in yield must follow, since every year the produce of weakly plants would be on the increase.

Experiments carried out by this Department with whole and cut seed have not produced results more favourable to one than to the other. If the season should be dry at planting time, it would be preferable to use whole potatoes, as the cut seed would dry out considerably before shooting, and consequently would not be able to give the young plant the same start



Tuber cut for two sets.

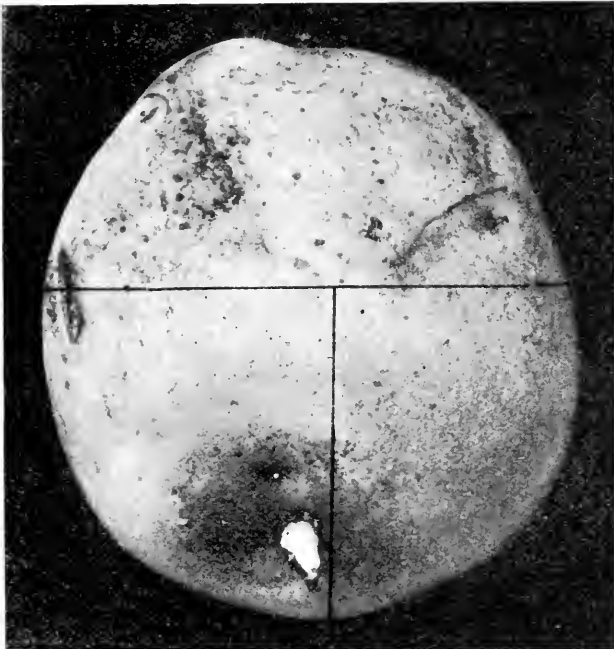
in life as a whole tuber. When cutting is resorted to, it is advisable that the planting should be done as soon as possible after cutting. The cut surface may be hardened by sprinkling with ashes or slacked lime.

In cutting the seed, the sets should be made as even in size as possible, with the least possible cut surface.

The practice of storing seed in large pits without providing ventilation has been the cause of a good deal of fermentation and consequent injury to the germ, with the result that the eyes of such seed fail to develop or the shoots are small and spindly, eventually dying off. In order to obtain seed

with strong vegetative power, it is essential that all heating and fermentation be avoided from the time the potatoes are taken out of the ground until planted.

As the condition of the seed has a big influence upon the yield, the following methods of treatment are recommended:—(1) Place the seed tubers in shallow boxes or trays, and store in a well ventilated and lighted room. The trays should be made with the ends higher than the sides; this will admit light and allow of a proper ventilation. By this method it will be found that the buds are short, dense, full of colour, and sturdy enough to resist fairly rough handling. Potatoes stored in this manner are not so liable to rot, and any diseased tubers can readily be removed, together with any that have produced weak shoots. The chief advantages of this system



Tuber cut for three sets.

are that the sets produce fine, healthy plants, and are in readiness for an early planting. As early crops are more likely to escape blight, this is in itself a big advantage in its favour. (2) A modification of the above method, which would involve less labour, would be to spread the seed as shallow as possible on the floor of a shed; or (3) store in a rick made of saplings, the floor of which should be about 6 or 12 inches above the ground level. The spaces between the saplings would allow plenty of ventilation.

For autumn planting on the coast only whole tubers should be used, as under humid conditions cut seed is liable to rot.

The amount of seed required to plant an acre varies according to the size of the seed and distance apart, ranging from 7 cwt. to 13 cwt. per acre.

Varieties.

The number of varieties grown in this State is large, but some of them are not of first-rate value. The following are the varieties recommended for various districts:—

NORTH COAST.

Up-to-date, Satisfaction, Early Manhattan.

LOWER NORTH COAST.

Early Manhattan, Satisfaction, Up-to-date, Factor.

SOUTH COAST.

Up-to-date, Early Manhattan, Early Manistee.

NORTH COAST PLATEAU (Dorrigo and Comboyne).

Langworthy, Factor, Coronation.

NORTHERN TABLELAND.

Main Crop—Coronation, Factor, Surprise.

Early Crop—Satisfaction, Early Manhattan.

SOUTHERN TABLELAND.

Factor, Up-to-date.

SOUTH-WEST TABLELAND (Batlow and Tumbarumba).

Main Crop—Factor, Coronation.

Early Crop—Early Manistee, Early Manhattan, Carman No. 1.

CENTRAL TABLELAND.

Main Crop—Factor, Late Manhattan, Surprise.

Early Crop—Early Manhattan.

Main Crop for Oberon District—Early Rose, Satisfaction, Factor.

MURRUMBIDGEE IRRIGATION AREAS.

Up-to-date, Early Manhattan, Early Rose.

Descriptions of Recommended Varieties.

The following are brief notes on the varieties recommended in the preceding table:—

Up-to-date.—A main crop variety. The tubers vary in shape from nearly round to long oval; the skin is white, usually smooth, but sometimes slightly rough; eyes shallow; a fairly reliable cropper.

Satisfaction.—A red-skinned variety of good shape. Being an early sort it is suitable for spring planting on coastal areas.

Early Manhattan.—A dark purple-skinned potato, mottled with white; flesh very white. Usually a good cropper, with a large percentage of marketable tubers.

Factor.—A white-skinned variety, very similar to *Up-to-date*, but has proved a better yielder in many districts. One of the best of the white-skinned varieties; eyes shallow, and tubers of good appearance and good cooking quality.

Early Manistee.—An early red skin. Tubers somewhat flattened; table quality excellent; shallow eyes.

Langworthy.—A white-skin variety. Tubers kidney shape, often tapering at "heel"; eyes shallow; sprouts purple. A variety which requires fairly good conditions; an excellent keeper.

Coronation.—A late-maturing variety; blue skin, mottled white, somewhat resembling Early Manhattan. Synonymous with New England Blue Skin or Guyra Blue. A heavy yielder under good conditions, but if the season is dry the proportion of small potatoes is very high. Particularly suited to New England and South-west Tablelands. Tubers of good shape.

Surprise.—A late-maturing variety, suited to the tableland districts. The tubers are rounded in shape, light-pink in colour, with deeper pink in the eyes. Wrongly known by some farmers under the name of Freeman. The large tubers have a tendency to become hollow, and are not the best of keepers. It is a splendid table variety, and the bulk of the tubers produced are of a marketable size. Little skill is required in grading to make an attractive sample. Very rich soils are not suitable to the growth of this variety, as over-large tubers are produced.

Carman No. 1.—An early white-skinned tuber of good appearance; somewhat inclined to second growth. One of the best varieties on granite soils.

Early Rose.—An old favourite which still retains a good deal of popularity among coastal growers. Suitable for early cropping. Tubers oblong, skin smooth, and red in colour; eyes are fairly numerous.

Late Manhattan.—A purple-skinned variety without white blotches. Grown fairly extensively in the Orange district as the main-crop variety. Usually a reliable cropper of good-shaped tubers. Flesh very white.

Planting and Cultivation.

The best depth to plant is 4 inches; it should not be more than 5 inches. The most common method of planting is by dropping at every third or fourth furrow during ploughing, according to the width of furrow cut and class of plough used. The rows should not be less than 27 inches apart, and a distance of 30 to 32 inches is preferred; on poorer soils this should be increased to 3 feet apart.

When the dropping of the potatoes is done by hand, the sets should be placed on the ploughed side of the furrow, reducing the possibility of their being damaged or knocked out of position by the furrow horse when being covered. The tubers are dropped from 12 to 18 inches apart, a good average being 15 inches.

On small areas the single furrow is in general use, but on the larger areas where the acreage under potatoes runs to or approaches three figures, multiple ploughs are used. On these ploughs the dropping is made lighter by having a box fastened on the plough to hold the seed, and a galvanized iron pipe, into which a man or boy, sitting on the plough, can feed the seed with his hands, the potatoes being dropped in the second furrow, and covered by the third sod.

Another system is to open out furrows with the plough at the required distance, covering the sets with plough or harrows. The drills should be covered as soon as possible to prevent drying out.

Of recent years the use of planting machines has been on the increase. Some of these machines are for use on multiple ploughs, being worked by chain-drive from off the land wheel. Another class includes those of American make, which are complete machines on their own wheels, and fitted with fertiliser attachment. These machines open out the furrow, plant the seed, and manure and cover in the one operation, and they tend, too, toward better farming methods. The potatoes are planted in straight rows, and the manure is placed in close proximity to the sets, even on windy days. Planting can be carried on in the hot weather with little loss of soil moisture, as the necessity of ploughing at this time is dispensed with. For these machines the land is prepared early in the year, being fallowed and cultivated until planting time. Planting on these lines is the ideal method if mechanical diggers are to be used for harvesting.

Soon after planting, the field should be lightly harrowed to break down the furrow ridge, thereby reducing evaporation. Just as the young plants are showing through, the field should be again harrowed, this being the last opportunity of killing young weeds between the plants, as all future cultivation is between the rows. When the haulms have grown sufficiently to distinguish the rows, the cultivator should be used to loosen the soil, keep down weeds, and retain the earth mulch so essential in retaining moisture. A cultivator of the Planet Jr. type is the most suitable, because when the tops become at all large the width of the cultivator can be narrowed, so that there is less damage to the haulms and the young roots in close proximity to the stem. Cultivate frequently in the early stages of growth, as the destruction of weeds at this time is easier, and means a clean crop later on. Towards flowering time the rows should be slightly hilled to protect the tubers from sun-scald, frosts, and potato moth. The hilling can be effected by using the mouldboard attachment during the last working with the cultivator.

Excessive hilling is not recommended, as it intensifies the injurious effects of dry weather, and also results in damage to the roots between the rows. The new tubers always develop over the old set, and as they become large may even be half out of the ground, and unless the crop has been hilled the newly-formed tubers become exposed.

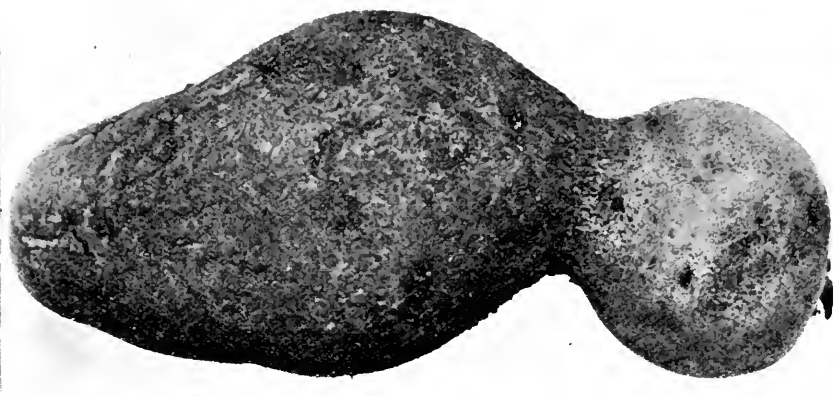
Hilling is also a preventive of rot during outbreaks of Irish blight, inasmuch as the greater thickness of earth over the tubers to a large extent prevents the washing of the spores from off the foliage on to the tubers.

Potatoes under Irrigation.

Work the land well, and if it be dry, irrigate just before ploughing. Plough deeply as soon as the land is dry enough, and plant immediately. Keep the ground well harrowed until the young plants are well up. One good irrigation (or at the most two) is all that is required for spring crops, and these should be given before the young potatoes are any size, as later watering will induce a second growth, which spoils the tubers.

The secret in potato-growing is good cultivation, combined with as little water as is necessary to keep the plants in good growing condition.

The spring crop should be planted as soon as the severe frosts are over, which is usually from July to September, and the fall crop in February. They should be planted in drills 3 feet apart, and when it is found necessary to irrigate, furrows may be drawn midway between the rows and water allowed to run until the ground is well soaked. As before stated, two waterings, with good cultivation, should be sufficient for any spring crop of potatoes. The autumn crop will naturally require more waterings during its earlier stages, as the ground at this time of the year is drier and the heat more intense.



Tuber showing second growth.

Second growth mostly occurs when rain follows a very dry period, and it has been rather frequent of late years, owing to the lateness of the monsoonal rains. A similar condition often occurs when potatoes are irrigated after a dry spell.

Manuring.

The use of fertilisers by potato-growers should be common farm practice, for their value has been proved.

Nitrogen is the most expensive of artificial manures: but, fortunately for the farmer, it can be obtained from the air by the growth of legumes, such as field peas or clover. These, when ploughed under, add to the soil nitrogen at no other expense than that incurred for seed and labour. In addition to the nitrogen supplied, a large amount of organic matter is added, which has an important influence on the soil's fertility. When land is cropped for a number of years, unless organic matter is added in some form, its humus becomes exhausted, and a marked change takes place in its character. It loses its fine friable nature, and has not the same power of absorbing and retaining moisture. In other words, it has lost what is generally known as "condition." The loss of retentive capacity is largely the cause of the noticeably poorer yields obtained from some soils after several years' working.

If farmyard manure is to be used, it should be partly fermented to destroy weed seeds, and should be incorporated in the soil some time previous to the planting of the crop. The use of fresh farmyard manure encourages Scab.

The following are manurial recommendations for various districts:—

District.	Manure Recommended per Acre.
North Coast	2 cwt. superphosphate. or 1½ cwt. superphosphate and 1½ cwt. bonedust.
North Coast Plateau	1½ cwt. superphosphate and 1½ cwt. bonedust.
South Coast	2 cwt. superphosphate and ½ cwt. muriate of potash.
Northern Tablelands	2 cwt. superphosphate and ½ cwt. muriate of potash on sandy soils. 1½ cwt. superphosphate and 1½ cwt. bonedust.
Central Tablelands	1½ cwt. superphosphate and 1½ cwt. bonedust.
Southern Tablelands	1 cwt. superphosphate, 1 cwt. bonedust, and ½ cwt. muriate of potash.

When to Harvest.

The spring crop on the coast is grown for earliness, and the tubers are harvested when considered large enough to market. At this stage the haulms are green, and the young tubers are very soft. Very often the potatoes could be profitably left for another week or so, because being nearer maturity they arrive in a much better condition on the market, and the additional weight, even in this short time, is considerable. Some of the potatoes dug very early present a very poor appearance on arrival at market; being devoid of skin, they are much bruised and black in colour.

Other than the spring crop, the time to harvest is determined by the dying-off of the tops and the maturity of the tubers. If the tops have been destroyed by frost, it will be necessary to allow the tubers to remain in the ground until the skin is firm and does not peel on handling.

Harvesting.

The most common method of harvesting is digging with the pronged digging fork, but digging machines have been increasingly popular in recent years.

Digging machines are of two types—(a) English.—The principle is for a share to pass under the row of potatoes, the earth and tubers being thrown to one side by revolving arms at the back, so that the tubers are left exposed, ready for picking up. The machines are light in draught, but the large spread given the tubers is one of their worst faults. (b) American.—The principle is for a share to pass under the rows, the tubers, together with the earth, then being carried on to a revolving apron. This apron, which is of cross bars, arranged up and down alternately, revolves rapidly, being given a sifting action by elliptical sprockets. The earth passes through the bars and falls back into the furrow already dug, the tubers passing over the back and being deposited in a row on the loose earth recently dug.

The tubers after digging are treated in different ways. A large percentage of the growers have of recent years been sending their produce to market straight from the paddock. In this case the large potatoes are first picked up and bagged and carted immediately to the station, the smaller tubers being bagged separately and stored for future use for seed and pig-feed.



One form of Potato Digger. Rear view, showing tubers leaving revolving apron and falling on riddle.

Storing.

The question of the treatment of seed tubers after digging has already been discussed. With those intended for culinary purposes it must be remembered that light causes a yellowing of the flesh, and produces bad boiling qualities; consequently, when any method of storing is adopted, it is necessary that the light should be excluded.

In order to prevent the spread of rot, the potatoes should be perfectly dry, no matter which method of storage is adopted. Pitting is not recommended where it can be possibly avoided.

It is preferable that the storing be carried out in sheds which are well ventilated, the potatoes being covered with straw or hessian to exclude light.

Where large areas are grown and pitting must be resorted to, a system of ventilation should be provided by leaving openings and filling them with straw, covering in such a manner as to keep out the rain, and at the same time to allow a free passage of air.

When dug, the potatoes should be left exposed to the sun for a little time before bagging. This will allow them to dry thoroughly, and there will be less adhering earth.

Preparing for Market.

Intimately bound up with the whole matter of profitable potato-raising is the demand of the market. It is not sufficient alone to grow potatoes, but it is equally necessary to send the product to market in a condition so as to be most acceptable to the buyer. In these days of keen competition buyers pick and choose to an extent not realised by one who has not witnessed the disposal of goods put on the market. The most essential points are to grade, classify, and bag in clean, new bags. In grading, all diseased, deformed, over-large and undersized tubers should be rejected from first grade. Before bagging, care should be taken to remove all soil that might be attached to the tubers, and the bags should be shaken down to ensure tight packing, but not too tight, for either too loose or too tight packing results in bruising, and decay follows. Second-hand bags are frequently the medium of carrying diseases that attack the potato, and they should certainly not be used unless they are clean wheat or flour bags, or have been obtained through agents who can offer some guarantee that they have been disinfected by boiling or steaming at a sufficient temperature before despatch to the farm. New bags may, perhaps, be a little more expensive in the initial cost, but they will repay the extra outlay. Each grower should adopt a special brand or mark, preferably a stencil plate, and use it on his first-grade produce. If he is marketing other grades he should use another brand, and mark the bags second and third grades.

Insect Pests of the Potato.*

The potato is subject to many diseases, and, unfortunately, these appear to be on the increase each year. Nearly all of them could be controlled, and many eradicated, if the well-known preventives and remedies were applied. It is seldom a farmer will be found making any attempt in this direction. The probable reason is not that he is careless, and neglects his crops as far as cultivation is concerned, but rather that he is ignorant of the trouble, and is at a loss to know what to do and what remedies to apply to prevent or exterminate them; or if he does know, he does not believe that the results obtained would pay for the trouble involved.

Potato Moth (*Litu solanella*).

This pest is more or less in evidence in every potato-growing district throughout the State, and the loss caused by it annually is enormous. The injury produced by the worm is extremely evident to the housekeeper, as much of the infected tuber is cut to waste, and is well known to all dealers in potatoes, but very generally they do not understand the nature of the insect producing the trouble. The injury done to the plant in the field is considerable, but not so great as that to the potatoes in store.

Potatoes left in the field after the previous season's harvesting provide the main harbour, and moths bred from these are on the wing and ready to infect the growing crop. The moths usually lay their eggs in the foliage, generally at the base of a leaf: the larva, when hatched, burrows its way down the stalk, and when full grown seeks a secluded spot, generally in the wilted tops, and there pupates. If any tubers are not completely covered with soil they will be infested. Potatoes are liable to infestation whether left in the field or placed in store after being dug.

* Compiled by Officers of the Entomological Branch.

The injury to the tuber is very similar to that done to the plant. The eye of the potato is usually the spot selected by the moth to lay its eggs. The larva, when hatched, channels its way through just beneath the skin, or through the substance of the tuber. Its presence can usually be detected by the castings or excrement which it throws out. Several larvæ have been found in the one tuber.

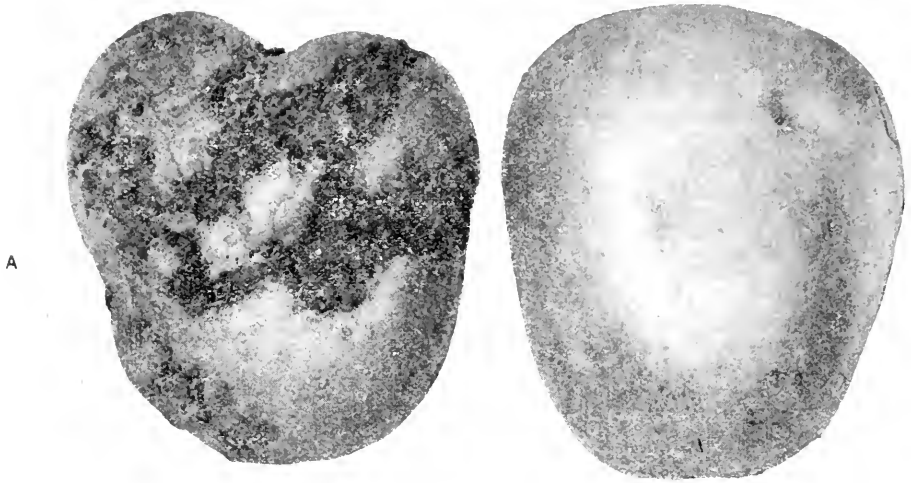
The battle should begin when cultivating. Where hilling is the practice it should be done with care, so that all tubers should be well covered with well-pulverised soil, and no clods should be permitted, as they form crevices for the moth to make its way in and do its work of destruction. Where flat cultivation is practised, plant deeply and keep the soil well stirred. When the potatoes are dug they should be bagged without delay; if they are exposed even for a short while infestation is almost sure to follow. It will be particularly noticeable in a season when showers are frequent that the percentage of infected tubers when dug is considerably smaller than in a comparatively dry one. This is mainly owing to the rain breaking down the clods and compacting the soil, effectually closing any crevices, thus preventing the moth from gaining an entrance to the tubers.

Many growers, after filling the bags, and before sewing them up, cover the mouth of the bag with stalks and leaves, probably to shade them from the sun. This practice cannot be too strongly condemned, as the moth is generally lurking in the haulms, and will immediately leave them to attack the potatoes. All stalks and foliage should be removed and effectually destroyed as soon as possible. The bags should be sewn up immediately after filling and removed without delay to suitable storage. If it is not convenient to remove them for some time they should be placed in stacks and closely covered with some cloth or tarpaulin. Extreme care and watchfulness all along the line are necessary, particularly in storage. The majority of growers think that there the tubers are immune from attack. Far from it; more damage is done while in store than elsewhere. But if suitable storage is provided, the ravages of the moth can be better controlled than in the field.

Frequently potatoes are stacked in the open shed on the farm, and no precautions taken in the way of securely covering them. To prevent infestation they should be stacked in a tight room. On top of the stack place a shallow vessel, and into this pour some bi-sulphide of carbon, and close the door tightly. This liquid becomes a gas when exposed to the air, and being heavier than air the fumes diffuse among the potatoes and destroy any moths and larvæ. This should be repeated every ten to fourteen days, in order to kill any larvæ or moths that might emerge from the egg stage. Four or five charges should be sufficient. About 5 lb. of liquid bi-sulphide of carbon to every 1,000 cubic feet of space should be used. As the gas is *highly inflammable*, the greatest care should be exercised. No lights of any kind should be near, or disastrous results will follow.

Of course it is recognised that many growers may not, perhaps, be in a position to provide themselves with a suitably-closed room, but every effort should be made to do so, and to adopt the treatment recommended. It will be found that the potatoes, being free from infestation, will realise better prices, and the trouble and expense will be warranted. In the absence of such a store-room, the potatoes should be drawn into a heap, a saucer containing carbon bi-sulphide placed on top, and the whole covered closely with a cloth.

Covering with grass from some place remote from the potato crop, or hay, and occasionally sprinkling with water, is a primitive method, but is found to keep the attack in check.



A

THE POTATO MOTH.

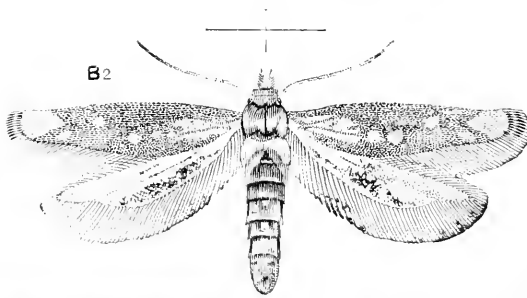
A—A potato showing traces of moth infestation on one side.

B1—The larva.

The lines indicate the natural size.



B1



B2

B2—The adult Potato Moth.

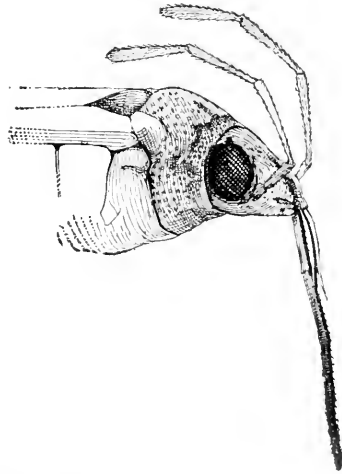
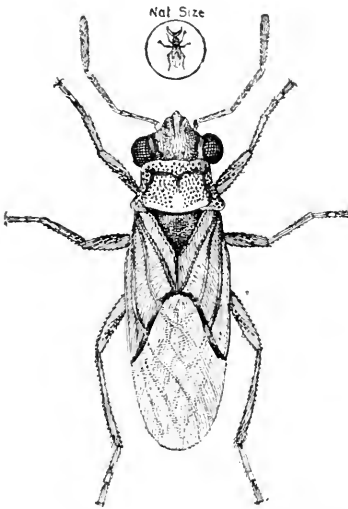
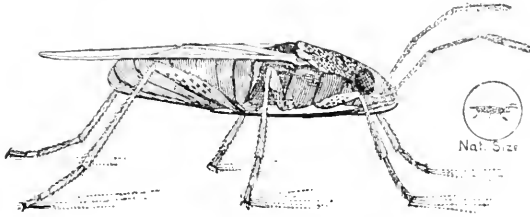
C—The same potato cut open, showing how the larvæ affect the flesh.



C

Rutherglen Bug (*Nysius vinitor*).

This little plant-bug is a tiny brown insect with silvery-grey wings, and measures about one-sixth of an inch in length. They suck up the sap with their beaks, and, where numerous, soon cause the plants to shrivel. They appear in summer from eggs that have been deposited on the grass and weeds by the autumn brood of the previous season, and are particularly fond of potato and tomato plants, though they infest many other plants and trees. They fly very well, and in the warmer part of the day are very active, and for this reason are difficult to destroy by a contact spray used when they are active; and, again, those that do not rise on the wing frequently

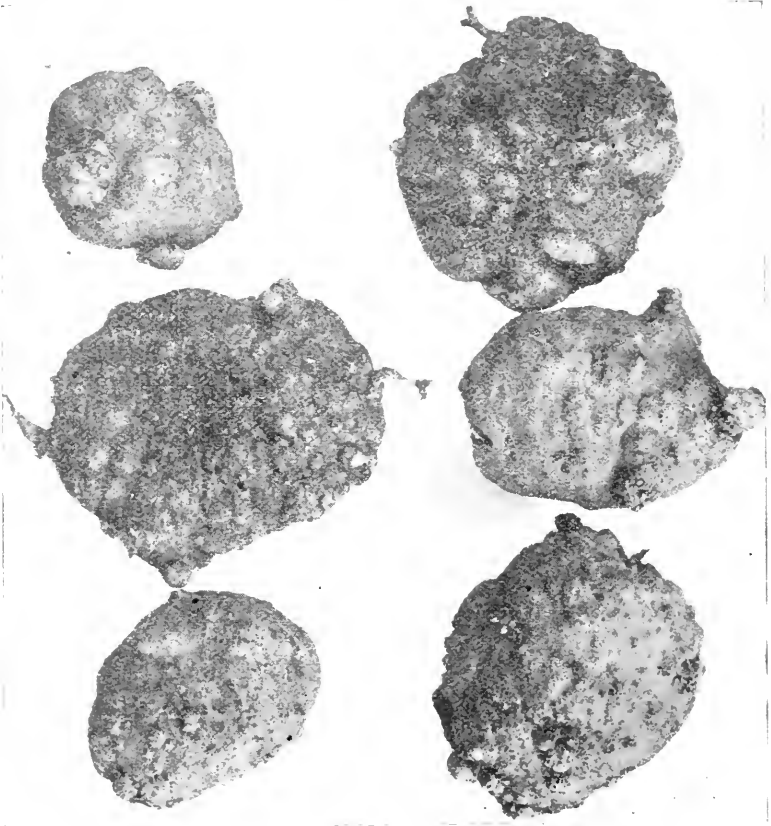


Rutherglen Bug (*Nysius vinitor*).

are sheltering on the under surfaces of the foliage, and thus escape the spray. The best method to rid the plants is to use a shallow dish or iron tray containing a mixture of water and kerosene, and draw this along between the plants, someone following behind, and, with an old broom or piece of brush, beating the foliage on either side as the tray of oil passes. If this is done in the early morning or in the dusk, thousands of the bugs are brushed in or fall into the oil and are destroyed. A sheet or strip of canvas can be drawn along, and the inactive bugs similarly collected, and then the sheet and bugs dipped into oil. It is generally necessary to repeat this operation several mornings running, or while the bugs still appear.

Eelworms or Gallworms.*

These are minute curved worms which live in the tissue, and are generally so small as only to be distinguished by the aid of a lens or microscope. They sometimes infest potato plants, and, when numerous, the growth of the plants is affected, and shrinking and crumpling of the leaves occur, while poor or small tubers, or even none, are developed. On the surface of infested tubers numerous nodules or flat blister-like excrescences are to be seen; these excrescences of infested tissue do not necessarily extend deep



Potatoes infested with Eelworms.

into the potato, but the market value of the produce is reduced, and care should be taken never to use even the most slightly affected ones for seed, or the soil, the resultant plants, and the adjacent plants, are likely to become infested with this pest.

Remedies and Prevention.—Destroy all infested plants and those immediately adjacent, apply lime to the whole patch of soil where infestation was found, and leave fallow for a season or replant with some dissimilar crop, such as wheat or barley, which is not attacked by the parasite.

* Reference to this pest is also made in connection with Root Knot or Root Gall a few pages further on.

Leaf-eating Ladybird Beetle (*Epilachna 28 punctata*).

This 28-spotted Ladybird Beetle causes great damage to potatoes, tomatoes, pumpkins and allied plants, and is illustrated and described under pests and diseases of Cucurbitaceæ (page 718).

Fungus Diseases.*

Late Blight, or "Irish Blight."

The potato is liable to be affected with many different fungus diseases, but the most widespread and destructive of all is "Late Blight." This disease is caused by a fungus known as *Phytophthora infestans* (Montagne De Bary), which is an active parasite, and can attack all parts of the plant—leaves, stem, and tubers. As a rule it does not attack the leaves until after the blossoming period, hence the name Late Blight.

Symptoms—Leaves affected with Late Blight usually become yellowish-green, and develop characteristic irregular dark areas. These frequently appear near the margins and tips and take on a water-soaked, muddy-brown appearance. If the weather remains damp the diseased areas rapidly enlarge and blacken. The leaves become wilted and soon rot, emitting a strong odour. On the under surface, within the advancing edge of the patch, a delicate whitish mould or downy mildew may be seen, especially if the leaf is held in a very slanting position. The destruction spreads to the whole leaf and then to the stem. Finally the whole plant wilts and becomes a crumpled, rotten black mass. The appearance is somewhat like that resulting from a very severe frost. If a dry spell or a succession of drying winds should occur after infection, the brown patches may become brittle, crack, and dry up. This condition may mislead the grower, as the appearance is like that caused by Early Blight, due to *Alternaria solani*, which appears as dark, irregular spots on the leaves, usually marked by concentric rings. These spots appear earlier in the season and more particularly in drier weather. The leaves may curl up and become brown, and often the spots fall out. Very often the first signs of Late Blight may be seen in the lower leaves on plants here and there. Although the disease usually becomes serious after the flowering stage, plants may be attacked at any stage of growth. From the time of infection of a healthy leaf until outward visible signs of disease appear a period of only five days is necessary, when the new generation of spores produced will be capable of infecting neighbouring plants.

With favourable weather conditions an infected leaf may be killed in a day, so that all plants near the original source of infection may be killed within a week. The area of infection continually spreads and a field may be largely infected before the attack is noticed. The fungus may be spreading through many plants for days, living within the tissues without apparent injury to its host, and then suddenly assume a devastating virulence, a condition chiefly controlled by the weather, but also having some relation to the food supply afforded by the host plant. Cool, moist conditions favour the growth of the fungus.

* Compiled by Officers of the Biological Branch.



Fig. 1. Potato haulm affected with Late or Irish Blight.
The inset **A** shows the two halves of a small tuber affected at an early stage.

Before the rapid killing of the potato plant takes place the fungus grows in the form of fine filaments or hyphæ, which thread their way chiefly between the cells, pressing closely against the walls, but frequently pushing them in and sometimes penetrating them. It has been shown also that they may send special absorbing organs (haustoria) or short branches into the cells. These enable the fungus to absorb its nourishment more readily from the cell contents, and are known to occur in any parts—the stems, leaves, or tubers, though not constantly.

The fungus may thus be said to pass through an incubation period, after which it prepares for reproducing itself. Through the openings (stomata) in the leaves on the under surface, it sends out branching filaments, called conidiophores or spore bearers (Fig. 3), on the ends of which its summer spores are produced. A spore is formed first at the end of a branch,



Fig. 2.—Sections of Potatoes affected by Late or Irish Blight (*Phytophthora infestans*).

but later becomes pushed aside, and remains for a time attached by a slender stalk, while the branch grows on and produces a second spore. This process continues many times, a new spore being formed at the end, and a swelling marking the place where each previous one has been borne. These branching threads and their spores form the downy mildew, best seen near the advancing edge of the brown spots of the leaves. The production and further development of these spores depend, as already indicated, on weather conditions.

Should the weather become dry the spores will soon perish and the development of the fungus and the spreading of the disease will be checked. It will thus be understood why some growers attribute the disease to the weather alone, and do not recognise the fungus as the cause, and so fail to take satisfactory measures to prevent the outbreak of Late Blight.

The spores are the agents for the production of two important results :—

- (1) Rapidly spreading the disease through a standing crop by infecting the leaves of healthy plants.
- (2) Infecting the tubers and thus providing the means of propagating the fungus through its mycelium (collection of threads or hyphæ in the tissues), which assumes a dormant condition in the tuber.

A spore alighting on a healthy leaf, will, if weather conditions continue favourable, soon bring about infection. Many spores will fall to the ground and others will be washed down by dew and rain. These may reach the tubers in the ground and produce infection. This raises the question as to the best time to dig, when a field becomes badly blighted. If the tubers are dug while the ground is covered with diseased tops, immediately after their collapse, there is danger of exposing many to infection from contact with the diseased plants, whereas if left in the ground for some days there is the other possibility of infection by the spores washed down through the soil. It is also known that the mycelium may pass down the stem, and cause infection through the underground parts. Experiments have proved that there is less loss if the digging is delayed a week or more after the death of the tops, except in very wet weather and on low heavy soils, in which cases early digging becomes essential.

Infected tubers may show little or no change. Typically there are dark-coloured areas on the surface, which become more or less sunken and crumpled and easily stripped of peel. If the skin is removed from these areas brown patches or streaks are to be found just beneath, extending varying distances into the flesh. As the disease advances these brown patches extend further inwards, and finally the potato shrivels and dries. This condition has given rise to the name of Brown Rust. More frequently, however, the diseased parts become softened and emit a peculiar foetid odour, or rapidly become a foul smelling, soft, rotting mass. This condition is brought about by the entrance of bacteria, which set up putrefaction. A sound potato infected with blight alone will become brown and dry up. The soft rotten condition is the more usual, as potatoes are very often dug just after an attack, during damp weather. Without being cleaned or dried they are put into bags, and may remain in them for days during transportation. They are thus exposed, in the first instance, to every chance of infection, if not already infected, and then placed under conditions most favourable for the attack to spread. The bacteria follow in the wake of the fungus and complete the destruction, with the result that the potatoes often reach market in a soft rotten condition—a dead loss or even an expense to the grower. Unless the foul smelling rot is present some people think the disease is not due to blight, while many growers attribute the wet rot condition to weather alone. While the presence of the fungus in the tubers may produce such changes, there may be, on the other hand, no visible indications of its presence. The mycelium may pass into a resting or dormant condition, and only resume its activity when the tuber is planted. This is the most important way in which the fungus is perpetuated and a new crop is infected. It is by this dormant mycelium that the disease has been spread all over the world.

When an infected tuber is planted the fungus may grow into the shoots produced, finally developing its spores which commence the infection of the new crop. Haulms and potatoes from a preceding diseased crop, if left in the field, may also cause infection. The fungus may also spread from tuber to tuber in the soil, more particularly when the soil remains wet

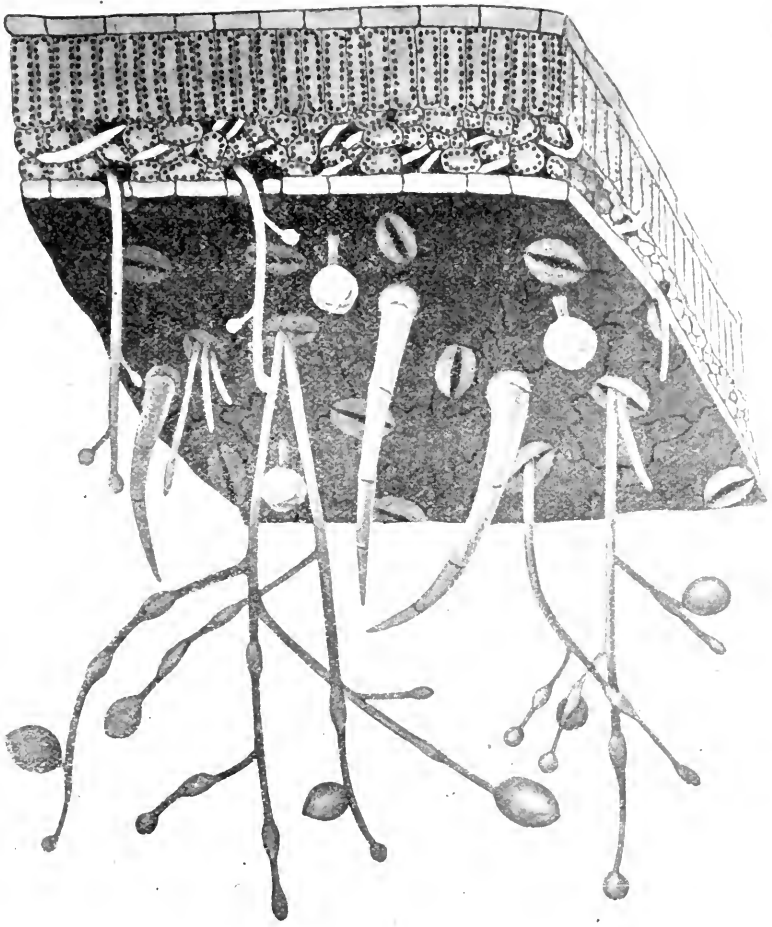


Fig. 3.—Diagrammatic representation of a square cut from a potato leaf infected with *Phytophthora infestans*.

The branching conidiophores are shown emerging through the stomata (breathing pores) on the under-surface of the leaf, and bearing many spores.

The other structures shown are two kinds of plant hairs (a) Long-pointed hairs, and (b) Short hairs with knob ends.

(Redrawn after Bureau of Plant Industry Bul. 245.)

Control.

(1) *The Use of light-free Seed.*—As the mycelium (the vegetative portion of the fungus) may be dormant in the tuber, and often shows no outward signs of its presence, no seed should on any account be used from a crop that is known to have been diseased. Seed should be obtained from a place known to have been free from blight for some years. Any seed showing traces of Brown Rust should be picked out and destroyed by boiling or burning. Often the grower saves his own seed, after sending the best to market. It would pay him to keep the best for his own sowing, remembering that “the best is never too good.”

(2) *Clean Land.*—If the previous crop was potatoes which were blighted, the infected field should be carefully cleaned. Parts of the plants, small or rotten potatoes left in the ground, and the soil are all dangerous, owing to contamination with the fungus and its spores. All remains should be carefully collected and burnt on the spot. The practice of ploughing in potato haulms is liable to produce greater loss through disease than any increase in yield from the manurial value. It must be remembered also that infection may be carried to other parts by the implements of the workmen. Where it can be arranged it is very advantageous to grow some other crop for the next season or two.

(3) *Spraying.*—There is now abundant proof that spraying has proved an almost complete remedy for Late Blight. It will not do to wait until plants show signs of disease. Spraying should commence early, and every care should be taken thoroughly to spray both the lower and upper surfaces of the leaves as well as the stems and the soil. It has been proved that spraying the soil prevents tuber infection by the spores that are washed down through the soil. Spraying must be repeated often enough to keep the whole plant covered with the fungicide, and to protect newly-formed foliage. It is not to be looked upon as a cure for blight, as once a plant is attacked it is hopeless, and should be dug out and burnt. Several sprayings should be given in February and March to protect the plants from infection induced by the active growth of blight owing to the summer rains. Either Bordeaux mixture, or where good lime is not procurable, Burgundy mixture is recommended for the spray.

Bordeaux Mixture.

The formula recommended by the Department for use in connection with potatoes is as follows:—

Copper Sulphate (Bluestone)	...	...	6 lb.
Freshly-burnt Lime	...	...	4 lb.
Water	...	...	50 gallons.

Two or three fairly large wooden vessels are required to make the mixture. If, for instance, it is intended to make 50 gallons of spray, two tubs or barrels capable of holding 25 to 30 gallons of water are needed and one of a capacity of 60 gallons.

For the copper solution, wooden vessels are preferable, though copper ones may be used. Iron should be avoided. For the lime, use wooden tubs or barrels.

Samples of bluestone sometimes come on the market which contain a quantity of sulphate of iron, and it is as well that the farmer should know the difference. Bluestone proper should be in the form of dark-blue crystals, while the adulterated mixture is a lighter blue; indeed, the characteristic colour of sulphate of iron is a light green. The bluestone may be tested by dissolving a few crystals in water and adding a little ammonia. A pale blue precipitate is formed which dissolves to an intense blue colour, and the solution remains perfectly clear and free from sediment if allowed to stand for a while. If a reddish sediment settles, it is due to the presence of iron.

It is of importance that the lime should be freshly burnt. To test whether it is so, a few lumps should be placed in a heap and sprinkled with water. If freshly burnt, these will gradually fall to pieces, becoming very hot in the process, giving off a quantity of steam, and crumbling to a fine, white powder. If it does not get hot enough to give off steam it has not been freshly burnt.

The first operation in making Bordeaux mixture is to dissolve the copper sulphate and to make the milk of lime separately. It is for this that the smaller vessels are required.

It is a common practice is to crush the bluestone crystals and then to pour boiling water over the powder. To dissolve the 6 lb recommended in the above formula, 2 gallons of hot water should be sufficient. When it is seen that the bluestone is dissolved, cold water should be added to bring up the quantity to half the total quantity of spray to be made. That is to say, if 2 gallons have been used to dissolve the 6 lb. of copper sulphate, then 23 gallons will have to be added so as to bring the water up to 25 gallons, which is half the total quantity to be made. Farmers often omit this last point, simply obtaining the solutions and mixing them before adding the requisite quantity of water; but the practice has a distinct effect upon the quality of the spray mixture, lowering its efficiency and increasing the probabilities of the nozzles becoming clogged.

It is not essential to dissolve the bluestone in hot water. Half the water (that is 25 gallons if 50 gallons are being made) can be put in the cask, and the bluestone suspended in a porous sack, as near the surface as possible. If thrown loose into the bottom of a tub of cold water bluestone will not dissolve in a week.

If large quantities of Bordeaux mixture are being used, it is handy to make a concentrated solution of copper sulphate and to use it as required. Such a stock solution of copper sulphate (bluestone) can be made in a large cask, of a strength, say, of 1 lb. to 1 gallon of water. This can be done by weighing out the desired quantity of copper sulphate, and suspending it in a piece of bag or hessian in the upper part of a measured quantity of water. When mixing the spray, a gallon of this solution is used for every pound of copper sulphate required. A mark should be made at the level of the liquid after removing any of the stock solution, so that if evaporation occurs it can be compensated for by the addition of more water.

The lime, which as stated above should be freshly burnt, is slaked by the addition of about half a gallon of warm water. Sufficient water must be used to ensure the whole of the lime being slaked, and it should be added from time to time in small quantities, to keep the action even and ensure perfect slaking. It is a common mistake to add too little water at this stage, with the result that too much heat is developed and the lime is burned, in which case there are many small lumps that do not slake down properly, and they have to be thrown out in the straining to prevent the nozzle becoming clogged.

The lime being reduced to a fine powder, water is added to produce a thin whitewash, and the whole should then be strained through coarse sacking to remove any lumps that may cause trouble in the nozzle. Enough water is then added to bring the quantity of milk of lime up to half the total quantity of Bordeaux mixture that is to be made. In other words, just as the copper sulphate solution was brought up to 25 gallons, so the necessary water is added to the limewash to bring it up to 25 gallons.

The bluestone solution and the milk of lime are now ready to be brought together. This must be done in such a way as to ensure their being thoroughly mixed. Pouring one into the other is not satisfactory. They should both be poured at the same time into the large vessel mentioned above. The operation can be best performed by two men, each with a bucket, one handling the bluestone solution and the other the milk of lime, and both pouring in together and stirring frequently. The sulphate of copper (bluestone) solution of the lime and water mixture can be kept separately for several days, but when mixed the resultant spray should be used at once, as it deteriorates when kept.

Where Bordeaux mixture is to be used regularly, and in fairly large quantities, it is profitable to have a larger equipment than the above.

Using a stock solution of copper sulphate made as directed above, 1 gallon of the solution for every 1 lb. of copper sulphate required should be put in a large cask, and correctly diluted with water. The milk of lime must be placed in another cask. Both casks should be on a raised platform, so that their contents can run through their outlet taps or cocks into a third cask twice the size. The third cask should also be on a platform high enough to permit its contents to gravitate quickly through a large tap or cock into the supply or spray cart. It is better to use the third cask as described, rather than to mix direct into the cart, as the mixture can then be strained as it runs from the third cask. When large quantities are being dealt with, one man can be mixing while another is carting out. The size of the mixing casks is governed by the size of the tank of the spray outfit. For instance, if the tank's capacity is 100 gallons, two 50-gallon casks and one 100-gallon cask could be used. But as 100-gallon casks are often not obtainable ready made, four 25-gallon casks and two 50-gallon ones will serve the purpose. To accelerate the supply the number of sets of casks is increased. The smaller casks should have the 25-gallon level accurately and plainly marked in two places on opposite sides of the interior; a countersunk hole or a short nail driven part of the way home answers the purpose. Larger casks should have the 50-gallon level marked in a similar way.

The object of Bordeaux mixture is to apply copper sulphate to the potato plants so that it may attack fungi that happen to be growing thereon; but it also attacks the plant tissue, and the lime is added to neutralise it, and prevent harm being done. The proportions mentioned in the above formula supply ample lime to more than neutralise all the copper sulphate, provided that the lime is pure, that it is freshly burnt, and that it is all made into milk of lime. It not infrequently happens that one of these three conditions is not complied with, and sometimes not more than half the quantity of lime recommended actually becomes combined with the copper sulphate. In such cases there will be free copper sulphate in the spray, and it will then be liable to injure the crop. It is desirable, therefore, to know whether the copper sulphate has been completely neutralised.

A rough but useful test consists in placing a clean knife blade in the mixture for a few minutes. If copper sulphate that has not been neutralised is present, a reddish stain will be left on the steel, and it will be necessary to add more milk of lime, and then test again. Should there be no mark on the blade this time it may be considered that the copper sulphate is neutralised, though it will be as well to add a little more milk of lime to make quite sure.

A second test as to whether or not the copper sulphate has been neutralised consists of adding a few drops of a solution of ferrocyanid of potassium (in the proportion of 4 oz. dissolved in 1 pint of water) to a small quantity of the Bordeaux mixture, preferably in a test tube. If any brown or black discoloration takes place more lime is needed.

If, however, the proportions recommended above, and the methods of handling described are carefully followed, there should be no reason to fear the burning that free copper sulphate causes.

Burgundy Mixture.

In this mixture copper sulphate is again the most important constituent, but its corrosive action upon the plants is prevented by the use of common washing soda as the neutraliser instead of lime, only a larger quantity is necessary.

It often happens that it is difficult to obtain freshly burnt lime for Bordeaux mixture, and the washing soda may then be used to produce Burgundy mixture.

The formula recommended is as follows:—

Copper Sulphate (Bluestone)	8 lb.
Common washing soda	10 lb.
Water	40 gallons.

The copper sulphate is dissolved in the same way as in the case of Bordeaux mixture, but the Irish Department recommends that the bulk of the water should be used for this purpose when making Burgundy mixture. If 40 gallons of spray is being made, 36 or 38 gallons of water should be poured into a clean barrel and the bluestone suspended in it in a bag.

The balance of the water should be put in another vessel and the washing soda dissolved in it in the same way.

When both the materials are fully dissolved, the soda solution should be poured slowly into the bluestone water, stirring continuously. The bluestone solution should never be poured into the soda solution.

Burgundy mixture should be regarded as a substitute for Bordeaux mixture, and should be used at the same times as recommended for it. It cannot, however, be combined with lead arsenate and some other sprays that can be mixed with Bordeaux mixture. (See Spray Leaflet, No. 11, "The Combining of Sprays," to be had on application to the Under-Secretary, Department of Agriculture).

Even when the above conditions are accurately carried out the mixture may not give the best results, owing to differences in the strength of the sulphate of copper and of the washing soda. Those who wish to get the best results should dip a piece of blue litmus paper in the prepared mixture. If the paper becomes red, more washing soda should be dissolved and added in small quantities at a time to the preparation, and with continuous stirring, until a fresh piece of paper dipped in the mixture remains blue. One pennyworth of litmus paper, which may be obtained from any chemist, is sufficient for a large number of tests.

In recent years a large amount of laboratory work has been done with Burgundy mixture with a view to determining the proportions that would be absolutely the best in practice, but the compounds obtained are very complex, and finality cannot be said to have been reached. The proportions recommended above have so far given satisfactory results in this State.

Leaf Spot, or Early Blight.

The cause of this disease is a fungus, *Alternaria solani* (or *Macrosporium solani*), which is capable of living as a saprophyte (that is, upon dead organic matter) in the soil, or as a parasite, attacking the living potato plant. Apparently as a saprophyte the fungus exists in the soil, perhaps quiescent enough during the winter, but developing with the warmer weather up to the point of producing spores which the wind or other means of transport may carry into potato plants. Here the spores germinate, forming the usual filaments or hyphæ which penetrate the openings (stomata or breathing pores) in the skin (epidermis) of the leaves, and extend within them between and through the tissue cells. In this way the fungus comes to permeate the leaves and stem, but it does not invade the tubers, which are affected by the disease only in a secondary way owing to destruction of the above-ground foliage. In course of time the fungus produces spores, which are borne on hyphæ pushed out from the leaf. They continue to be formed on old dead pieces of potato plants in which the fungus may remain actively living owing to its saprophytic capabilities. Being dropped upon the soil, or reaching it with bits of decayed plant, the fungus passes there its winter period of rest, to rouse itself and form spores against next season as already mentioned. Since the tubers are exempt from attack the fungus is not carried in them; the danger as far as they are concerned is the possibility of spores being transported in the soil or dust which clings to them.

As one of the names signifies, the disease may appear early in the season upon quite young plants, but is apt to become more common and destructive as the season advances. The plants are said to be liable at the blossoming period, when approaching their natural loss of vigour; quite healthy strong plants possess considerable resistance. When attacked the leaves first show small more or less circular brownish patches which slowly enlarge and join together and cover the greater part of the leaf, the affected tissue becoming brown, withered, and brittle. The surface of these areas is marked with fine wrinkles which form imperfect rings lying one inside the other like markings on a target. The diseased leaves curl up, especially at the tips and margins; the affected parts lose their healthy green colour and become sickly-looking and yellow. The stems may remain free, and stand defoliated after the destruction of the leaves; but it is said they may be attacked first, the disease working upwards from near the ground. Whichever be the first point of attack, the end is usually the death of the whole plant. The tubers show no sign of disease, but will only be in such a state of maturity as they may have reached when the foliage perished, since at that period the food material supplied to them by the leaves is cut off, and they cannot further grow. Thus, whilst the disease itself does not attack them, their incomplete development spoils them for market and exposes them to rot from other causes.

The preventive measures consist of the avoidance of infected ground and of seed from infected or suspicious sources, and spraying with Bordeaux mixture before the disease is prevalent. As far as possible all diseased material should be burned. The chance of cleaning the soil demands that it be kept free from potatoes for several years.

Dry Rot and Wilt (*Fusarium* diseases).

These are two distinct fungus diseases of the potato, due to two closely allied species of *Fusarium*. Dry Rot is generally found to be more prevalent than Wilt. The potato (plant and tubers) is the host for about thirty different forms of *Fusarium*, at least twenty being distinct species. While some are confined to the tubers, others occur in the stem parts.

Dry Rot.—A very common form of disease is a dry, whitish, crumbling condition of the tubers. An affected tuber, when cut through, often shows a part of the interior to have a putty-like appearance. If diseased tubers are kept dry they mostly shrink up and become hard, whereas if kept at all moist or stored in a damp place, they soon become covered with an abundant white, felt-like growth of fungus threads.

Investigations have proved that Dry Rot can be produced by many species of *Fusarium*, some of which are true parasites, and can entirely destroy the tubers, while others are saprophytes, which cannot by themselves destroy the tubers, but only assist in the destruction after the tubers are attacked by other fungi or bacteria. The species causing Dry Rot are not the same in all countries.

Wilt.—A species of *Fusarium* is typically found in the vascular (sap-conducting) system of the potato plant, clogging up the conducting vessels and so producing a wilting of the plant. It does not cause any Dry Rot of the tuber, but sometimes makes its way into the stem end, where it may live through the winter.

When infected seedlings are planted, the result is a poor germination and an uneven stand. The disease, however, does not usually attract attention until the plants have attained the height of a foot or more. A wilting plant shows a drooping of the lower leaves, which are the first to die. This is followed by a wilting of the upper foliage, and by a premature dying of the tops. Wilted plants are at first light green, then yellow, and finally dry up and die. The presence of the fungus in the tubers is indicated, on cutting across the stem end, by a dark ring a short distance below the surface. Wilt of the growing plant and "stem-end ring" discolouration must be distinguished from Dry Rot of the tuber. This brown ring may be produced by many of the other species of *Fusarium* that cause Dry Rot, and it is often one of the symptoms of the presence in the vascular ring of many species of *Fusarium*. It has been found that even when the brown ring is visible, it may not be caused by a fungus, so that this condition cannot be looked upon as absolute evidence of any fungus disease. The ring may not always be present, as the fungi may gain entrance through wounds. The disease gains entrance through the tender rootlets in the soil, gradually working up into the main roots, stolons, tubers, and some way into the stem. In splitting open a diseased stem, the water-conducting vessels are found to be slightly browned.

Planting only sound tubers from a clean crop, and planting only on clean land, are the most satisfactory control measures. Where there is any suspicion that the seed may be diseased, it would be advisable to cut all tubers, and any showing a brown ring or any other suspicious marking should be rejected, and so also should those showing any sign of surface rotting. As the fungi can live over for some time in the soil, infected areas should have a rotation of crops. Diseased plants and tubers should be burned.

Bacterial Diseases.

The potato is known to be the host for many species of bacteria, both parasitic and saprophytic. Of the parasites only two need be referred to here, as they cause the diseases known as Brown Rot and Black Leg.

Brown Rot.—The cause of this disease is *Bacillus solanacearum* (Erwin Smith), which attacks potato, tomato, tobacco, peanut, and egg plants. The structure of the bacterium is very simple, consisting of minute rod-shaped bodies, with rounded ends. Each little rod is a complete individual, which multiplies by dividing into two. This process of multiplication may take place under the most favourable conditions with some bacteria every half-hour. It is the collective result due to such extraordinarily rapid increase that soon brings about great changes in the host. In the plant the bacteria fill the sap channels (vascular system), and cause the plant to wilt. On



Brown Rot, or Bacterial Rot.

cutting across an infected branch, brown discolorations are seen, and the bacteria may ooze out as a dirty white slimy mass from the cut surface. As the infection spreads, the stem turns prematurely yellow, shrivels, and wilts, or it may wilt suddenly without loss of green colour, and the whole plant may soon collapse. The bacteria pass up and down the stems considerably in advance of the shrivelling, and the accompanying brown stain can often be seen through the younger and more translucent stems and petioles, as long brown streaks, although the surfaces of these parts still appear to be normal. The roots, as well as the stems, are subject to attack. In the tuber itself, infection first shows as a browning of the vascular ring at the stem end, and on cutting across, the dirty greyish bacterial slime may ooze out. Infection may take place in two ways: (1) If slightly

infected potatoes are used for seed (the disease will not be noticed unless the tubers are cut), the bacteria are able to spread to the growing plant; (2) leaf-eating insects feeding on diseased plants can transmit the disease from plant to plant. Thus, the chief means of control are careful selection of seed, spraying to keep down insects, and the selection of clean land and rotation of crops (excluding those host plants mentioned above).

Black Leg.—This disease is also called Black Stalk Rot. The cause has been investigated in several countries, and each investigator has given a different name to the organism causing it; e.g., Ireland, Pethybridge, *Bacillus melanogenes*; Canada, Harrison, *B. solanisaprus*; Germany, Appel, *B. phytophthorus*. The bacillus causes the seed tuber to rot early, sometimes before the sprouts break through the ground. The rot spreads up the base of the stem, which turns quite black, shrinks, and rots as far as the surface of the soil, and often above it. This is the best indication of the disease. As a result of this injury, the whole plant begins to die, generally without setting any tubers. Wet and cold weather apparently favour the disease. Other plants such as turnips, swedes, carrots, and parsnips are also attacked.

As it is practically confined to the underground parts, the disease may be greatly controlled by carefully digging out and burning all diseased plants. Selection of seed and dipping in formalin or corrosive sublimate also assist in preventing its introduction. If the potatoes are steeped in formalin (40 per cent. commercial formaldehyde), the proportions should be 1 part of formalin to 300 parts of water. The tubers should be immersed in this solution for about two hours. Should young shoots be developing at the eyes, the proportion of formalin recommended to be used is 1 part to 500 of water, otherwise the growing shoots may be injured.

Corrosive sublimate is used in the proportion of 1 part to 1,000 parts of water. The crystals are dissolved in a small measured quantity of hot water, and this is made up to the required amount by the remainder of the water. Corrosive sublimate is a very strong poison, consequently great care must be exercised in its use.

Disinfection with formaldehyde gas is also recommended for the control of Blackleg. This method requires care, or the seed may be badly injured. It is necessary to have 167 bushels of potatoes for each one thousand cubic feet of space in the disinfecting room; with less quantity of potatoes in this space the formaldehyde gas will affect the germination. A tight room is used in which to carry out the disinfection, and the seed potatoes are placed in open crates or in small piles on the floor. For each 1,000 cubic feet of space, 3 pints of formaldehyde (40 per cent. pure) to 23 ounces of potassium permanganate should be used. The potassium permanganate is placed in earthenware dishes, and the formaldehyde is poured on the crystals, the operator rushing out and locking the door at once. The fumigation chamber should be kept closed for twenty-four hours.

Rotation of crops is also recommended as a control, excluding such crops as beans, beet, carrots, cucumbers, mangolds, turnips, and vegetable marrows, which are susceptible.

Brown Fleck.

This is a fairly common condition.



Brown Fleck.

Tubers that to all external appearances are healthy and sound, when cut open show rusty markings of various sizes and shapes. These discoloured areas consist of dead tissue, and must not be confounded with blight. In the latter case the diseased parts are, at least at first, immediately beneath the skin, whereas in Brown Fleck the markings are more internal, scattered, and usually not in contact with the skin. No signs of disease are to be found on the stem or leaf parts of the plants which produce such tubers, and the cause of Brown Fleck is not known. The disease does not necessarily appear if seed with Brown Fleck is planted. Many conditions relating to the nature and composition of the soil, amount of moisture, and weather have been investigated as contributing causes, but no definite conclusions have been arrived at.

Scab.

Several forms of "scab" are to be found on potatoes, three of which are dealt with here, viz.:—1. Scab due to thread-forming bacteria, *Actinomyces chromogenus*; 2. Rhizoctonia scab, due to a fungus, *Rhizoctonia solani*; and 3. Eelworm scab, due to a nematode worm, *Heterodera radicum*.

The skin of a potato is really of the nature of cork; it is only a thin layer, but so long as it is intact it is highly protective. When the skin is injured the potato endeavours to repair the damage by producing an extra amount of corky cell substance around the seat of injury. In this way a scab is produced, and scabbing may be regarded as the manifestation of the efforts of the plant to repair injury and to protect itself from further attack. Various conditions have been at times suggested as the cause of scab, such as the presence of lime, ashes, fresh stable manure, cinders or grit in the soil; also the dryness of a season, and the nature of the soil (whether acid, alkaline, sandy, heavy, &c.). Where experiments, carefully conducted with proper scientific precautions, have been carried out, it is becoming evident that some living organism is always the cause, and that the above conditions may influence its growth. In New South Wales the best known scab producers are eelworms and the fungus *Rhizoctonia*.

Scab Due to Actinomyces Chromogenus.—This disease is skin-deep only, and its attacks are limited to the tubers. Spots consisting of accumulated cork tissue are formed; these may be readily removed. This form of scab does not impair the germination of the seed, but it reduces the yield, as well as prejudicing the keeping qualities of the tubers. It does not in any way impair the edible quality.

The disease is carried about with infected tubers. The latter when fed to cattle will infect the manure. Before planting, seed potatoes should be disinfected with corrosive sublimate, formalin, or formaldehyde gas. (See page 505). Fertilisers which tend to make the soil alkaline, such as fowl manure, lime, wood ashes, or bone-meal, all tend to increase scabby potatoes.

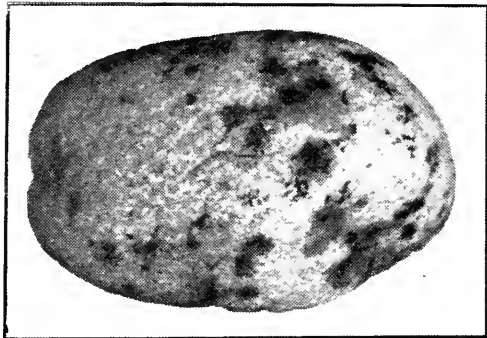
A recent paper by Mr. W. A. Millard, University of Leeds., states:—

“ this organism attacks the potato tuber only when the supply of its natural food in the soil becomes exhausted.

“ This scab is most prevalent on light open soils, where the decay of the organic matter is rapid. It appears to a much smaller degree on heavy soils, since here the decomposition of organic matter and the growth of the scabbing organisms are alike retarded by lack of air. Common scab may be prevented by introducing into the soil a sufficient quantity of green plant matter, which acts as a decoy for the scab-producing organisms and protects the potatoes from attack.”

Scab due to Rhizoctonia solani.—It is quite common to find on the surface of tubers dark-brown lumps of irregular shape and size, like small lumps of soil, but which become black and show up distinctly in contrast to the potato skin when wetted. They do not adhere very firmly to the skin,

and can be scratched off with the finger-nail or easily rubbed off; when removed they leave very little scar on the skin. This condition is sometimes called Black Speck Scab. Sometimes, however, the lumps may be found to be deeper in the tissues, and even beneath the skin. Each of these lumps is known as a sclerotium, and consists of a mass of fungus tissue, which in a resting condition, is capable of resisting adverse conditions for long periods.



Tuber showing scab due to *Rhizoctonia solani*.
(The small black nodules are the sclerotia of the fungus).

and under favourable conditions gives rise to new growths of hyphae. When planted with the seed the young shoots may be attacked by these hyphae developed from the sclerotia, and many plants killed. The stems of young plants are often rotted round the collar or beneath the soil. Some die from what appears to be a wet rot.

Other conditions found associated with this fungus are scabbing, resembling that caused by sclerotium, a bunching or rosette appearance of the tops and small potatoes (aerial tubers) formed on the stem above the seat of injury, and sometimes in the axils of the leaves along the stem.

Besides causing the death of plants, the fungus also produces a rotting of the tubers. This typically consists of a dry brown rot, which extends inwards from the skin, and very much resembles the true rot produced by Late Blight when bacteria are absent. This condition is common in Tasmanian potatoes, and is known as Brown Rust. As indicated above, the sclerotia are the chief agents in spreading the disease. The remedy is selection of seed and the dipping of all seed before planting. The sclerotia

are hard to kill, requiring about two hours' soaking in a solution of 1 part formalin in 200 parts water, or a solution of 1 part corrosive sublimate in 1,000 parts water. According to some Departmental experiments, even a 1-in-300 solution of formalin is apparently injurious to any young shoots developing from the eyes at the time of dipping, and in such circumstances a solution of 1 part formalin in 500 parts of water can be used.

Recent experiments have shown that hot formalin controls *Rhizoctonia* scab effectively. A solution of 1 part of commercial formalin (40 per cent. formaldehyde) in 120 parts of water is made and heated to 122 deg. Fah. The potatoes are immersed for two minutes in the solution, placed on a draining board and covered with a cloth that has been soaked in the hot solution and wrung out slightly. The tubers are left covered for one hour and then laid out till air-dry. This method requires care, as the temperature of the solution has to be noted with a thermometer and must be maintained at 122 deg. Fah. while the seed is being treated.

Scab due to Eelworm (Heterodera radicum).—This disease, which is also known as Root Knot or Root Gall, appears to be spreading very much in New South Wales. Such plants as the following are attacked:—Field crops:



Potato attacked by Eelworms (*Heterodera radicum*).

See further illustrations on page 492 .

Lucerne, some cowpeas, soy beans, pumpkins, melons, tobacco. Vegetables: all kinds, as cabbage, cauliflower, spinach, lettuce, beans, peas, tomato, potato, carrot, and parsnip; many flowers and trees. About 500 different kinds of plants are known to be attacked. The cause of the injury is a tiny round worm—*Heterodera radicum*, often called an eelworm, and also (from the effects of its attack) a gall worm. It belongs to a group of worms known as nematodes, many of which are injurious to plants, while others attack animals. The disease is readily seen on examining the roots. Irregular enlargements, either scattered or so close that the whole root system is abnormally thickened, will be seen. These enlargements interfere with the functions of the roots, and often the first indication of attack is the wilting and failure of the plant. In the potato plant, the tubers themselves are usually attacked. Blister-like lumps are formed, and often the surface of these break, thus producing a very scabby appearance.

The young celworm larvae move through the soil with considerable activity, and on finding a root, bore their way into it. Once inside, the young worm ceases its active movements, and begins to enlarge. By means of a spear-like organ within its mouth, it commences to feed on the root tissues. Its presence irritates the tissues, and so stimulates them to enlarge, thus forming the gall. The young worms are not very resistant to unfavourable weather conditions, and soil treatment aims at destroying the worms while still young and tender, as the eggs have a resistant coating, and the mature females are safely protected inside the root. Drying out of the soil, or flooding the soil, is usually fatal to them in a comparatively short time. Soil kept free from vegetation for about two years usually results in the worms being killed out.

There are a few plants that are practically immune to attack, so that the most economic way of controlling Root Knot is by a proper system of rotation, at least two years coming between each crop of potatoes. The following plants are not at all, or very rarely, attacked by celworm:—Barley, broom millet, maize, Iron cowpea, peanut, pearl millet, rye, sorghum, velvet bean, wheat, and winter oats. Potatoes used as seed should be free from scab, as the scab areas may contain the worms. In a small garden, two or three treatments of the soil, at intervals of about eight or ten days, with formalin 1 part in water 50 parts, applied at the rate of 2 gallons to a square yard, should be used. It is of advantage to cover the soil with sacking after each application.

Leaf Roll.

The symptoms of this disease are somewhat varied, according to the stage of infection reached. Two American scientists, Schultz and Folsom, have shown that the disease is spread slowly from plant to plant in the field by aphids—possibly also by other sucking insects. Once a plant has been infected, the contagion is readily carried over from season to season in the tubers, and practically all the tubers from an infected plant convey the disease when used as seed.

In the first year of infection very little sign may be seen on the leaves—possibly a certain amount of curling of a few leaves. Tubers from plants which have been infected give rise in the next year to plants showing marked rolling of the lower leaves, and possibly of some of the upper leaves.

In addition, a proportion of the leaves display a form of yellowing, or chlorosis. This is particularly marked along the rolled margins of the leaves. In varieties where pigment is present, the rolled margin may be marked with purple. The manner of rolling is characteristic. The sides of the leaves curl inwards from both sides, so as to form two rolled cylinders parallel with the midrib. If a plant so affected is examined, the seed tuber may be occasionally found intact. In addition, the new tubers will be found to be few in number and greatly reduced in size.

In some cases the stolons, or stalks, which connect them to the plant, are shortened. The disease interferes in some way with the manufacture and transfer of the starch from the leaves to the tubers. If tubers from affected plants be again sown, there may be a proportion of marked failures, and in any case a serious depression of yields results.

Control.—A system of selection of hills must be practised. The best way to secure good potato seed is to raise it on the farm under one's own observation. Farmers who have large areas to plant should maintain a seed plot. To commence this, they should select only tubers from hills which are quite free from Leaf Roll and which are not in proximity to affected plants.

These seed tubers should then be planted in a seed plot, situated some little distance from the main or other potato crops, and in the following season all plants in this plot which show Leaf Roll should be noted and removed promptly, as soon as they are recognised. The remaining tubers will provide the seed for the main crop in the following year, with the exception of the small number necessary again to maintain the seed plot.



(a). Initial Stage of Leaf Roll (variety—Surprise).
 (b) and (c). Advanced Stages (variety—Satisfaction).

If this system of two-year selection of the seed potatoes was practised, or a known disease-free strain were propagated in a seed plot, and rogued only one year, it is certain that much higher yields would be obtained. The method would not be costly, but would involve attention to that most vital of all potato-growing problems—the selection of the best seed. The present haphazard methods of securing seed from the crop without any knowledge as to whether the tubers come from Leaf Roll plants or not will only result in further depression of the yields.

TURNIPS AND SWEDES.*

Turnips of first-class quality for sheep and for domestic use and market can be produced abundantly in many parts of this State. In the coastal and tableland districts the crop can be grown with comparative ease; and in many of the wheat districts where the rainfall does not fall below an annual average of 20 inches, turnips are well worthy of attention if sheep are kept in conjunction with cereal production; and a quick-maturing fodder crop can be thus profitably utilised in rotation.

The turnip crop may be either left in the ground to be eaten out by the sheep during winter, when greenstuff is scarce, or it may be harvested, trimmed, and stored in pits made by stacking the roots on straw in a long, narrow, ridged heap, and then covering with a thick coating of straw and soil.

Almost all soils are suitable for the production of turnips, the governing factor being more the supply of moisture than the richness of the land. Hence it is desirable to employ a soil with a fair percentage of sand, if possible, the physical condition then favouring the retention of moisture.

Preparation of the Land.

The turnip is a shallow rooter, and every effort must be made in the cultivation of the soil and in the application of manures to retain the plant-food near the surface where it can be readily drawn upon by the crop.

The land should be ploughed deeply, if possible, a couple of months at least before sowing, and then lightly reploughed just previous to sowing. The soil should then be brought to a very fine tilth by means of the harrows and cultivator. This is essential to ensure the proper germination of the fine seed of the turnip. On very loose soils the hand-sower at times shows an inclination to run too deep, and in order to lighten the work it is advisable to use the roller to compact the seed-bed. In such cases it is necessary after sowing to break up the rolled surface between the rows by giving a light scuffling.

Time to Sow.

In most parts of the State it will be found that February and March sowings will produce the best results, but on the tablelands earlier sowings are not out of place. Swedes do not do well in New South Wales when sown early in the summer, the crop being one that is native to cool conditions, and hot weather being, therefore, unfavourable to proper development. The attacks of aphid in summer time also contribute to failure, while the heavy moisture requirements of the crop further demand that it shall be grown at a time when the rainfall is most regular. Autumn sowing avoids the hot weather and the attacks of aphid, and allows the development of the roots at a time when the rainfall is usually more regular, and the evaporation very much less. Moreover, the February-March sowings of Swedes bring the crop to maturity at a time when graziers find it of greatest value. There is almost always need for succulent feed in the winter and early spring, especially for ewes approaching lambing, or with lambs at foot, and Swedes sown as suggested will mature at the time required.

* A. J. Pinn, Inspector of Agriculture.

White turnips can be grown at almost any time of the year, except in midsummer, though in vegetable gardens where water is available there is no need to avoid even that short period. The sowings of these varieties, however, should only be sufficient to cover the immediate requirements of the season, especially in hot weather, as they readily run to seed.

Sowing.

In the coastal and tableland districts 2 lb. of seed is generally sown in drills about 2 feet 6 inches apart, and 3 lb. to 4 lb. broadcast. In the drier districts a smaller quantity of seed, say 1½ lb. drilled per acre, would be ample.

When turnips and Swedes are grown under dry conditions, the best results will be invariably obtained when they are planted on the flat, in land deeply worked and well cultivated.

Fertilisers.

The results of experiments with fertilisers for Swede turnips go to show that a supply of soluble phosphoric acid is very essential to the crop, owing, not so much to the quantity taken from the soil as to the peculiar inability it appears to have, in comparison with many other crops, of utilising the supplies naturally existing in the soil. Superphosphate, applied at the rate of ½ cwt. to 1 cwt. per acre, supplies a readily available form of phosphoric acid, and the crop responds to its application with a largely increased yield. It has a marked effect upon the young plants, inducing a vigorous, healthy growth from the very start; indeed, no crop is more readily benefited by applications of this useful fertiliser, or makes more efficient and apparent use of it when the results are determined by the weight of the yield.

Treatment of the Growing Crop.

As soon as the young plants are about 1 to 2 inches in height, it is advisable to thin them out. For a field crop the plants should be left 12 to 15 inches apart in the drills. The thinning out is best done with a sharp hoe. The soil between the drills must be kept well loosened with a cultivator. This will keep down the weeds and help the soil to catch and retain moisture.

Value as a Stock Food.

The following may be taken as the average composition of a Swede root:—

Water	...	...	...	...	88·6
Ash	...	...	...	...	1·2
Protein	...	...	...	...	1·2
Fibre	...	...	...	...	1·3
Carbohydrates or Nitrogen-free Extract...					7·5
Fat...	...	...	...	...	·2

100·0 parts.

Although the percentage of water appears high, it must be remembered that the dry matter is practically all digestible. This cannot be said of a great many other stock foods. Succulence, bulk, palatableness, digestibility of the dry matter, and the high percentage of sugar contained, give turnips a peculiar value as a food. Sheep and goats fatten readily when fed on them

alone, and they are also valuable for pigs and cattle, coming in at a time when other foods are often scarce. They should be fed to dry stock on the dairy-farm in preference to milk cows, as if given to the latter the milk will be tainted. The Swede turnip possesses good keeping qualities, and may be either stored or left in the field for a couple of months till required. If left for any considerable length of time the proportion of woody matter increases, rendering the root unpalatable and less easily digested.

Swedes should be cut in pieces before being fed to cattle, as the animals are apt to swallow the whole or a large portion of a root, and the shape of the piece may result in it becoming stuck in the gullet when it is forced back into the mouth for rumination. The choking so produced has killed more than one cow.

Sheep may be utilised for feeding off a crop without the labour of digging: when confined to limited areas by means of portable fences, they will eat out the whole of a crop, leaving only a thin shell that, together with the animal residues, will plough in to advantage.

Turnips as a Catch Crop.

The cheapness of the seed, and the ease with which a crop of Swedes can be grown in the tableland areas, offer considerable inducements to those engaged in mixed farming to sow a fairly large area each season as a rotation crop. Following, for instance, a crop of hay, where the stubble is ploughed immediately after harvest with a view to sowing potatoes in the spring, it is possible for the farmer to sow, say, $\frac{1}{2}$ lb. to 1 lb. of turnip seed per acre in February, or just after rain in March, and with very little extra cultivation to produce a crop that can be used either as stock feed, or, if prices warrant it, as vegetables for the market. In such a case, the preparation of the land would be little more than would be required for an early fallow after the hay crop, and the practical certainty of a good yield, together with the possibility (always present) of good prices for Swedes in the vegetable market, should make the venture a good one.

The seed should be mixed with, say, 56 lb. superphosphate, and sown through the manure box of the wheat drill, certain feeders being blocked so that the mixture of seed and superphosphate shall be sown only through every fourth feeder. Care will require to be taken to maintain a proper mixture of the seed and fertiliser, or the seed will all work to the top, just as in the case of rape. The hand should be run through the manure box every now and again to mix the contents up evenly, or the drill will presently be sowing all superphosphate, and then, as it empties, all seed. No more than sufficient to sow one acre should be put in the drill at one time, and as only one-fourth of the feeders will be sowing, it will be necessary to set the cogs of the manure drive to sow at about 2 cwt. per acre.

In districts favoured with good rainfall, such as the Dorrigo and Comboyne, profitable crops have been obtained by simply broadcasting seed on the ashes after a successful "burn."

These suggestions for the use of turnips as a catch crop, however, must not be allowed to obscure those for their production on more systematic lines, whether for farm or for vegetable garden purposes, as described above.

Varieties.

For Table Use.—White Stone and Nepal appear to be the best varieties of turnips. Orange Jelly is a first-class variety as far as quality is concerned, but it is a somewhat light cropper.

Of the Swedes, Champion Purple-top, Imperial Purple-top, and Garden Swede may be mentioned as good table sorts.

For Stock Feed.—Green-top and Purple-top, Yellow Aberdeen, and White Pomeranian Globe are fairly good croppers among the turnips.

There are a number of good varieties of Swedes suitable for feeding to stock. Imperial Purple-top, Champion Purple-top, and Skirving's Purple-top may be mentioned as good, even croppers.

Diseases and Pests of the Turnip.

The turnip, like most cruciferous plants, is subject to several insect and fungus pests. It will scarcely pay to spray large areas of turnips, and the best means of control is to stimulate the crop to such an extent by means of good cultivation that the plants may resist the ravages.

White Rust of the Turnip, Cabbage, &c. (*Albugo (Cystopus) candida*, Pers.).

This fungus attacks nearly all plants belonging to the crucifer family, in every part of the world. Among species of economic value may be enumerated cabbage, turnip, cress, horse-radish, and radish. Among cruciferous weeds, Shepherd's Purse suffers most severely, and as this and other related weeds may harbour the pest particular attention should be given to their destruction. The fungus attacks the plants when they are seedlings, entering into the tissues through the stomata (breathing pores) of the tender young leaves. The fungus threads or mycelium grow up with the plant, and at a later stage produce on the leaves, stem and flowers, small white areas presenting the appearance of little blisters.

These little blisters are due to the presence of the fungus beneath the cuticle of the host, and when later the cuticle bursts, countless small spores, which are borne in chains, the oldest being near the apex, are set free. Each of these spores, after being for a short time in a film of water, sets free several minute spores, which swim freely in the water, and thus make their way to fresh spots, to again set up infection.

A second kind of spore—the oospore (resting spore)—is sometimes produced, but this likewise eventually gives rise to minute spores, which swim freely in a film of water, and thus spread infection. When it is borne in mind that the infecting bodies are free swimming spores that can only make their way about when a film of moisture is constantly present on the host plant, and when it is remembered, further, that infection can only be effected during the seedling stage of the host, it will be realised that seed-beds should occupy a fairly dry, open situation.

The effect of the fungus upon the different hosts are somewhat various. In the case of the Shepherd's Purse, for example, the stems become enlarged and distorted; usually no malformations of the flowers or leaves occur, though in the radish the flowers often become strikingly modified.

Controls.—These may be briefly stated thus:—

1. Rotation of crops.
2. Destruction by burning of all diseased plants.
3. Destruction of cruciferous weeds, such as mustard, Shepherd's Purse, &c., which harbour this fungus.
4. Dust on the plants a mixture of equal parts of freshly-slaked lime and sulphur.

Phoma Rot.

A disease due to a species of *Phoma* has been noted on turnips in this State. (See remarks concerning allied species causing Blackleg on cabbage [page 670].)

There are other fungus diseases of turnips that are common to cabbages and cauliflowers, references to which are made in connection with cauliflowers and cabbages in the vegetable section of this Handbook. (See Black Rot [page 668]; Club Root [page 668]; Downy Mildew [page 670].)

Turnip Aphis (*Aphis rapæ*, Curtis).

This is the common turnip aphis, which infests the under surface of the leaves, in the first instance, causing them to become wrinkled and curled up.

The last brood of the winged summer aphides lays winter eggs, protected with a stout skin, and attached to the plants and rubbish. These eggs produce the first generation of wingless females. These produce larvæ which become the second generation of winged males and females.

It is the first brood from these wingless females that, forming little colonies, spread over the plants, sucking up the sap and aborting the tissue, cause the damage to the plants. These aphides mature and multiply with such marvellous rapidity that, unless some precautions are taken, the plants soon sicken and stop growing, or at least produce poor turnips.

The males are dull yellow creatures with long slender antennæ, delicate glassy wings, and very soft bodies. The females are similar in form, but somewhat larger, and deep green in colour.

Clean cultivation is the most satisfactory method of control, the eggs deposited by the last brood of the season being destroyed, and the following crop thus saved from attack. Field spraying is expensive, but if it pays to spray the crop, kerosene emulsion or tobacco wash is effective, provided it is used as soon as the first aphides appear. If once the plants become badly infested, it is very hard to keep the aphis down.

In the case of field crops, the promotion of vigorous growth by surface cultivation and manuring will help more than anything else. Fortunately there are an immense number of parasites that live upon and in all kinds of aphids, and they are a great factor in ordinary years in keeping the pests under control.

Other Insect Pests.

A small light-brown moth (*Godara comalis*) will, in its caterpillar stage, attack the foliage of turnips and the horse-radish. Where plentiful enough to seriously affect the turnips, a spray of arsenate of lead (1 lb. in 20 gallons of water) could be used.

Cabbage Moth (*Plutella maculipennis*) will occasionally attack turnips, and garden crops could be treated with lime and tobacco dust, in accordance with the suggestions as to the control of this pest under cauliflowers and cabbages, if the infestation becomes severe. For field crops reliance must again be placed on clean cultivation, and the destruction of rubbish on neighbouring land, where the moth is likely to deposit eggs.

Cutworm (page 437). eelworm (page 508).

MANGOLDS AND SUGAR BEETS.*

Botanically speaking, the mangold and the sugar beet are identical. The present distinction between them has been brought about by years of selection—in the one case to evolve a root giving a high yield of succulent and palatable food with a maximum content of dry matter; and in the other case to obtain a root containing the maximum amount of sugar, care being taken that efforts to obtain high yields did not mean a sacrifice of sugar content. In this connection it has been established that the development of beets beyond 2 lb. to 3 lb. in weight is invariably accompanied by a decrease in the percentage of sugar. The following table shows the comparative compositions of samples of mangolds and beets grown under the same conditions:—

	Water.	Ash.	Protein.	Carbohydrates.	Fat.	Nutritive ratio.
	per cent.	per cent.	per cent.	per cent.	per cent.	
Mangolds	90.9	1.1	1.4	6.4	0.2	1 : 5
Sugar Beet... ..	86.5	0.9	1.8	10.7†	0.1	1 : 6

† This sugar content is rather below what is usual.

Efforts have been made in the past to establish the beet sugar industry in Australia, but there are many difficulties to be overcome, and Maffra, Victoria, is the only locality where a factory is in operation. This factory has had many vicissitudes, but is now working with a fair degree of success.

Principally owing to our extensive systems of animal husbandry, as compared with those of more intensely populated countries, the cultivation of root crops is by no means widespread in this State. The mangold and sugar beet provide a very useful addition to a ration for pigs, dairy cattle, or stud sheep by reason of their ready digestibility and palatability, and as agriculture becomes more combined with dairying and stock-raising in this State, there is no doubt that they will gradually play a more important part in our crop rotations. The average yield of mangolds in New South Wales, under good soil conditions, is about 25 tons per acre, while that of sugar beets at Maffra, in Victoria, is 12 tons, and about that yield should be secured in suitable districts in this State.

The methods of cultivation of the two crops are essentially the same, and in this article they are treated together, any necessary modifications being indicated.

Soil and Climate.

Mangolds and beets do best in deep, well-drained loams, or clay loams. Poor sandy soils or shallow clay soils will not suit them, in spite even of water supply and other conditions being favourable. The costs of production are high, and to meet these a good crop must be secured. Soils which grow good maize and potatoes as a rule grow good crops of mangolds and beets.

Although fairly drought and frost resistant, these crops do best in a mild climate with a good rainfall, such as that of the coast and tablelands. Beets do not require such a heavy rainfall as mangolds, and in some recent trials

* A. H. E. McDonald, Chief Inspector of Agriculture, and R. G. Downing, Senior Experimentalist.

showed promise in certain parts of the western slopes, such as Inverell. In cold districts they must be sown as a summer-growing crop, but in localities where the winter is mild, best results are obtained from autumn sowing, since weed competition is then at a minimum, and the crops escape the excessive heat of summer, which may induce the plants "to run to seed."

Varieties.

A number of variety trials have been carried out by the Department, at Hawkesbury Agricultural College, and at Grafton, Wollongbar, and Glen Innes experiment farms, and a large number of imported and local varieties tested. As the result, Mammoth Long Red is recommended where procurable. Other varieties which have done well are Sutton's Sugar, Sutton's Red Intermediate, Sutton's Prize Winner, Golden Tankard, Yellow-fleshed, and White Sugar Rose Top (the last two being imported varieties from U.S.A.).

Preparation of the Land and Sowing.

Thorough preparation of the land is absolutely necessary to ensure successful cropping. The mangold and beet are deep-rooting plants requiring a loose soil for proper expansion, while their large feeding-root systems cannot be utilised to best advantage unless the soil can be easily penetrated. For these reasons, and to conserve the large amount of moisture required by the crops, preparation should be commenced some months prior to planting, when a deep ploughing should be given, followed by as many harrowings as are necessary to consolidate and to fine the soil. Just before planting the land should be cross-ploughed and harrowed, care being taken not to plough quite as deep as for the first ploughing.

In the case of mangolds, best results are usually obtained by sowing on ridges; this, particularly in clayey land, allows free expansion of the growing roots. The ridges should be 2 feet 6 inches to 3 feet apart, and are made by throwing two furrows together with a plough having a fairly long mould-board, and then running a light roller over the ridges from end to end to firm the soil. Beets may also be planted in this manner, but if to be grown for their sugar-content (*i.e.*, to supply a factory or to make syrup) they are better grown "on the flat," as they will then develop to the size found to give best results for this purpose.

March and April are the best months for autumn planting, and September and October for spring sowing. Planting is carried out by a special beet drill where the beet sugar industry is established, but a wheat-drill, with all but the necessary tubes blocked, may also be used; the rate of seeding in such cases is 10 to 12 lb. per acre. When sown by hand half the above quantity of seed is sufficient for both crops, and seeds should be dropped about 6 inches apart. The seed should be covered $\frac{1}{2}$ inch to 1 inch deep, according to the amount of moisture present in the soil at planting time. In this connection it is advisable to choose a time when the soil is moist, for planting in dry soil or deep planting produces slow and patchy germination.

A very important factor in the production of a good stand is that only the best seed should be used, and it should be tested before planting by placing between sheets of damp blotting-paper or flannel and keeping in a warm room for a few days. What is commonly called the seed is a fruit containing three to five seeds, and 100 of these should give at least ninety

to 100 young plants. The germination percentage will determine whether the rate of seeding should be increased beyond that stated above. A good plan is to soak the seed in warm water for some time before sowing, but care should be taken not to soak much more than is required for immediate sowing, as the keeping quality of the seed may be impaired.

Manuring.

Both crops are gross feeders, and will respond to heavy manuring, although in the case of beets grown for sugar-content it is not desirable to encourage too great a development of the roots. Manurial requirements of the crops will vary according to local soil conditions, but as a general rule it may be laid down that mangolds should not be planted except in very rich soil without a liberal dressing of a phosphatic and potassic manure. Nitrogenous fertilizers will only be necessary in soils known to be very deficient in nitrogen, as they tend to stimulate leaf growth at the expense of the roots.

In Victoria good results have been obtained by the use of about 1 cwt. superphosphate per acre when planting sugar beets, and it is not considered advisable to apply any other fertilizer to this crop.

Cultivation and Thinning.

A seed-bed containing plenty of moisture and free from weeds will result in an early start, which is half the battle with crops of this nature. As soon as the plants can be discerned above ground (with favourable conditions usually about nine days from planting) a good cultivation should be given to conserve the moisture, and this should be followed up by cultivation wherever required to cope with weed growth. The roots must not be injured by the cultivator, as this causes them to decay; until they have a firm hold of the ground the rows must be kept free of weeds by the use of the hoe. Care must also be taken not to destroy the ridges during working.

Thinning is a very important operation, and should be carried out when the plants show four leaves. If left until later it is more costly, and results in a considerable reduction in yield. The work is best done with a short-handled hoe, and the object, in the case of beets, is to space single plants about 8 to 12 inches apart, according to whether the soil is rich and moist or medium dry, and 12 inches to 18 inches apart in the case of mangolds. A clump of seedlings results from the germination of a seed ball, so that, in addition to hoeing, hand-picking is necessary to leave single plants. Where sugar beets are grown on large areas for sale to a factory this work is done by contract, as also is "side-hoeing," which consists of removing from the rows weeds not destroyed by cultivation.

Harvesting.

The ripening of the crop is indicated by the leaves turning yellow. This usually takes place seven to eight months from the time of planting. Harvesting should not take place before maturity is reached, for in the case of mangolds the maximum yield is not obtained, and immature mangolds are likely to taint milk if fed to dairy cows, and in the case of beets the maximum sugar-content is not obtained. Lifting may be extended over a fairly long period to fit in with other farm work, without deterioration of the roots, but in hot districts the autumn-planted crop must not be left in the ground during the summer, as the plants are liable to run to seed.

Mangolds may as a rule be lifted from the ground with the aid of a strong digging fork, but in the case of beets the best plan is to turn a furrow next to the row to be dug, with the land side of the plough close up to the beets.

They may be then forked out and "topped" (the leaves removed just above the crown) with large beet knives (a sharp corn knife answers the purpose). This operation is usually done by contract, when the crop is grown on a large scale; grown for feeding purposes the plants may be topped in the rows with a sharp hoe and dug later, as required.

Storing.

The tops of both mangolds and beets form splendid cattle feed, and in America are often converted into ensilage. The roots may be stored by stacking in heaps about 2 ft. high on a bed of straw, under shelter, with plenty of ventilation, while they may also be covered with straw and earth, as is done in the case of potatoes. In a warm climate storing cannot be carried out through the summer, owing to a high temperature favouring the development of the agencies which cause decay. Roots to be stored should be handled carefully to avoid bruising, which provides entrance for fungus spores, causing decomposition.

Feeding Value.

Mangolds and beet contain a very large proportion of water (more than any other root crop), and the average of a large number of analyses in connection with trials of mangolds at various experiment farms shows the moisture content to be 92.01 per cent. Although they are a very bulky crop, containing a very small proportion of actual nutriment, a comparison of the total feeding value of the yield of an acre, with that of a crop of maize or oats cut as green fodder, shows the mangolds to a very slight advantage. Allowance must also be made for digestibility and palatability, particularly in relation to dairy cattle.

Summary.

The advantages and disadvantages of these crops may be summarised as follows:—

Advantages.—(1) The crops form a useful supplement to a ration for cattle, pigs, or stud sheep.

(2) They stimulate the milk yield of dairy cattle.

(3) Their cultivation may be very profitably combined with the operations of a mixed farm.

(4) The thorough tillage necessary for the successful growing of these crops results in a splendid soil condition for the following cereal crop.

(5) The practice of feeding the roots on the farm means that soil fertility is maintained to a greater extent than where crops are sold off the farm.

(6) They may be easily stored and utilised in the early spring when succulent feed is scarce.

Disadvantages.—(1) The crop entails a great deal of labour, which means that it is preferable to sow a small area and give it proper attention, rather than to neglect a big area by reason of labour shortage. The estimated cost of production of a crop at Grafton Experiment Farm, which yielded 25 tons per acre, in 1920, was £8 per acre.

(2) On account of their bulk, compared with their actual food content, the roots take much handling, and for this reason should not be fed unless supplemented by more concentrated foods, or a falling-off in condition will result.

(3) They are a soil-exhausting crop, and should not be grown on the same land more than twice in succession.

THE SWEET POTATO.*

The sweet potato is not cultivated in this State as it deserves to be, or as extensively as our climatic conditions will allow. At present its cultivation is confined almost to the thin fringe of coastal area, but its range of suitability has by no means been determined; in fact, its determination has hardly been commenced. If proper care be taken with regard to the raising of the "plants," and the selection of varieties, many districts hitherto regarded as totally unsuitable will be found to suit this crop. Sweet potatoes have been successfully grown at Queanbeyan and Howlong, and in a few isolated parts of the dry west where water is available. Generally speaking, better results may be expected in the warmer districts on the coast or inland than on the cool tablelands.

At Hawkesbury Agricultural College the crop has proved a splendid drought-resister. If a little attention be devoted to keeping down weeds and conserving moisture by hoeing—hand or horse—it is surprising how much dry weather the sweet potato will resist; and as for heat, some of the varieties simply revel in it.

Soil Required.

The ideal soil for this crop is a sandy one, well supplied with organic matter. In a soil of this character, the plants possess almost all the hardiness of weeds, and the roots develop well, being even in quality and of good shape. Light loams are also very suitable; but the more clayey a soil is, the more unsuitable it is. In poor sandy soil, 4, 5, and 6 tons per acre are obtained with but little trouble.

Preparation of the Soil.

Usually two ploughings are considered necessary to prepare the soil for this crop. The first is done during the winter or early spring but sufficiently early to allow the soil to settle and become compact before planting. It will then be in a suitable condition for the young plants to utilise the moisture in the subsoil should it be required. This first ploughing can be as deep as the soil will admit without bringing the sour subsoil to the surface. The second ploughing, on soils at all light, should be only shallow—say, about 4 inches. Unless this precaution be taken the roots in sandy soils are apt to become excessively long and thin, rather than chunky, which latter characteristic is to be desired. Some varieties, notably Pierson, are not as bad in this respect as others.

Manuring.

If the roots are intended to be used as a vegetable, the direct application of farmyard manure to this crop is not recommended. Whilst stable manure improves the yield both of vine and roots, it is at the expense of quality in the latter.

If plenty of farmyard manure be available, it is a good plan to apply it to the crop preceding the sweet potatoes.

The practice at the College, attended with excellent results, is to maintain the supply of organic matter in the soil by the system of cropping adopted, and to use the following mixture of fertiliser:—

Superphosphate	..	..	..	4 parts.
Sulphate of potash	..	..	..	1 part.

This is applied at the rate of 3 cwt. per acre in the drill when the plants are set out. In cool districts it is likely that the application of 25 to 50 lb. of nitrate of soda in addition to the above mixture will be found beneficial.

* A. J. Pinn, Inspector of Agriculture.

Propagation.

Many failures with this crop have arisen through planting it in a similar manner to that adopted with the ordinary potato, *i.e.*, using the roots whole or cut as sets. Whilst this practice will produce a crop, though somewhat late, in the North Coast or long-season districts, yet in a short-season or a dry district to adopt such a practice is to court failure at the outset.

The crop is best propagated by means of shoots or "plants" which grow from the tuber. When bedded or planted (see Fig. 1), sometimes as many as fifty "plants" will grow from a single small tuber, and two or three pullings may be obtained in a single season.

How to raise "Plants."

The plants necessary for producing an early crop are obtained by placing the roots—usually small, slender tubers, kept over for this purpose from the previous season—on sand in a cold frame or hot bed. These seed tubers are placed close together, but not touching each other. They are then covered with 2 or 3 inches of sand (river sand preferred); the whole bed is then well watered and covered with a glass sash or frame of hessian. By raising a corner of the frame, enough air is admitted to prevent rot setting in. The bed should be kept moist, but not wet, and covered until the plants show through the sand. The covering is then removed during the daytime, but replaced at night. This is done until all danger of frost is past. The "plants," when 6 or 8 inches long, are ready for planting out. (See Fig. 1.)



Fig. 1. Sweet Potato "root," with plants ready for breaking off and planting out.

By bedding the roots early, the addition of bottom heat is unnecessary in comparatively warm districts. If tubers are set in the frame about the end of July or beginning of August, plants will be ready as early as it is safe to put them out. Plants raised on sand, and without artificial heat, are hardier than if raised in a rich compost and on a hot bed, and in addition, the risk of introducing disease is lessened. In a cold district, or where bedding-down has been delayed, it will probably be found necessary to use some sort of bottom heat.

For raising early plants, a cold frame, covered with a sash of glass (see Fig. 2) has given the most satisfactory results. Where glass is not available, hessian or bagging may be used to retain heat and keep off frosts (see Fig. 3); it gives good results, but in the end is more expensive as it requires renewing each year, whilst glass, with care, lasts indefinitely. One or two tubers, bedded in a small box or kerosene tin, if placed in a sunny situation, and covered at night, will supply sufficient plants for a kitchen garden.

In mild districts, plants quite early enough for a main crop can be obtained by bedding the tubers in the open ground in a sheltered situation with an easterly aspect, or cuttings 6 or 8 inches long may be made from the vines of the early-planted crop and set out in the same way as the plants obtained by bedding. These cuttings will grow quite readily. The crop produced by planting them seems to keep better than the early crop. Small tubers are the best for producing plants: 1 cwt. will produce at one "pulling" 4,000 to 5,000 plants, and will occupy 90 to 100 superficial feet in the cold frames.

Raising tubers specially for Bedding Purposes.

Though small tubers are the best to use for bedding-out, it is poor policy to use the small ones or culls from the main crop for this purpose. Prof. Massey, of the North Carolina Experiment Station, some years ago advocated the growing of a crop of small tubers specially for bedding purposes. This plan has been adopted at Hawkesbury Agricultural College with very satisfactory results. The method recommended by Prof. Massey is as follows:—

Cuttings 12 to 15 inches long are taken from the growing vine, and after being rolled around the hand are planted in the usual way, with just the tip showing. At the College this planting is done about the middle of January. Almost every joint of the buried vine produces a cluster of potatoes. The result is a large number of small tubers, the best of which are selected and are just the right size for bedding.

Planting Out.

The planting is commenced at any time when all danger of frost is past. It can be continued in the coastal districts right up to the beginning of January with every hope of a good crop.

The shoots or plants 6 or 8 inches long are carefully drawn from the bed, and are set root downwards in a bucket of water or a mixture of cow-dung and water. They are then taken to where they are to be grown. They are drawn from the bucket as required, and placed, with the roots dripping, 2 feet apart in rows which are 3 feet apart.

The plants may be ploughed in at the time the ground is getting its second or final ploughing. When this method is adopted, the plants are placed the required distance apart in every third or fourth furrow, the necessary covering being given by the plough as it turns the succeeding furrow. (See Fig. 4.)

A common plan is to thoroughly prepare the ground first and then dibble the plants in with a spade (see Fig. 5). This method is somewhat slower than ploughing in, but for ordinary conditions it has been proved the most satisfactory. A man and a boy can plant with a spade 3,500 plants in eight hours.

Fig. 2. — Glass frame bed, in which to raise Sweet Potato plants for setting out.

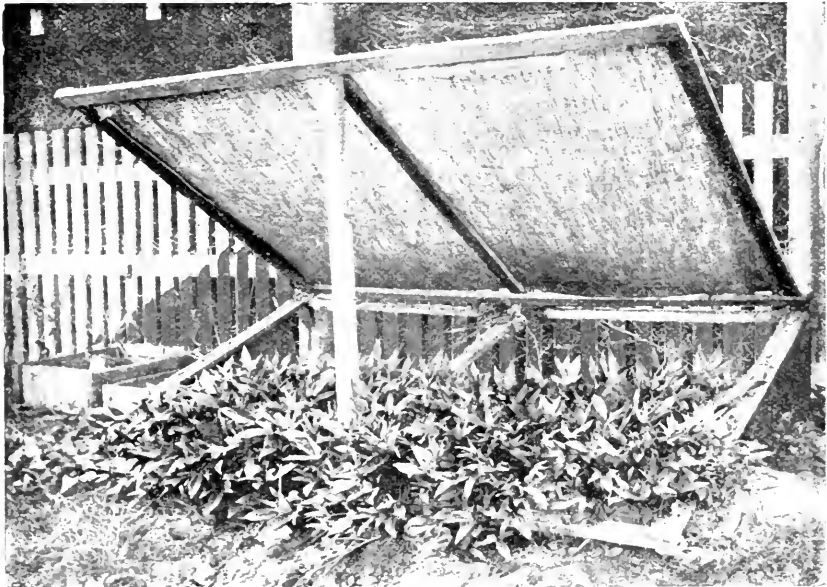
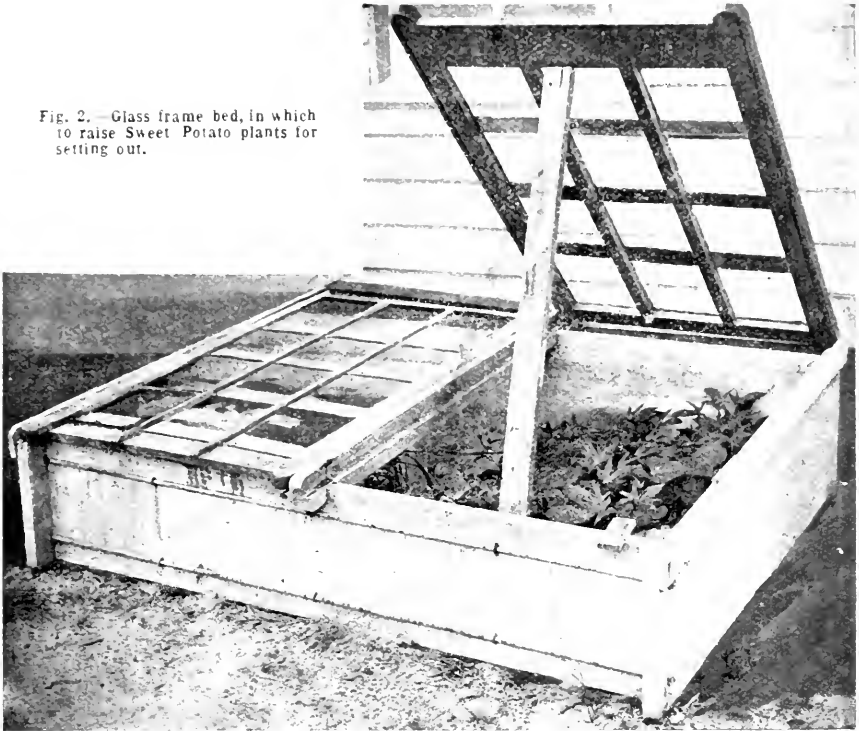


Fig. 3. —Hessian frame bed, in which to raise Sweet Potato plants for setting out.



Fig. 4.—Planting: Ploughing in.



Fig. 5 — Planting: Dibbling in.

A point of very great importance when planting by either method is to see that the soil is thoroughly compacted around the plant. This is especially necessary in dry weather. When the plants are dibbled, this compacting is done by the man pressing the soil firmly against the plant with his foot. When ploughed in, a heavy roller with a large diameter should follow the planting. A roller with a small diameter will drag the plants up. Whatever method of planting is adopted, if the ground be at all moist, the plant will root without difficulty.

It is the practice of some growers to plant on ridges. In cold districts this is probably beneficial, but at the College satisfactory results have always been obtained without the trouble and expense of ridging.

After-cultivation.

The subsequent cultivation given to this crop is such as will keep the weeds down and conserve moisture. Cultivation with a small-toothed scuffler may commence as soon as the plants are set out, and can be continued until the vines cover the ground. Other than disturbing the vines whilst cultivating, no attempt is made to prevent them rooting where they touch the ground.

Harvesting.

Plants set out early in October should produce tubers fit for the table by the end of December. This time, however, will be determined by the nature of the season. In a forward season sweet potatoes fit to eat may be available before Christmas, but in a cool year the earliest potatoes may not be ready until the middle of January.

The mature stage can be determined by cutting one of the potatoes. If the cut surface dries white and does not turn greenish-black round the edge, the potato is fit to eat. If a milky juice exudes which, on exposure to the air, turns black, the potato is not mature enough.

The potatoes will continue to grow until the first frost is experienced; this destroys the vines, and, of course, the tubers will cease to grow after this. The crop may be left in the ground until then, and, if the frosts are not very severe, they may be left until they are required, but the vines should be removed, or when they decay they will communicate rot to the tubers.

During the last two months of the growing season the yield per acre is very much increased; in some cases it almost doubles itself. Where, therefore, bulk is a desideratum it is well to leave the tubers in the ground for as long as possible after they become fit for the table.

The harvesting is usually done by hand labour. Some diggers prefer to use a pronged hoe, others a digging fork; it is a question of use. With some varieties which produce their roots in clusters around the "plant," the labour of digging may be lessened by throwing a furrow away from each side of the potatoes. Digging machines are in use in the United States, where considerable areas are devoted to this crop.

When digging, care should be taken not to bruise the roots; a bruised potato rots easily, though a clean-cut one keeps well.

Storing.

No difficulty has been experienced in keeping small quantities in dry sand. The tubers on being dug are allowed to dry in the sun for a few hours, and are then placed away in sand, and keep through the winter perfectly.

In America large quantities are kept through the winter by storing. In mild climates they are stored in conical heaps under a shed. A thick layer of straw is placed on the ground, the tubers, about 15 cwt., are piled on this straw and then covered with the same material; they are allowed to remain like this for a few days, until the sweating period is over. After this the whole heap is covered with several inches of earth. In cold climates the method of storing is somewhat similar, but specially constructed buildings are necessary so that an even temperature can be maintained.

As a Stock Food.

In addition to the value of the roots as a vegetable they are also a valuable stock food, and the vines make an excellent cattle food. The roots have a slightly higher feeding value than common potatoes, but like them are producers of fat, heat, and energy rather than of flesh. Pigs are very fond of the succulent roots, and can harvest them without difficulty or assistance. It is said they keep the kidneys and bowels in good order.

Pig farmers who have poor sandy land would do well to consider the advisability of raising this crop extensively in the place of maize for fattening.

It is estimated that it requires $4\frac{1}{2}$ bushels of sweet potatoes to equal 1 bushel of maize grain in feeding value. But much sandy soil that does not produce 40 bushels or 1 ton of maize could, with little trouble, be made to produce 5 or 6 tons of sweet potatoes.

Varieties.

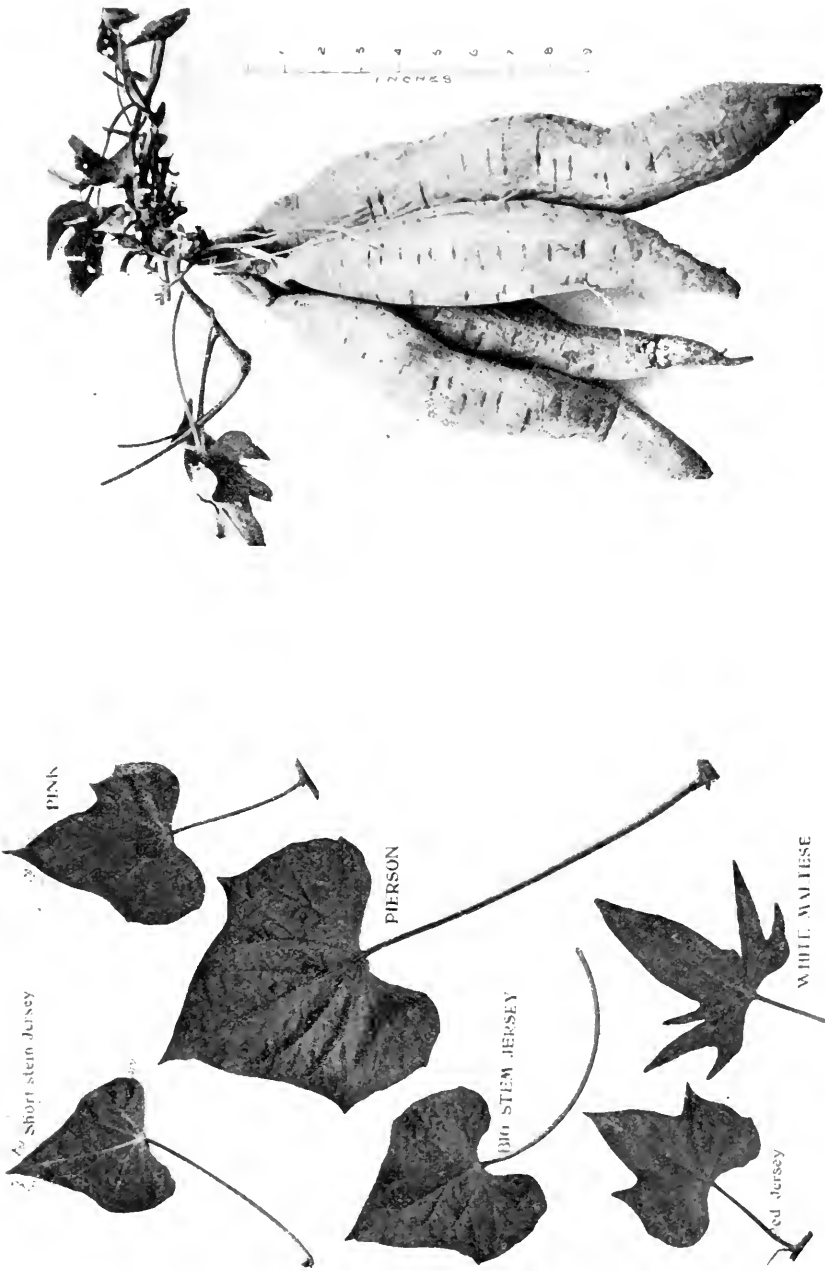
There are several varieties in cultivation, but only two, White Maltese and Pink, have been grown to any great extent in New South Wales, though there are others worthy of attention. The following brief notes will be of interest:—

Big-stem Jersey Yellow.—A vigorous and very productive variety. The vines are abundant, with rather large leaves of the ivy shape. The roots are a good shape, yellow in colour. A rather late variety.

White Maltese.—This is a reliable old favourite. The vine is semi-bushy in character, with little tendency to root at the joints. The leaf is quite distinct in shape from most other varieties, except Bush Vineland. The roots are white in colour, with a tendency to grow very long in loose soil. Many of the roots weigh 11 lb. each. The roots are of fair quality, somewhat dry. They keep remarkably well. A mid-season variety.

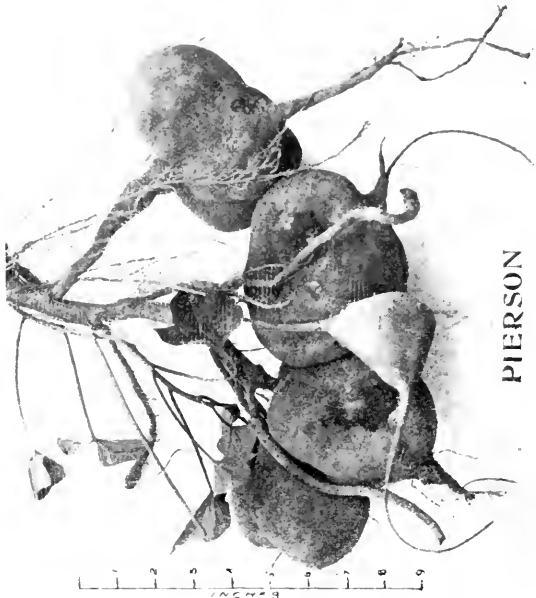
Pink.—A late variety. A good yielder, but rather coarse; more suitable for stock feed than for the table. The growth of vine is not excessive, but the runners attain a great length and root at every joint. The leaf is small, of the usual type. The most prolific, but the worst for the table. A fair keeper.

Pierson.—A vigorous grower. Produces plenty of vine, with large leaves of the ivy type. A good cropper. Roots of good shape, but inclined to crack; of good quality for the table; the roots keep well; the colour of the roots is a deep cream. This variety is one of the best of the introduced ones. The roots cluster round the main stem, are attractive and chunky in appearance. An early variety.



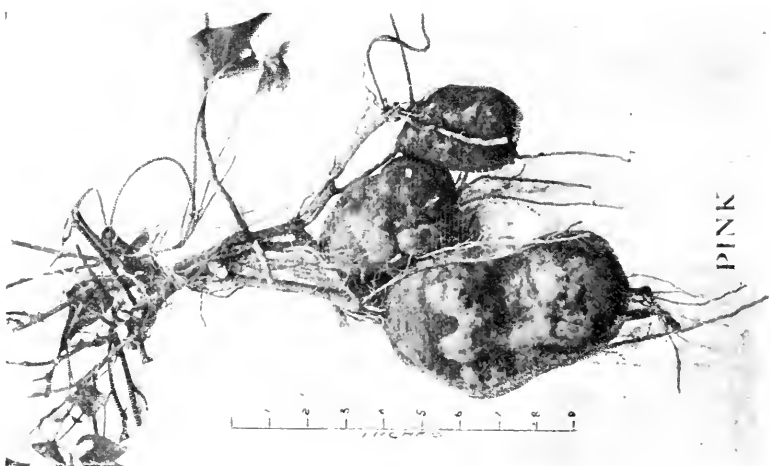
WHITE MALTESE
Fig. 7.

Fig. 6.—Typical leaves of some of the principal varieties of Sweet Potatoes.



PIERSON

FIG. 9.



PINK

FIG. 8.

Some varieties recently imported give great promise, and as they become better known will, no doubt, displace some of the varieties at present under cultivation. The best of these recent introductions appear to be:—

Yellow Strassburg.—A good yielding variety, producing long, yellow-coloured roots. The vine growth is abundant, with large leaves; a mid-season variety, of high cooking quality.

Porto Rico.—A vigorous and very productive variety. The leaves are large, of the ivy-shape type; roots golden in colour and spherical in shape, large and inclined to crack; mid-season in maturity. A good table variety and a good keeper.

Triumph.—A high-yielding sort, of vigorous growth. The leaves are of medium size and ivy-shaped; the roots are of good shape, white in colour, and of fair keeping quality.

Southern Queen.—A fairly productive variety, bearing abundant growth and large leaves. The roots are of good shape and size, of a cream colour, and mid-season in maturity; a fair table variety and a good keeper.

Diseases and Pests.

So far this crop has not shown itself susceptible to many diseases or pests. It is possible this is due as much to the hardy varieties grown as to the inherent ability of the plant to resist disease. In most districts where the crop is grown, an occasional root may be found to be affected with rot in a season, but not more.

An exception must be made of the Richmond River district, however, where a disease locally known as Curly Top caused serious loss on a number of farms a few years ago. Experiments have been conducted by the Department, but the real nature of the disease, and the actual method of attack, remain somewhat obscure. The disease shows itself in the early stages of the growth of the plant, generally in isolated plants throughout the crop. In affected plants the leaves turn black and the whole plant wilts.

In districts where the disease occurs, it is found that by planting in the warmer months the vines grow more vigorously and are less susceptible to the disease. The sweet potato is a tropical plant, and the ground is apparently not warm enough in early spring to produce a sufficiently rapid and vigorous growth.

It is advisable to plant varieties which are not liable to this condition.

Convolvulus Hawk Moth.

A hawk moth which is sometimes a pest of sweet potato is *Protoparce convolvuli*, the caterpillar of which feeds on the leaves. The caterpillars also attack convolvulus and privet foliage. These caterpillars are of a general green colour, with paler-coloured diagonal streaks along the sides of the body, and possess a spine or horn on top, near the hind end of the body. The caterpillars may vary much in colour; some are yellowish, and others, especially well-grown specimens, may be brown and almost black. They feed voraciously, riddling and even eating the leaves completely off. The caterpillars may grow to 3 inches in length, and are thick-bodied. When full grown, they bury themselves several inches down in the soil, where they pupate, changing into a dark chocolate-brown pupa, with a curved exposed beak, shaped like a jug handle. The first brood of pupæ produces a second brood of moths, which again lay eggs on foliage, and give

rise to the second brood of caterpillars. The second brood, on pupating in the soil, may remain over winter as pupæ, and produce the first spring brood of moths next season.

The adult moth is dark-grey on the body and wings, with two rows of pink patches on the upper surface of the hind half of the body.

Controls.—Once an attack has commenced, spraying with arsenate of lead (about 1 lb. to 20 gallons of water) can be recommended where the foliage is not very thick. This would be more effective against the young stages of the caterpillars. In dense plots of sweet potatoes there seems to be nothing to do except to now and again shake the plants and search for and destroy the caterpillars.

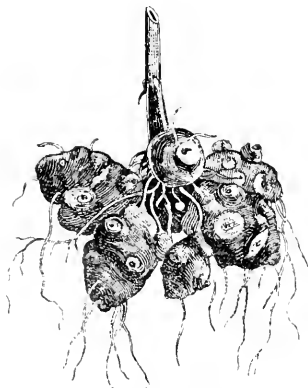
To prevent an infestation, turn up the soil in autumn and winter to expose and destroy hibernating pupæ in areas where they have previously attacked the crop.

THE JERUSALEM ARTICHOKE.*

This plant belongs to the sunflower genus and grows to a height of 6 to 9 feet, resembling closely in appearance an ordinary sunflower with a miniature flower.

It produces a large cluster of rhizomes or tubers, as shown in the illustration, useful for culinary purposes, and of special value as fodder for pigs. The leaves and stalks are of some value for sheep and conversion into silage, but it is almost invariably for the abundant crop of tubers that the plant is grown.

The Jerusalem artichoke is very persistent in growth, and, if raised in suitable soil, it is difficult of eradication. Enough tubers, as a rule, are left each year to continue the crop; hence it is wise to set apart a permanent paddock for it, or the odd corners of a farm or waste places of little value for other crops may be used for growing artichokes.



A cluster of rhizomes.

Suitable Climate and Soil.

The plant is extremely hardy. Whilst the best crops are raised on good mellow loams, profitable yields are secured on stiff clay lands, light sandy or gravelly soils.

The land is best suited where the drainage is good. In fact, any soil suitable for potatoes will answer for artichokes. It is a crop that requires little attention when it is established.

The soil needs thorough cultivation. It should be deeply ploughed about May or June. During the winter it may be harrowed occasionally, lightly reploughed about September, and well manured as if for sweet potatoes.

The tubers are then planted by dropping them into furrows 3 feet apart, with a space of 2 feet between each tuber. If the sets are small, plant whole, while large ones may be cut. Cover by turning a furrow over them. About 4 cwt. of tubers will plant an acre.

* A. J. Pinn, Inspector of Agriculture.

Ripening.

The crop matures in five months. Should rain fall immediately after planting, the harrow may be run over the land to fine the surface. This should be repeated when the plants are about 4 inches high to check evaporation and destroy weeds. Later on the cultivator should be kept moving between the rows about once a month.

When the crop flowers and the tops droop and die, about April or May, it is ready for harvesting.

Fodder Values.

In feeding to pigs it is best to turn the animals into the crop to root out the tubers. It must be remembered that where it is desired to continue the crop the pigs should be removed before all the tubers are eaten out, and the only cultivation then necessary is to plough the land and keep the surface loose and free from weeds until the next growth is above ground.

Few foods are more relished by pigs. The tuber in the raw state is very nutritious, more especially for pregnant sows, and also sows reduced in weight and condition after suckling and weaning big litters.

Young growing pigs make considerable growth when fed with artichokes for a short period. The exercise obtained in harvesting or rooting up the tubers has a beneficial influence.

A number of tests go to show that for fattening purposes these tubers must be given with grain, and have a similar result to feeding with ordinary potatoes; 325 lb. wheat, fed with 820 lb. artichokes, gave 100 lb. increase.

The average composition of the artichoke is shown here in contrast with the potato:—

	Water.	Ash.	Protein.	Carbohydrates.	Fat.	Nutritive ratio.
Artichoke	79.5	1.0	2.5	16.7	0.2	1 : 7
Potato	78.9	1.0	2.1	17.9	0.1	1 : 8.6



A crop of Jerusalem Artichokes.

SECTION VII.

Leguminous Crops.

EVERY farmer is now familiar with the group of plants known as legumes (so called because their "fruit" which contains the seeds is a legume or pod). These plants are of the highest value and possess characteristics that distinguish them from all others, notably the high protein content of their seed, the excellent feeding value of their whole vegetative system, and their capacity for storing nitrogen in their roots and thereby leaving the soil actually enriched in that important item of plant-food.

In New South Wales legumes are grown for various purposes: Lucerne for hay, field peas, vetches, and cowpeas for green fodder and hay, and also for green manuring and soil renovation, and garden peas and beans for the vegetable market and home use. Their place in our farm practice, indeed, is even larger than might be apparent at first sight, for the "herbage" that springs so abundantly on wheat lands when these are "left out," and that is so highly esteemed as pasture, consists largely of trefoils, which are as much legumes as lucerne or clover.

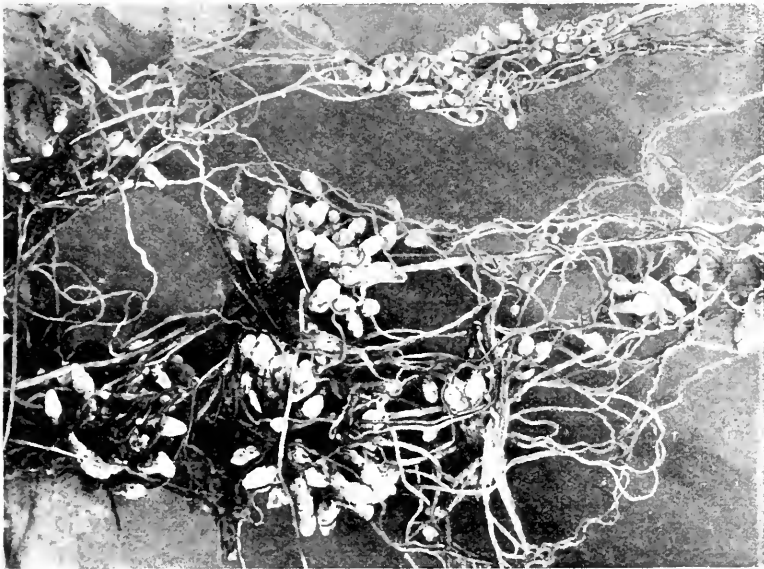
The secret of the value of these plants to the farmer is the possession of a source of plant-food that is not accessible to most other plants, particularly not to cereals. The practical experience of hundreds of years led farmers of past generations to believe that leguminous crops possessed some peculiar power of making succeeding crops grow better, and it was not till the last twenty-five or thirty years that this could be explained. It is now known that association with certain bacteria in the soil enables legumes to make use of the air in a way that other plants cannot. This association is one of mutual helpfulness, or symbiosis, the bacteria requiring considerable quantities of certain kinds of food that are generously supplied in the plant juices of legumes, while the plants derive from the bacteria, in some way not yet fully understood, a supply of nitrogen that the bacteria have taken from the air and built into nitrogen compounds within their own cells. It is supposed that the nitrogen compounds thus manufactured by the bacteria are diffused through the cell-walls and absorbed into the general circulation of the plants, where they are used for the building up of the protein compounds that are characteristic of the legumes in whatever form they are considered. The presence of these bacteria is indicated by the development on the roots of the little growths now universally known as "nodules." These little swellings vary from the size of a pin-head to the size of a small pea, and they may sometimes be seen by carefully digging up a plant with as many of the small roots as possible and then washing away the earth in a gentle stream of water.

There is unfortunately an impression amongst farmers that if the leguminous crop is removed from the land and the roots with their nodules remain, the soil is thereby enriched in nitrogen. It must be clearly understood that the nitrogen taken from the air by the organisms does not exist in the nodules, but is made use of and distributed throughout the plant.

and that the removal of the aboveground portion of the plant from the land means the removal of a large amount of nitrogen. An increase in the nitrogen content of the soil can only result from the growing of leguminous crops when they are fed off, ploughed in, or soiled to stock, and the resultant manure from the stock returned to the soil.

Soil Inoculation.

The soil conditions that in general favour nitrification also favour the presence of nitrogen-fixing bacteria in association with legumes, and consequently the number and development of the nodules. Ill-drained, acid soils, deficient in organic matter, tend to weaken or destroy the bacteria, and it is probable that this in part explains the failure of leguminous crops under such conditions. The introduction of cultures of bacteria into the soil has been attended with considerable success in some parts of America, and has



Bacterial Nodules (natural size) on roots of Tares at Hawkesbury Agricultural College Orchard.

been much advertised as a method of promoting fertility, especially where the growth of legumes is proposed. In some parts of the United States, in fact, use of such cultures appears to be advisable—even necessary. In New South Wales, however, experiments with cultures have revealed no advantage from their use, the soil and atmospheric conditions apparently favouring nitrification in a natural way.

In localities where lucerne has not been grown before, it may be necessary before sowing to inoculate the seed with nodule bacteria in order that the plants may attain a healthy and vigorous condition. The best way of

obtaining this infection is by the use of soil from an old lucerne patch where the plant has grown well. The soil should be in a dry dusty state, and the seed should be mixed with it thoroughly so that there is no doubt about infection taking place. The seed should then be sown with a drill or broadcasted in the ordinary way. The soil should be dried in the shade and the sowing of the seed carried out during the afternoon. Sunlight will kill the organisms—hence these precautions.

It is sometimes advisable to use very thin glue, passing the seed through it and then dusting with soil obtained from the old lucerne patch. The glue should be very thin and the seed only lightly coated.

In some instances soil is taken from an old lucerne field and scattered and worked into the proposed lucerne area, though this is a rather cumbersome method. The Department supplies artificial cultures, but culturing weakens the organisms, and a natural infection from the soil is always preferable.

Summer Legumes.

In this section prominence is naturally given to lucerne as the legume most in cultivation, but an increasing number of plants of this family are being utilised for a variety of purposes in the economy of the farm. Apart from lucerne and clovers, the leguminous crops may be conveniently classified according to the season of their optimum growth and climatic requirements as follows:—

Summer legumes—Cowpeas, peanuts, soybeans, and velvet beans.

Winter legumes—Field peas, vetches or tares, and tick or horse beans.

In districts with a severe winter climate, *e.g.*, the tablelands, the winter legumes given above require the summer season for their growth.

Similar advantages to those which are derived from the use of mixed pastures of grasses and clovers are obtainable from growing in combination a leguminous fodder crop and a cereal. A good deal of judgment has to be exercised in deciding on the most suitable combination. The exact time each crop takes to mature is an important factor, and it should be arranged so that they will both give their maximum yield and be ready to harvest at the one time. When grown alone many of these legumes creep along the ground, but when sown with a cereal they stand more upright, and are consequently easier to harvest. For use on the farm they can be made into excellent hay, but there seems to be no demand for such mixtures on the New South Wales market, and the presence of any foreign matter, regardless of its feeding value, will reduce the price of the chaff.

On account of their high feeding value and of their utility for soil improvement, the annual leguminous crops will always deserve a place in general farming and will yet come to be regarded as essential in any system of intensive farming in many districts of this State.

Generally speaking, these crops are not as particular in their soil requirements as many other crops, growing well on poor soils as well as on many acid soils to which clovers and lucerne are quite intolerant. These characters make them all the more valuable from a soil-improvement point of view.

Of the summer crops, velvet beans will make the best growth on poor land, though fertilisers, particularly superphosphate in small quantities, usually make a vastly increased growth of any one of them on such land. Soybeans are a little more resistant to dry weather than the other two crops, though none of them can be strictly called drought-resistant.

While not regarded as main fodder crops in any district, they have decided uses in this direction which are very little known at present. Apart from soil improvement each of these crops has its particular excelling sphere of utility—cowpeas as a purely hay crop, soybeans as a grain crop for pigs (particularly for hogging down) and also as an emergency hay crop, and velvet beans as a catch crop for winter grazing. It is the utilisation of the tops of peanuts for hay after the nuts have been threshed that makes the crop so valuable for fodder, though the whole plant may be used for hogging down.

As hay crops, cowpeas and soybeans cannot compete with lucerne where this crop can be grown, but lucerne has its soil and climatic limitations, and it is here that cowpeas or soybeans are deserving of a place. Their hay is more difficult to cure than lucerne hay owing to the thicker stems, but has the advantage of being actually less damaged by rain during hay-making. The following analyses show how favourably the hay compares in feeding value with that of lucerne or clover:—

PERCENTAGE of Digestible Nutrients.

Crop.	Protein.	Carbohydrates.	Fat.	Nutritive ratio.
Lucerne hay.....	11.0	39.6	1.2	1 to 3.9
Soybean hay....	10.8	38.7	1.5	1 to 3.9
Clover hay.....	6.8	35.8	1.7	1 to 5.9
Cowpea hay.....	5.8	39.3	1.3	1 to 7.3

Soybean hay appears to be therefore about equal to lucerne hay and superior to clover hay, while cowpea hay is only slightly inferior to clover hay.

Winter Legumes.

Field peas are being more and more extensively grown for the combined purposes of soil improvement and stock feeding. In the coastal districts they are sown alone, mostly in late autumn, for late winter or early spring grazing for dairy cows, or if feed is not short at the time they are ploughed in as green manure, and then followed with a maize crop with beneficial results. They can also be sown in combination with oats or wheat for green feed of better feeding value than the cereal alone. On the tablelands, where the crop is mostly used as a fodder crop for sheep, sowing must take place in early autumn or early spring, as severe frosts cut the plants to the ground. In the more favoured wheat districts field peas could with advantage be grown with the oat crop for hay for farm use.

Vetches and tares, too, are used as a dual-purpose crop, mostly in coastal districts, the greater bulk of the growth being used as a soiling crop, and the remainder ploughed in as green manure. The vetch is also used in combination with a cereal.

Tick or horse beans have found their best development so far as a green manuring crop in orchards on the Murrumbidgee Irrigation Area. They are not a palatable fodder, though they derive their name from the popularity of the seed for horse feed.

Those legumes that are grown for the vegetable market—beans and peas—are dealt with in the vegetable section of this Handbook (page 679).

LUCERNE.

Lucerne is now the chief leguminous crop in New South Wales, and its fodder value is becoming more and more widely recognised. Its most extensive cultivation in earlier years was in the Hunter district, and at Tamworth; but it has shown itself capable of adapting itself to a variety of soils and climates, provided its peculiar sensibilities are studied carefully, and it is now spreading over a much wider area of the State.

Suitable Soils.

It is seldom safe for a farmer to say that lucerne will not grow profitably on his land before he has tried it. It thrives on an extraordinary variety of soils, though maximum results cannot be expected from land which offers violence to the essential qualities of the plant. It is sensitive in certain respects, and disregard of its special susceptibilities will result in reduced yields, but payable results may be expected from almost any land, except that which is badly drained, or is very sandy. The plant roots very deeply, and it is obvious that a deep, permeable subsoil contributes to maximum results. Still, this is not an absolute essential to successful growth, as is proved by the results obtained on soil that at one time would have been considered quite unsuitable.

The heaviest yields are obtained on the very best alluvial soils found on river banks, particularly deep, free soils well supplied with lime and potash, and with free water 15 to 30 feet below the surface. A farmer possessing such ground will find it hard to discover a more profitable use for it than to grow lucerne. The suitability of lucerne to such a soil is the secret of success on the Hunter River flats, where comfortable livings are made on 30-acre holdings, and where first-class lucerne land brings from £70 to £100 per acre.

Drainage is absolutely essential to success, and if the soil is not naturally drained to a depth of at least several feet, action must be taken to bring about this condition before lucerne-growing is attempted. Where badly drained patches occur in the soil, the lucerne soon dies out absolutely, and its place is taken by couch grass and weeds of other kinds. Flood-waters do not affect it, because as a rule they soon run off, but to cover a lucerne field with water for two or three days is a sure means of eradicating it altogether.

Lucerne will not grow in sour soil. Lime is extremely beneficial, if not absolutely necessary, probably on account of its sweetening effect on the soil more than its mechanical effect.

Where the ground has become exhausted through frequent cropping or is naturally poor, artificial fertilisers will be required, and the suggestions made with regard to lucerne and clover on page 113 of this Handbook as well as the references to manuring in connection with the cultivation of each of the leguminous crops, should be carefully studied.

Preparation of the Soil.

The first matter to be considered by the farmer proposing to grow lucerne is the question of weeds. Young lucerne plants grow comparatively slowly, and are apt to be killed by weeds during their earlier stage of growth. For this reason it is generally preferable to sow lucerne in autumn, when the growth of weeds is not so great; but even then, in some districts, the problem is a difficult one.

If the ground be ploughed several months before sowing, and the weeds which then spring up destroyed by frequent cultivation, a large proportion of the weed seeds will have germinated and will be effectively disposed of. This method, however, will not be sufficient in districts or on soils which are specially subject to the growth of weeds, and cleaning crops such as barley, Hungarian millet, cowpeas, &c., to suit the district, can be grown to profitable advantage, the land being thoroughly cultivated and kept clear of weeds and couch grass while they occupy the soil.

Lucerne is a deep-rooting plant, and although its roots have great penetrating power, the plants will thrive better, and a better stand will be obtained, by opening up a stiff subsoil as deeply as possible. Plough 8 inches deep, if the nature of the soil will permit, and follow in the furrow with a subsoil plough from 12 to 14 inches. This depth of loose soil will enable the young plants to root well, after which they will be strong enough to pierce even a very stiff subsoil; though, of course, the deeper the friable soil goes the better.

A good rainfall cannot always be depended upon at seeding-time, and light falls of rain may have the effect of germinating the seed without being sufficient for further growth. For dry districts, therefore, fallowing can be recommended, and the land should be ploughed in autumn or early winter the year before it is intended to sow the seed. Plough 9 inches deep, provided the top soil reaches down to that depth. In case the top soil is only 5 or 6 inches deep, then the land should be ploughed to that depth, and a second plough, with the mouldboard taken off, should follow the first plough, and stir the subsoil to a further depth of 6 inches. Care must be taken not to bring any of the subsoil to the surface.

The ploughed land should then be allowed to lie in the rough state during winter, and be broken down in the beginning of spring with harrows. During the summer months the land must be frequently worked with harrow or cultivator, so as to allow neither growth of weeds nor the formation of a hard crust on top. If the seed-bed cannot be worked down sufficiently fine with the harrows, a one-way disc cultivator or roller will soon do all that is necessary. If the land is rolled it should be harrowed immediately after the rolling.

The success of lucerne-growing in dry districts depends almost entirely upon the thorough preparation of the soil, and the ideal conditions to be aimed at are a deeply ploughed soil, in which the previous year's rainfall has been conserved, together with a finely worked surface as a seed-bed.

The Seed-bed.

Just before the seed is sown a light ploughing should be given, and the land well harrowed and rolled, to level the surface, and to give a firm, fine seed-bed. Generally, about three or four harrowings and one good rolling are required, but in some circumstances it is necessary to roll twice. If weeds or grass are still present they should be worked out with a spring-tooth cultivator and removed.

Since the surface soil undergoes the greatest change, it follows that it becomes the most fertile, and it is necessary to retain it where the young plants will be benefited by the enhanced fertility. The seed is planted near the surface, and it is there that the young roots gain the sustenance required by the plant. If deep ploughing is given the second time, this improved soil is inverted and put beyond the range of the young roots. The second ploughing should, therefore, be shallow.

Selecting Lucerne Seed.

Good lucerne seed should be sound, mature, plump, bright, well saved, and reasonably even in size. It should not contain more than 1 per cent. by weight of impurities and weed seeds, with no dodder or harmful weed seeds present (purity standard 99 per cent.). It should be free from insect pests and fungus disease; and there should not be less than 85 germinable seeds in every 100.



Dodder Seed.
(*Cuscuta trifolii*).

X 10.



Lucerne Seed.

X 5.

If grown in New South Wales, the seed is likely to give better results than if imported, even though the germinating powers may be alike. It is wise to test all seed for purity and vitality. To carry out the test, take a piece of blotting paper about 6 by 8 inches in size, folded across the middle, and place on an ordinary dinner plate. Moisten the blotting-paper with water, and spread 100 seeds evenly over one half of the paper; turn the top flat down, and invert another dinner plate over the lower one so as to serve as a cover. The plates should then be set in a warm place, where the temperature can

be approximately maintained at about 80 degrees Fahr. The blotting-paper must not be allowed to become dry, and every twenty-four hours the germinated seeds should be removed and the number recorded.

To test for purity, take a given weight, say 1 oz. of the seed; spread it out on a sheet of white paper, and pick out all impurities. These may consist of sand, dirt, vegetable matter (small twigs of the plant, for instance), mouse-dung, weed seeds, or insect remains. These should be carefully weighed, and the proportion in the sample arrived at thus:—

$$\left. \begin{array}{l} \text{Total weight} \\ \text{of sample} \\ \text{tested} \end{array} \right\} : \left\{ \begin{array}{l} \text{weight of} \\ \text{impurity} \\ \text{found} \end{array} \right\} :: 100 : \left\{ \begin{array}{l} \text{actual} \\ \text{percentage} \\ \text{of impurity.} \end{array} \right.$$

The weighing can be done with very little trouble. If the individual cannot manage it, no doubt the local chemist would oblige, the simplest weights to use being avoirdupois, 437½ grains to 1 oz., or 7,000 to the lb. The calculations are then easily made.

If it is found that seeds of noxious weeds exist (more especially dodder), the bulk should be sifted, using a mesh that will retain the lucerne whilst allowing the dodder and other small things to pass through. Broken and small seed may pass through also, but this will be no loss.

Varieties of Lucerne.

Farmers have so far given but little attention to the subject of varieties of lucerne, the local strains, Tamworth, Hunter River, and Mudgee, having such an advantage in acclimatisation as to make the discovery of a better a difficult matter. The Department has tested a number of lucernes from other lands, however, seed being obtained from time to time, as the published reports appear to suggest their possible utility here. It is still extremely doubtful if any can be recommended in preference to the local strains that have been deservedly popular for so long.

Time of Sowing.

In land which has previously been infested with barley grass, or other weeds whose seeds germinate in autumn, August and September are the best months for sowing; and under irrigation in the western districts spring sowing is preferable on account of the rapid growth which weeds make in winter, whilst lucerne is comparatively slow in germination during the cold weather. But throughout the bulk of the areas where lucerne is grown autumn sowing is preferable. For instance, on the North Coast, if lucerne is sown in spring or summer it will have but a poor chance of surviving amongst the heavy growth of weeds, and March and April are the months recommended. On the New England tableland and similar elevated districts the seed should be sown in March, so that the roots may be well down before frosts set in; in the most important of our lucerne areas the sowing should be a little later than that. In the southern and south-western districts, where lucerne might be profitably grown on many farms, a little discretion should be exercised, autumn being the best time if the season has been a wet one and the soil conditions are such as favour early germination, while in the case of a dry summer and autumn the sowing should be delayed till about September.

Quantity of Seed.

The quantity of seed applied varies widely with the method and the district. In the Richmond River district heavy seeding, 15 lb. to 20 lb. per acre, is strongly recommended. In the regular lucerne districts of the State from 12 lb. to 15 lb., and even 20 lb., per acre is applied, and the hand-broadcaster, known as the "fiddle," is employed. For dry districts, such as the Riverina, 10 lb. to 12 lb. will be found ample if evenly applied.

It is not wise to run the risk of a thin crop through a little parsimony in seeding. It is all-important, with a permanent crop such as lucerne, that a good stand should be obtained at the outset. Re-seeding cannot be done without again breaking up the land, and this means that a year or more is lost. If re-seeding is not done, the yields are permanently affected through the poor stand. Attempts are sometimes made to remedy unsatisfactory stands by sowing further seed, but they are seldom successful. The soil is not in a receptive condition, and what plants do grow have to contend with established vigorous plants.

At the same time it is a mistake to endeavour to remedy defects in preparation, or in the state of the soil, by heavier seeding. Favourable conditions are required to promote germination and to help the young plant, and seeding should only be done after they have been obtained. If the ground should happen to be dry at seeding-time, heavier seeding will not secure a proper stand.

Machines for Sowing.

Farmers generally prefer to broadcast the seed where the area is small, but sowing through the grass seed attachment of the wheat drill is a useful method when the area is larger.

A method of sowing that is well suited for wheat districts is to mix thoroughly 70 lb. of superphosphate with 10 lb. to 12 lb. of lucerne seed, put the mixture into the manure-box of an ordinary seed drill, and set the drill to sow about 80 lb. of manure per acre. The discs or hoes of the drill should not be set into the soil too deeply. Some drills, especially when new, cannot be set to a shallower depth than $1\frac{1}{2}$ to 2 inches; in such a case a good plan to follow is not to set the lever of the drill into the first notch, but to let it dangle. The cogs of the drill will be in gear, but the hoes will not go down as deeply as if the lever had been set into the first notch. In this way the seed will be sown about $\frac{3}{4}$ inch deep. Special care must be taken not to fill the manure-box right up. Not more than sufficient seed and manure for 1 acre—*i.e.*, about 80 lb.—should be put into the drill at one time, and this should be stirred up occasionally to prevent the seeds rising to the top of the manure. In order that the seed may be thoroughly covered, it is advisable to either improvise a brush harrow at the back of the drill, or to harrow with light poppy harrows after the sowing.

A fine, level, rolled surface is required for sowing. The seed must be covered not more than 2 inches deep, nor less than half an inch, and to secure this, fineness is essential. An even distribution of the seed is required, and although some men are sufficiently expert to obtain it by hand-sowing, such a method is not recommended. Many good machines are available which do the work satisfactorily.

If a farmer is compelled to resort to hand-broadcasting, half the seed should be sown in one direction across the paddock, and the other half at right angles across the first cast, so that strips missed the first time will receive some seed. Select a calm day or early morning, as it is hard to distribute the seed evenly on a choppy, windy day.

Covering the Seed.

The seed should be covered with a light harrow, though a brush harrow is often used. Adjustable lever harrows are very effective for this work, as the depth can easily be regulated. Ordinary harrows, with the tines set obliquely backwards, will also ensure light covering. The seed should not be covered deeply, and precautions must be taken to prevent a crust forming on the surface. The harrow is generally followed by the roller, the effect being to give a more finished surface, and at the same time to bring the moisture from below to the surface, thus ensuring a more even and generally a quicker germination. The compacted surface produced by the roller results in increased evaporation of moisture, but before the evaporation can take place the moisture must have been concentrated near the seed, which thus benefits. Moreover, unless the roller is used a cloddy surface is left, which is ruinous to the knives of the mower.

In heavy, cloddy ground, which cannot be broken down finely, it is better not to cover the seed in any way, as under fair conditions it will germinate freely on the surface like the clovers.

Cultivation and Early Mowing.

Lucerne sown in autumn should receive no cultivation until the following spring at earliest. The young plants are tender, and will not stand rough handling. On friable, loose soil especially the effect of cultivation would be to pull many of the plants out, and consequently the harrowing must be light, and should not be attempted until the roots have a firm hold, but after the second cut, particularly on ground that sets hard, the harrow can be used.

The method of keeping early spring weeds in check is to mow frequently. The mower should be put over the crop before any of the weeds have commenced to flower, and the operation should be repeated a month or two afterwards. Two mowings will generally be sufficient. They must not be omitted if weeds are getting a foothold, even if the lucerne is not ready to cut, as the object is to destroy the weeds. If the quantity should warrant it, the cut material can be raked for green feed, but if left on the ground it makes a useful mulch.

Once lucerne becomes well established its vigorous growth keeps most weeds in check, but a certain amount of cultivation is necessary. The crop should be disced and cross-disced early in the summer, before the first growth if possible, or after the first cut, and again about midsummer. The discs should be set rather straight, and the harrow weighted to cause it to sink to the right depth. The loosening of the surface allows moisture to percolate to a greater depth, and prevents it from wasting by flowing away over the surface. Owing to the depth to which even light showers then penetrate, less loss occurs through evaporation. The splitting of the crowns by the discs encourages tillering, and the crop thickens.

If a disc-harrow is not available, an ordinary spring-tooth cultivator can be used very effectively, and one fitted with special narrow tines is satisfactory on moist ground. The spading harrow is also a useful implement for the cultivation of lucerne fields. The lucerne cultivator, which is practically a spiked roller, has given satisfactory results at Bathurst Experiment Farm when the soil is in a desirable condition as regards moisture. At Wagga Experiment Farm, a light ploughing with rotary disc ploughs has proved successful when the soil has become set.

Lucerne Haymaking.

Lucerne is more difficult to cure than any other kind of hay crop, and greater loss occurs to it than any other when improperly treated. Careful handling is required from the time the crop is cut until the hay is baled for market. The eagerness with which buyers snap up well-cured lots of lucerne hay indicates the importance of curing and of marketing in the very best condition. They prefer hay that is bright, green, dry, free from weeds and rubbish, and that contains a large proportion of leaf. A dirty appearance, indicating careless handling in the field, or the slightest sign of heating in the bale, causes buyers to reject the lot or to only accept it at much reduced prices. Since quality is of just the same importance when lucerne hay is fed on the farm, the same care is necessary in its treatment.

Lucerne should be cut just after the first flowers have appeared, though many growers prefer to watch the crown for the young shoots of the next cut. Much more depends upon the selection of the right time to cut lucerne



Mowing Lucerne, Hawkesbury Agricultural College.

than with other hay crops. In the latter cases loss is chiefly due to deterioration in digestibility, but in lucerne the loss is not confined to this, but extends to actual loss of weight in the hay and to poorer growth in the succeeding crop. After lucerne flowers, the nutriment in the stems and leaves is withdrawn and transferred to the upper portions of the plant, and the stems harden and become indigestible and of less value as food. The leaves wither also and begin to fall, which results in loss of weight, and as these are the richest portion of the plant every effort should be made to retain them in the hay. No advantage is obtained when the crop is allowed to remain uncut past the stage recommended. The only time when such a course is justifiable is when the weather is unsuitable for hay-making, and the crop is left standing until good weather is assured. A loss in the succeeding cuttings also follows when cutting is left past the time indicated. This loss is due to two things. When the crop is left uncut until past flowering, it is found that the succeeding crop does not start away so quickly

as it does when the cut has been made earlier. Secondly, loss occurs through the greater time which the crop occupies the land. Lucerne only grows during the summer, and, provided rain is plentiful, good crops can be obtained at frequent intervals. If the average time for a cut of lucerne be taken at six weeks, and five cuts are obtained in a season of thirty weeks, it means that if each cut is allowed to stand seven weeks, only four cuts can be obtained, which means an actual loss of 15 cwt. to 1 ton of hay per acre per annum.

It usually happens that owing to the cool weather the first growth of the season is late in flowering, and the leaves begin to drop and the stems to harden before the bloom appears. The crop should be carefully watched and the cutting made when the lower leaves begin to change their colour.

Cutting is done with the mower or scythe. A time should be selected when the crop is at the right stage, and when there is a prospect of fine weather lasting until curing is completed. Showery or cloudy weather renders curing difficult, and hay of the best quality cannot be made. The usual practice is to start the mower going in the morning as early as possible, but if a heavy dew is on the crop, cutting should be deferred until it has evaporated. External moisture, owing either to rain or dew, is objectionable, and causes deterioration in the quality.

Handling the Crop in the Field.

If the day continues fine the rake should be started about midday, so that the cut crop will be raked into the windrows before nightfall. Hay should not be allowed to lie in the swath too long, especially in hot, scorching weather, when it should be put into the windrows almost immediately after cutting. The heat causes rapid drying of the tender leaves, and these



Students harvesting Lucerne, Wagga Experiment Farm.

become quite dry, while the stems are still sappy. When the hay gets into this condition in the swath, a large amount of the leaf will shake off when raking into the windrows, and in cocking. In good hay the quantity of leaf ranges from 45 to 50 per cent., and as it is considerably richer than the stems in nutriment, a very serious loss in both quality and quantity may occur through careless handling.

After the hay has wilted a few hours in the windrows it should be put into cocks. The time varies according to the condition of the weather. In cool, fine weather it may be left about half a day, while in hot, scorching weather it should be put into cocks almost immediately. In cloudy, dull weather it is left from one to two days. Drying is done to remove the excessive quantity of moisture, and to get the hay in such a condition in the field that when stacked it will not heat too much nor become mouldy. The moisture is removed by the heat and wind drawing it off directly, as it is removed from a wet cloth, or by the leaves transpiring as they do when the crop is growing. Heat dries the tender leaves rapidly, causing them to become too dry while the stems are still insufficiently dry. The hay dries best when the activity of transpiration in the leaves can be maintained. This gradually exhausts the moisture of the stems, and the curing takes place more evenly. This natural transpiration of moisture is obtained by putting the hay into cocks soon after raking into windrows. The leaves in the cocks are protected from the direct rays of the sun, and are not scorched. By following this plan the loss of both quality and quantity is materially reduced. Hay cured in this way is sure to keep well in the stack, while if dried in the swath or windrow it is almost sure to blacken or burn.

The cocks should be made narrow and high, rather than broad and flat. In wet, muggy weather, moulding is liable to start in the cocks, especially where leafy, sappy stuff is handled. To obviate this danger the cocks should occasionally be gently moved to let in the air. Just before stacking, the cocks are sometimes moved to expose the lower hay, which is inclined to be slightly damp. Exposure to the air for an hour or two soon drives off the moisture and puts the hay in a proper condition for stacking.

The time the hay is allowed to remain in the cocks depends upon the weather conditions. In fine, hot weather it can be stacked two days after cutting, while in cool weather three to four days are necessary. Care has to be taken that it is not stacked whilst so damp that combustion or mould will occur in the stack, but, on the other hand, it is equally important that it does not become so dry that its palatability, digestibility, weight, and appearance are injured. It is work in which some experience is required to secure the best results. A farmer with a large quantity of valuable hay lying in the field is tempted to bring it in too early to avoid the risk of damage from rain, while in good drying weather he is inclined to leave it longer than necessary to avoid the risk of loss in the stack. It must be remembered that good colour is of great importance, and by leaving it too long, the hay on the outside of the cocks will bleach, and lose its green colour, and seriously affect the appearance of the whole of the hay. Generally speaking, good drying weather can be obtained in most of the lucerne-growing districts of the State, and the chief danger to provide against is over-drying.

Stacking.

It is almost impossible to indicate exactly when the hay is at the right stage for stacking. Little danger exists of insufficient drying of the leaves; the chief danger exists in the stems. These should be examined carefully to ascertain whether they have lost their sappiness. If they are sappy and moist, the hay should not be stacked. Generally it is right to bring in when it has a crisp feel rather than a dead, damp feeling. Lucerne hay should preferably be stored in sheds. It does not shed rain well, and

should never be stacked in the open unless thatched or otherwise covered to protect it from rain. Storing in sheds, besides being more convenient, has the advantage that when baling or feeding no damage can be done to the hay by rain or heat. Before building, a foundation of poles should be laid down to give ventilation to the bottom of the stack; if stacked on the ground, some of the hay is sure to spoil. In building the stack, the centre should be kept high, so that rain will not run in from the sides.

Under some circumstances the hay is liable to become so heated in the stack that firing occurs. In other cases heat is generated, but not sufficient to cause firing, and the hay is only charred. As a rule, spontaneous combustion is found to occur in hay which has been made from heavy, sappy crops, especially if it is made when the weather is not suitable for drying. Great difficulty is experienced in getting the moisture out of very green lucerne, and even when the stuff is apparently dry, charring or combustion may occur. When the crop is very sappy, and the weather not favourable to drying, the hay should be put up in narrow cocks, and left in the field until no trace of moisture can be detected. As the first cut of the season is generally rather sappy, extra care should be taken with it.

Baling and Marketing.

Although baling is sometimes done direct from the field, or very soon after stacking, the practice is not the best. A certain amount of curing takes place in the stack, the hay mellowing there before being baled. In baling from the field care must be taken that the hay has time to sweat before it is put into tightly-compressed bales; otherwise rapid heating may occur, and the slightest suspicion of heat will cause buyers to reject it. Of late the old large-size bale has fallen into disfavour, and many buyers now prefer a smaller-sized bale.

It is to the farmer's own interest to put his product up in such a way that it will command the best price, and it is absolutely certain that if he does not send his produce to market in a proper condition a fair price will not be realised. The keenness with which buyers note the different brands of produce on the market is indicative of their desire to be sure of the quality of the stuff they buy. Good known brands are snapped up readily because they have been proved by experience.

Brown Lucerne Hay.

This is made either accidentally or by design. Sometimes, when it is intended that dry green hay should be made, the crop is stacked while containing slightly too much moisture, and the changes in the stack result in a brown hay being formed. This is claimed by some to have certain advantages over dry green hay. It is more succulent, freer from dust, and stock, in some cases, showed a decided preference for it. Generally speaking, the price obtained is slightly lower than that for prime green hay, but when the sample is good the difference is not very marked. Probably brown hay would be more largely made, especially for dairy cows, were it not for the greater risk of loss by firing. The methods of cutting and curing are the same as in making green hay, except that the hay is not allowed to become so dry in the field. The risk of spontaneous combustion is therefore greater than in the case of green hay, and experience is required to get brown hay.

Grazing.

In dry districts the value of lucerne as a **grazing** crop commends itself to stock-owners. Being very drought-resistant, it often provides acceptable green feed when other succulent fodder is scarce or non-existent, and after a long dry spell it is almost an axiom that lucerne is the first plant to grow when rain comes.

The pasturing of stock upon lucerne, however, is attended by two risks—one to the plants and one to the stock.

Lucerne should not be pastured during the first or second season of its growth, as the plants are not then sufficiently strong to withstand the inevitable trampling. Again, it will not stand continual grazing at any time, and the method should be to put sufficient stock on to eat it down quickly, and then to move them off before the young plants have commenced to shoot. The paddock should be subdivided into small lots for grazing, so that the stock can be moved from one to the other in quick succession. Temporary fences should be erected and shifted as required. This prevents injury to the plants, and reduces the loss of feed.

Even with reasonable care, the use of lucerne as a pasture will inevitably lessen the life of the plants. Lucerne not irrigated and fed off by stock in the drier districts will probably require to be resown after a very short period—perhaps as short as four years. Whenever possible, a cut for hay or green feed should be taken.

“Bloat,” or hoven, is caused by feeding stock upon green, succulent fodder at a time when the stomach is practically empty; or by giving an abundance of gas-producing feed before the digestive organs of the animal have been accustomed to dealing with such material. Cattle and sheep appear to be the only domestic animals subject to the danger. If the lucerne is wet at the time of eating, the liability to bloat is increased, and the danger is especially great when the crop is in the early stages of growth.

In the drier districts there is not as great danger of bloat as on rich alluvial flats, for the simple reason that there is not the same abundance of succulent fodder.

Stock should not be put on lucerne when it is wet. The danger is accentuated in humid, windy weather. If possible the animals should go on with a full stomach. They should first have their appetite appeased with grass, green maize, sorghum, or other similar feed. Bloating usually occurs when hungry animals are put on the feed and eat large quantities, and it also occurs if they are put on and taken off for periods. They should be kept on continuously and never allowed to get hungry.

If the stock cannot be placed in the paddocks with full stomachs, they should be taken on and herded for twenty minutes or so, and then taken off for about an hour; then put on for another twenty minutes, and the process repeated until the stock are no longer hungry. This practice is recommended whenever stock are being introduced to lucerne after other feeding. When they have become accustomed to the feed they can be left alone.

Soiling is far more economical than pasturing for all kinds of live stock. Animals grazing on lucerne generally destroy far more than they eat by trampling down the fodder. Various estimates are given of the increased number of animals which can be carried on a given area by this method,

several authorities stating that from three to six times as many head of stock may be maintained by soiling as compared with grazing. The advantages claimed for soiling over grazing may be summed up thus:—

1. It saves land.
2. It saves fencing.
3. It economises food.
4. It keeps cattle in better condition and greater comfort.
5. It produces more milk.
6. It increases the quantity and quality of manure.
7. There is greater docility and discipline of animals.
8. There is less breaking of fences.
9. There is increased order in all business of the farm.
10. It ensures regularity of feeding and output.

The Lucerne Seed Crop.

The production of seed is mostly confined to those districts where lucerne has been grown for a number of years, and the practice is to allow one crop to go to seed when the conditions appear to be suitable. The venture is a somewhat risky one, but experienced growers appear to be able to judge the conditions with considerable accuracy. A well-established and somewhat thin "stand" is preferred for the purpose, though sometimes three-year-old plants are utilised. As a rule it is the second cut, or the one that would produce hay early in December, that is allowed to go to seed. The crop should be cut when the pod has turned a deep yellow, but before it has turned brown. The grain is then also yellow, and, though quite soft, will mature into prime seed after it is cut. If it is left standing too long in the paddock the colour will be spoilt, and, rightly or wrongly, buyers have a prejudice against dark-coloured seed. Should the crop not be ripening evenly, the aim should be to harvest when the greatest quantity of prime seed may be expected; otherwise the matured pods will burst and the grain be lost. The crop is cut with the mower early in the morning and in dry weather. Sometimes the swathboard is attached to the mower and the crop left in the swath for two or three days, then drawn into heaps with pitchforks (not rakes), and left another day before being carted in and stacked. If the swathboard is not used it is put into heaps on the same day or the next morning, and carted in about the third day. In either case the handling must be with care so that the pods will not be knocked off.

The crop is threshed from the stack, an ordinary wheat thresher with very fine screens or a special lucerne thresher being used, together with a blast winnower through which the seed is put to clean it. The seed is usually stored in air-tight iron tanks, or in double bags in a dry place where it matures before it is marketed. During this period it must be kept perfectly dry or it will turn brown and depreciate in value.

Lucerne seed is a profitable crop, 4 bushels to 6 and 8 bushels per acre being obtained, and with the price to growers reaching and even exceeding 1s. per lb., the monetary return is good, but the risk is considerable. If the weather proves unfavourable the farmer finds he has lost valuable time in the extra period the crop has occupied the land, and that he has to be satisfied with an inferior sample of hay.

The Life of a Stand.

The time during which lucerne, once properly established, will continue to yield payable crops will be found to vary with the nature of the soil and subsoil, and the use to which the plants are put. On the best soils, such as the deep, well-drained alluvial soils of the Hunter Valley, the period for which it will pay to crop lucerne before breaking up the ground is much longer than on granitic uplands with an unfavourable subsoil or rock close to the surface. Grazing any kind of stock on lucerne is much more injurious to the life of the plants, owing to the consequent trampling, than removing the cuttings for hay. While, therefore, it may be said that the average profitable life of a lucerne paddock is seven years, this estimate will be found to be the mean between rather wide extremes.

Lucerne gradually dies out, the termination of the life apparently being due to the plants losing their vitality, as all plants do; but the termination of its profit-yielding period is governed by other factors as well. The continuous growth of the one class of crop exhausts the fertility of the soil, although lucerne, unlike clover, does not appear to cause land to become "sick" in the ordinary sense of the term. After the land has been utilised for other crops for a time, it can again be successfully laid down to lucerne.

TOP-DRESSING WITH SUPERPHOSPHATE.

There is a mistaken idea, prevalent among certain growers, that a lucerne field requires no further attention than perhaps the usual cultivation given early in the spring, and that it naturally increases in fertility. These farmers argue that lucerne, being a legume, can gather nitrogen from the air and enrich the soil; moreover, say they, its wonderful root system can traverse a wide area in the soil in search of other necessary plant-foods. All these things are undoubtedly true; but to be profitable, and to be continuously so, lucerne requires attention as much as any other crop, and the farmer who would lengthen the life of his stand and also derive from it the maximum return while it is with him, will take care of it and neglect nothing that will invigorate and maintain it. Lucerne removes much larger quantities of other plant-food from the soil than most farm crops, and therefore depletes the soil of these elements more quickly.

The value of top-dressing lucerne with superphosphate as a means of increasing the yield has been proved in quite a number of trials conducted by the Department, first at Glen Innes Experiment Farm some years ago, and more recently in several other parts of the State.

On the Coast.—During the season 1919-20 a number of tests were made at different centres in the central coastal district, viz., Mondrook, Pampoolah, and Dungog. Amounts of 1 and 2 cwt. of superphosphate per acre were used on the plots, and comparisons made with unmanured plots. Very considerably increased yields resulted from the application of the superphosphate, the difference attributable to the top-dressing being as much as 8 tons from a total of four cuts in one instance. These increases in the yields speak for themselves, but it was also observed at each centre that the general condition of the stand was improved and that the crop was of better quality.

On the Tablelands.—In a trial conducted in 1916 and 1917 at Glen Innes Experiment Farm, increased yields of 3 tons 17 cwt. and 6 tons 10 cwt. resulted from applications of 1 cwt. and 2 cwt. per acre respectively of superphosphate. Top-dressing now forms part of the regular farm practice.

In Western District.—Some interesting figures that prove the value of top-dressing come from a farmer in the Orange district. Portion of a good stand of lucerne, which had nevertheless not been yielding as well as it might, was top-dressed with 1 cwt. per acre, and another portion with 2 cwt., while a third portion was left untreated for comparison. The whole paddock was worked with the spring-tooth cultivator both ways in the beginning of August, again "spring-toothed" late in the month and the superphosphate sown with the wheat drill on the 29th August. The difference in the growth of the plots was very marked; the unmanured plot showed sickly growth mixed with grass, and the leaves died off as a consequence in the dry weather. The manured plots, on the other hand, grew luxuriantly, and showed a dark, healthy, green colour. On 25th November the plots were cut, and the crops weighed at once, with the following results:—

	tons.	cwt.	lb.
No manure	0	5	64
1 cwt. superphosphate per acre	2	12	64
2 cwt. superphosphate per acre	3	7	78

These results were so satisfactory that the whole area was dressed with superphosphate, and though very dry weather followed and seriously checked growth, the manner in which the lucerne revived after rain suggested that the fertiliser really saved the stand from extinction.

Under Irrigation.—As the result of experiment, the top-dressing of lucerne with superphosphate in the spring has become a recognised feature of the farm work at Yanco Experiment Farm, and in various experiments conducted by the Department in conjunction with settlers on the Murrumbidgee areas, applications of 2 cwt. of superphosphate have been the means of increasing the yields by as much as 1 ton 14 cwt.

Summary.—The outstanding advantages that are to be derived from the top-dressing of lucerne with superphosphate may be summarised thus:—

- (1) The green fodder yield is greatly increased.
- (2) A better quality product results—in fact, a healthy, dark-green colour is noticeable throughout the whole growing period.
- (3) The general condition of the stand is built up consequent upon the vigorous growth developed.
- (4) The useful life of the stand may be extended, and depleted stands largely restored.

Lucerne under Irrigation.*

Throughout the western and south-western districts of this State there are many thousands of acres of land admirably adapted to the growth of lucerne under irrigation. The main requirements of the crop are plenty of sunshine, high summer temperature, sufficient moisture, and a deep, well-drained soil, rich in plant food. Any porous soil with proper natural drainage will be found suitable for the growth of lucerne under irrigation. Heavy clay land should be avoided on account of its close texture, which prevents the free percolation of air and water, and also on account of the mechanical obstacles which it offers to cultivation. But clayey loam is quite suitable, and heavier soils will yield good results if they are of such a nature that the lucerne roots can penetrate freely through the subsoil.

* Compiled from Farmers' Bulletin No. 143 by F. G. Chomley and F. A. Chaffey (Yanco Experiment Farm), and other sources.

Limestone country is particularly suitable for lucerne, and has the additional advantage of being naturally well drained. Lucerne under irrigation does particularly well on such soil. Wherever large mallee timber grows there is usually plenty of limestone in the soil, consequently in such country lucerne usually grows to perfection.

The consistent returns obtained from the production of lucerne hay on the Yanco Experiment Farm during the past few years make a study of the methods adopted at that institution worthy of consideration.

The soil on the farm consists for the greater part of a heavy clay loam, the top soil varying from 5 to 8 inches in depth and being underlaid by a band of clay that varies from 2 to 22 inches in thickness in reverse ratio to the top soil.

When to Sow Lucerne.

Under such conditions care is essential in order to ensure the establishment of a good stand, and the first thing to take into account is the time when the seed should be sown. It might be said in one word—autumn. The soil is then warm, it is possible to apply the water in such a way as to ensure a saturated subsoil, and to work the surface so as to produce an almost ideal seed-bed, and the lucerne can be got above ground sufficiently before winter to enable it to continue slowly to establish itself during the cool months, so that in the spring it is ready to respond to the increasing temperatures and to such applications of water as the weather makes necessary.

Spring sowing is quite possible, but the plant is more delicate and requires more attention, greater care, and extra labour to ensure a profitable stand. Young spring-sown plants necessarily feel the effects of the advance of summer more, not being so well established as those sown in autumn, and will yield at least one cut less in the first season than a stand sown five or six months earlier. On this farm it is common now to sow blocks of 30 acres in the autumn and to do so with reasonable assurance of a good stand, but of spring sowing the area would not exceed 5 acres. The methods adopted in spring sowing are, in essence, quite the same as for autumn sowing, the only differences being those obviously imposed by the season. For convenience, the method described in this article is that adopted for the autumn.

Preparing the Ground.

It will perhaps be appropriate to remark at the outset that as the unhindered flow of irrigation water across the field has at all times to be kept in view, it is essential that all operations shall be conducted in the direction of the fall. The ploughing must be in small lands and not round and round, or it will be found that dips will remain in the centre in which water will lie and will kill out the lucerne; on one occasion such a mistake was made on the farm some years ago and the stand suffered accordingly. Similarly, the ploughing must not be across the fall, or the inequalities of the ground will interfere with the flow of the water. Cultivation (except of the very lightest character) must be in the same direction for the same reason. The seed drill must work the same way or the rows of the lucerne, crossing the fall of the water, will impede its advance and produce uneven watering with possibly the killing out of certain patches. The surface cultivation to which the crops are annually treated after they are two or three seasons old must be guided by the same principle. In a word—all work likely to affect the levels, even a little, must be the one way.

The first ploughing is usually given in December or January. It is generally found a good practice to precede the sowing of lucerne with a cereal crop. The working tends to produce a good tilth and also enables the character of the soil to be known accurately. As soon as the crop is off, the stubble land is ploughed 6 or 7 inches deep, the disc plough being used, though there is no reason why a mouldboard implement should not do quite as well. A short fallow of two or three months is allowed before a louvred grader or smoother is put over the land, across the plough, to produce an even surface.

A type of scoop called the buckscraper, shown in Fig. 1, is also very useful for this purpose. If it is followed by a leveller made on the lines indicated in Fig. 3, a very satisfactorily graded field can be made to result.

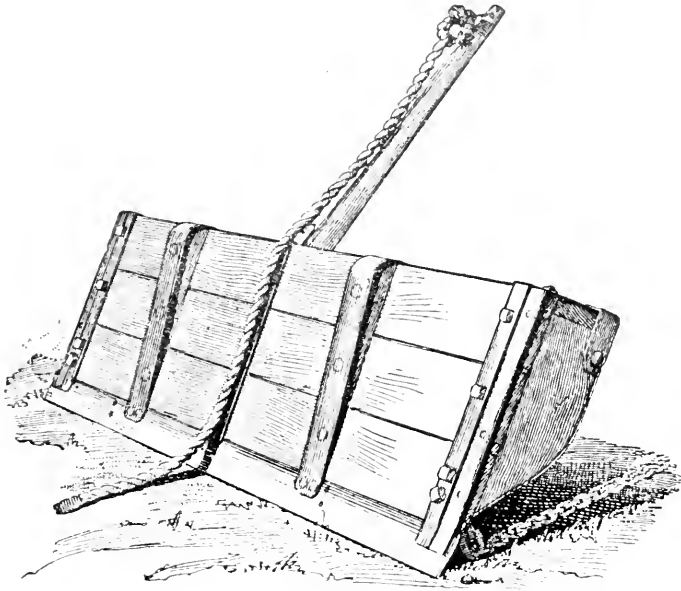


Fig. 1.—The Buckscraper.

As is usual with scoops, the weight of the loaded buckscraper is carried on steel-shod runners, and the blade is of steel. When empty it is usually drawn in the position shown in Fig. 1, the ends, which may be also shod with steel, serving as runners. A strong rope is attached to the end of the handle, and the operator brings the implement into position

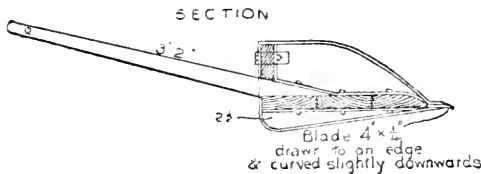


Fig. 2.—Section of Buckscraper.

for filling by placing his foot on the blade, which is on the ground, and giving the rope a sharp pull. For the purpose of emptying the scoop he raises the handle gradually while the horses are moving, and the earth empties itself slowly out and is distributed evenly over the ground. It is not dumped into a heap as is usually the case with scoops.

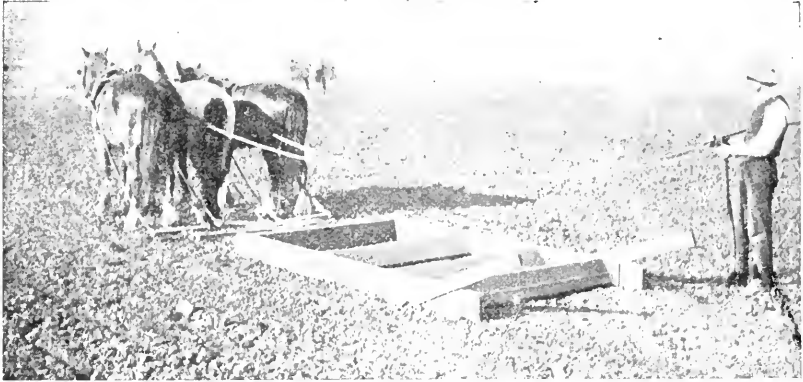


Fig. 3.—Home-made Leveller at Work.

Careful yoking of the horses is necessary to prevent "see-sawing," and the balance of the scraper must be regulated by the point of attachment of the draw chains.

Making the Check Banks.

The method of irrigation adopted is flooding, but flooding over limited areas, and between check banks that run down the field in the direction of the fall. The formation of these check banks is the next operation. They are placed half a chain apart and are formed by throwing two furrows together with a single-furrow plough. The soil is then filled into the furrow with a road grader to which is attached a long blade made on the farm, so that the soil is levelled and the banks strengthened. The preservation of these banks throughout the life of the lucerne stand is essential, for they are a most important feature in thorough and efficient application of the water. Hence, on account of these banks, as well as the preservation of a level surface between them, all subsequent work must be in the same direction—that is, from head ditch to drain. The ends of the checks have to be finished off by hand, as the road-making or levelling machine referred to will not work right to the end of the paddock.

It is most essential that the blocks should not be too long; in other words, the distance between the head ditch and the drain at the lower end should not be more than 6 or 7 chains. At that length the levels can be easily obtained, and an even flow of water from the upper end to the lower assured, but longer blocks are irrigated with difficulty. On a block made 15 chains long some years ago, it was found that the upper end of the lucerne had got too much water before the lower end had got any at all.

The drain along the lower end of the paddock is quite essential, as every irrigationist well knows. Stagnant water is a thing not to be tolerated on a well-managed irrigation farm; hence, drainage must be provided as a concomitant of the head ditch, or damage will certainly occur.

Working the Seed-bed.

In April the land thus prepared for sowing is treated to an application of water. No doubt some will wonder, but so it is. It is found that if the soil (already warm and well worked) is also moist, the seed germinates quickly and also evenly. Sowing in a dry seed-bed has been one of the common causes of failure on the irrigation areas. In such cases the seed is sown with the intention that the ground shall be irrigated after sowing (perhaps, too, with the hope that rain will make irrigation unnecessary), but the method is rarely satisfactory. In many cases the effect of the irrigation water is to cake the surface over the tender little seedlings, which are therefore unable to reach the sun and air. It does not need to be pointed out that to attempt to disturb the surface at that stage is almost as fatal to the little plants as to leave it alone. The lucerne seedling is a very tender thing indeed, and disturbance in its early life is one thing it takes as most unkind. All cultivation of lucerne must be after the plant is well rooted—and to sow the seed in a dry seed-bed is simply sowing a crop of troubles. One grower who tried this method had a novel experience: the water floated the seed off the higher portion of the ground and deposited it on the lower, giving him half his area much too thick and the rest much too thin.

In April, then, the land is furrowed out between the cheek banks with special furrowing shovels attached to an ordinary cultivator. These shovel points, which really belong to the Planet Jr. type of fittings, make the furrows 2 feet apart, which means three or four of the points on the cultivator. The water is then turned into these furrows from the head ditch, and the land thoroughly saturated; the water is confined to the furrows as much as possible, and it advances slowly along the furrows, soaking downwards and laterally, and giving a far better result than would be obtained by flooding between the cheek banks without furrows. It takes the water three or four days to reach the lower end, but the furrows are not allowed to overflow.

Should the land have been fouled with weeds, it would be well, perhaps, to forego (in part) the advantages of the fallow period, and to form the cheek banks and furrows earlier in the year, turn in the water to germinate the weed seeds, and kill them by cultivation. A further irrigation in view of the sowing of the lucerne will probably then be necessary, according to the state of the ground when the beginning of April arrives.

The Sowing.

The land being thus well irrigated, as soon as the surface is dry enough to carry the teams, the tine cultivator is employed to produce a level and fine surface. The seed-bed is now in an ideal condition, and the seed is sown at once, the drill being generally no more than half a day behind the cultivator. If by any mischance the ground unfortunately dries out before the seed can be sown, it is better to cultivate and irrigate again before sowing rather than to attempt to do any good on the dried out surface. If, for any other reason, the seed fails to germinate after treatment on these lines, it is better to leave the whole thing until next year, and to use the paddock in some other way in the meantime.

The seed used on the farm is obtained from Tamworth, that being the only seed now sown for farm crops. Many varieties and sub-varieties have been sown, but Tamworth Broadleaf lucerne has given far better results than any other.

For the sowing, the grass-seed attachment of the ordinary wheat drill is used, the seed being fed at the rate of 10 lb. of seed per acre through all the tubes into the main holes of the drill. Some farmers use the drill but sow broadcast, leaving the tubes out of the hoes; the results are seldom so satisfactory as when the seed is put down into the soil with the aid of the hoes (withal, of course, not too deeply). Let it be remembered in what a prime condition the soil now is, and all that is required to ensure good germination is to place the seed down on the moist soil. The soil warmth and the moisture will do the rest.

To ensure a sowing $1\frac{1}{2}$ inches to 2 inches below the surface, the drill is set in the first notch; the soils on this farm, as already stated, are stiff, and this is necessary under such conditions. Where the soil is a fine loam, the hoes could run free, and not in the notch at all, and the weight of the hoe would be sufficient to sow the seed deep enough. When sowing the headlands where the horses have trampled down the surface, the practice is to put the drill in the second notch in order that the seed may be sown at the right depth. The principal thing is to ensure that the seed is put down on the moisture and to work the drill to that end.

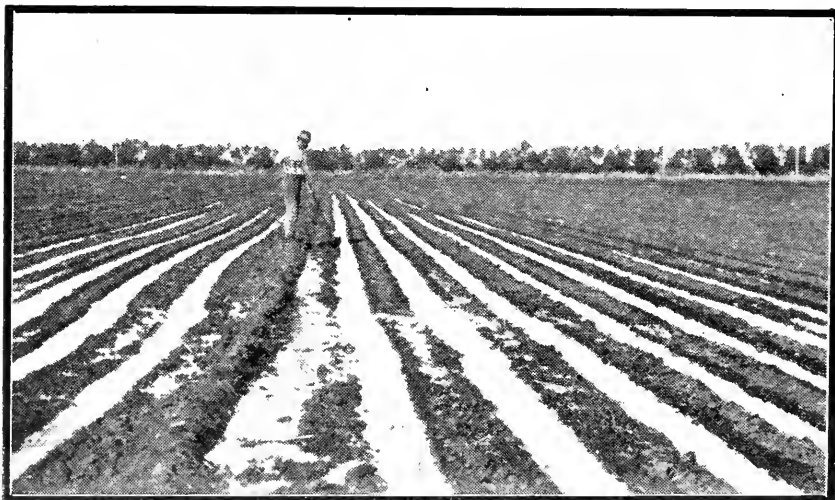


Fig. 4. Irrigation by furrows previous to cultivating and sowing.

Superphosphate is sown through the manure box of the drill at the same time as the seed, 56 lb. per acre being applied. The manure is also sent down the hoes of the drill, so that it may be deposited close to the seed where it can be made use of at once. Superphosphate has a distinct value in relation to lucerne, having given better results under our conditions than any other fertiliser. The top-dressing of lucerne stands in the winter or spring has given marked results and should become part of the farm practice of growers in almost every part of the State, but in connection with the establishment of a stand it also has a definite utility.

The lucerne seed is thus put in the ground under conditions that could hardly be improved upon. The last farm operations—the furrowing, irrigating, and sowing—are accomplished within a few days; the soil is still warm and it is thoroughly moist. Amid such favourable surroundings the lucerne seed, hard though it is, usually germinates within four days, and the rows can be clearly seen in ten days.

Handling the Young Stand.

The seedling lucerne plants are thus up by the early part of May and winter showers keep them growing slowly until the spring. Nothing in the nature of cultivation is attempted, with the possible exception (under very adverse circumstances) of running a light seeding harrow over the crop with the tines sloping backwards. The plant is delicate and will not stand being disturbed at this stage, though it will resist drought surprisingly. Indeed, more young lucerne plants are killed by too much water than by too much dry weather, for lucerne is distinctly hardy in respect to the latter.

In the spring—about September—it is advisable to run the mower over the ground and to allow the very light cutting to remain on the ground; the same may have to be done again in October, though it may be possible with a good stand to let the second growth go for a light hay crop. The plants must be encouraged to stool at this stage, however, and cutting is valuable to that end. The growth must be watched with care, for (as with most other plants) as soon as the conditions become a bit adverse there is an impulse to preserve the species by setting seed—an occurrence that cannot but exhaust the plant and permanently affect its vigour.

Perhaps in November a cut worth saving as hay will be obtained, and by that time an application of water will most probably be necessary. It is one of the disadvantages of spring sowing that before the plant has attained any height it may be necessary to apply water, which in turn makes a light harrowing a necessity in order to loosen the surface and let the little plants grow. Such a disturbance is never in favour of the plant, but in such circumstances it may be unavoidable. Sometimes, if the surface has become set, it is possible to give a very light watering and then to run an ordinary tine harrow over the ground.

The Irrigation of Lucerne.

The first application of water is given as soon as the first crop of hay is off the land in order to stimulate an early growth, and further irrigations follow as the season requires. Generally speaking, one irrigation for each cut is sufficient in the early part of the season, but as the weather gets hotter more are necessary, averaging two per cutting, and the exact time when these are made must entirely depend on the season.

The practice at the farm is to irrigate a week before cutting. A second watering is given as soon as the hay has been taken off; this makes two waterings per cutting, which is usually sufficient. Should the weather be excessively dry and hot an extra watering about fourteen days after cutting may be found necessary. The object aimed at is to keep sufficient moisture in the soil to produce maximum results. Other periods of watering have been tried, but the above practice has been found to give the best results. It is not advisable to wait until the lucerne shows signs of distress; this must be anticipated as much as possible.

As already indicated, a big body of water is never turned on the lucerne at one time. The head ditch is filled and then a gap is opened in the bank about half-way between the check banks, allowing enough water to escape to spread from bank to bank, just covering the surface and moving forward very slowly. The slow advance of the water robs irrigation of much of its attractiveness, no doubt, but a rush of water is never satisfactory, for it wets the surface without saturating the subsoil. It should take from six to eight hours for the water to reach the lower end of the block 6 chains away,

by which time the water can be shut off at the upper end. If the land has been well graded, and the water properly applied, there should be very little surplus water to fall into the drain.

The above method is that adopted on a heavy soil, of course; on lighter soils, which absorb water more rapidly, the flow can be a little faster. The land on the farm will absorb $2\frac{1}{2}$ to 3 inches of water, whereas light soils with such a slow flow would take up too much. If too much water is applied the effect is a consolidation of the surface that deprives the roots of the lucerne of air, and hinders bacterial activity in the soil.

It is imperative that facilities be provided for thorough surface drainage. Water lying on lucerne for three hours on a hot day will scald the plants and do irreparable damage to the stand. Special attention is necessary in the evening in ceasing operations to ensure no flooding. This is achieved by starting more checks, which will take the whole night to run through.



Fig. 5. - Flooding a Lucerne Block.

Slow soakage is the method sanctioned by experience at Yanco Experiment Farm.

A close watch must be kept on the growth, and so soon as there is any appearance that water is required it should be applied. Farmers are inclined to consider any special irrigation as either too much work or too much expense, but if lucerne-growing is to be a success any reluctance on either of those scores or any imaginary grievance about the price of the water must be put aside. It is the commercial result that has to be kept in view, and water must be applied at intervals required by the crop—not at the convenience of the grower. If the water is left too late the growth seems to harden off, and can never be brought back to its original freshness; indeed, watering after the top growth has hardened off only promotes the development of the next growth from the ground, and does little for the standing crop.

The secret of success with lucerne is to watch it at all stages, to keep it growing as you would a soft green vegetable for the table, and to cut it as soon as it is ready.

The "hardening off" referred to is difficult to describe in any other term, but the observant farmer will quickly detect it. The best treatment is to turn in the water immediately that symptom appears; if done quickly enough the effect may be to save the crop and bring it back to its original freshness. If it is impossible to water at once it will be better to proceed to harvest the crop for hay in the ordinary way, and to take greater care thereafter not to allow the crop to go so long without water. When the crop has lost its fresh, green colour and has acquired a bluish appearance, it is too late to restore it to the sappy condition that makes the best hay.

Harvesting.

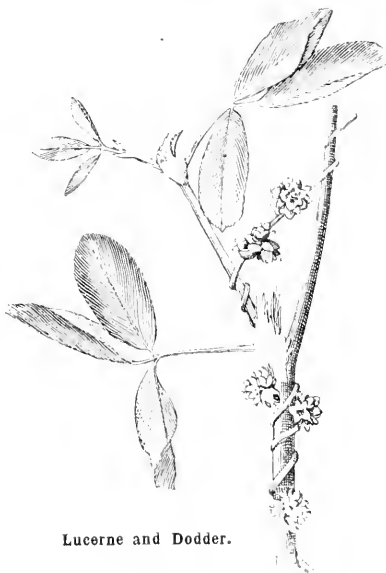
With the aid of thoroughly up-to-date machinery, lucerne haymaking on the farm has become a regular routine. Briefly, the hay is cut with an ordinary mower, drawn into windrows with a rotary rake, picked up by a hay loader, carted direct to a derrick press, baled and wired without the formality of being stacked, and drawn at once to the railway. From waving lucerne in the paddock to fragrant hay on the truck something less than three days is involved in the height of the season, and a team of eight men, including the foreman, keep pace with the growth of 120 acres.

Enemies of Lucerne.

Dodder.

This is the greatest enemy of lucerne. It is a parasitic plant, with long, leafless stems, orange yellow in colour. The dodder-seed germinates in the ground, and the young plants attach themselves to the lucerne seedlings. As soon as the thread-like vine is firmly attached to the lucerne plant, the stem connecting it with the ground withers away, and the dodder draws its sustenance from the lucerne by means of tiny suckers, which enter the tissues of the host plant. The dodder flowers are a beautiful golden colour. As the parasite develops, the tangled masses in which it occurs have the appearance of ringworms, working from the centre outwards.

On no account should dodder be sown with the lucerne seed. Fortunately the removal of seeds of dodder is a simple process, as they are much smaller in size than lucerne seeds, and can be removed by screening through a mesh



Lucerne and Dodder.

sufficiently close to retain healthy lucerne seed, whilst allowing the dodder to pass through. If dodder appears in a lucerne paddock it should never be allowed to seed, but the affected growth should be removed as soon as possible. The plants should be chipped to the crowns, or straw should be

carted on to the patches and burned. The patches should be mown and treated before the general crop is cut, as otherwise the parasite may be distributed throughout the field by the machinery. Burning is the safest remedy, and will not injure the lucerne plants.

Insect Pests.

Tortrix glaphyriana, Meyrick (Lucerne Web Moth).

The little leaf-rolling caterpillar of this moth is a well-known pest among the lucerne fields in the Maitland district, and is more or less in evidence nearly every season, but it is only now and then that it increases in such numbers as to become a very serious pest. As a general rule, it appears early in September, and does not disappear until the end of February.

The caterpillar is a bright green grub, slightly over half an inch in length and slender in form, with a white hair or bristle on the sides of each segment. Generally several live upon each head of lucerne in a mass of silken threads and curled leaves, finally pupating in loose cocoons among the foliage. The small moth, which measures slightly over half an inch across the outspread wings, is dull yellow, mottled with dark brown on the fore wings. When a crop is found to be badly infested by this moth the farmer usually cuts it down close and keeps it well fed off with stock.

Bruchophagus funebris, Howard (Lucerne Seed Wasp).

This is a microscopic black chalcid wasp that punctures the young seed and deposits her eggs beneath the skin, under shelter of which the little maggot feeds upon the contents and pupates in the empty shell. When matured it emerges from the pupal covering and gnaws its way out through the side of the seed. Such a large percentage of lucerne seed is often so damaged that the parcel is worthless.

The only method of dealing with this seed-destroyer is to cut the crop before the seed has ripened, and utilise it as a green fodder or convert it into hay.

Fungus Diseases.

Rust.—A disease of the lucerne leaf due to the fungus *Uromyces striatus*, Schroet. The leaf becomes dotted with small brownish spots, which, if closely examined, are seen to be raised above the general surface of the leaf. Some may have burst open, exposing a red-brown mass of rust spores. The spots are usually better defined than those produced by the leaf-spotting fungus (*Pseudopeziza*). The discoloration is practically limited to the rust pustule, whereas in the other case the margin of the spot is frequently ill-defined, though the mid-region of the "spot" is much darker in colour, and becomes raised to form a pustule, in which the spores are produced.

Leaf Spot.—The fungus *Pseudopeziza medicaginis*, which causes "leaf-spotting," is very different from the rusts in its characteristics. The leaf shows its presence by numerous small brown discolorations on both sides. The green colour is soon lost, and the bleached leaf readily falls to the ground, whence the spores become scattered to attack fresh host plants.

The usual method for combating both Leaf Spot and Rust is frequent cutting of the crop, as the affected portions of the plants, or the greater part, are removed each time before the fungi produce their full crops of spores.

Downy Mildew (*Peronospora trifoliorum* De Bary).—In attacked plants the stem and leaves are covered by a thick greyish or violet-grey downy layer. It often occurs more profusely on the under than the upper side of the leaves. The leaves attacked are usually of a yellowish colour, and their edges curl downward and inwards towards the mid-rib. Such leaves fall quickly. The fungus also attacks clovers.

Patches of the field attacked, should be at once covered with straw and burnt over to destroy all diseased plants and fallen leaves.

When a crop is once infected the disease spreads rapidly if the weather remains warm and

moist, whereas a spell of bright dry weather often stamps out the disease. If the pest spreads, it is best to cut the crop before the leaves fall to the ground.

Crown Wart (*Urophlyctis alfalfa*) is characterised by galls occurring on the roots of the lucerne plant and on the stem close to the ground. It results in the wilting and death of the plant. The disease is known to remain in the soil when the lucerne plant decays owing to the resistant nature of the fungus spores. It is a menace to the lucerne grower, but it is not known to be widespread in the State though recorded once. When detected the diseased plants should be dug out and burnt. The patch affected should not be resown to lucerne. Care should be taken to see that soil is not transported from the area affected.



Lucerne Leaves showing Rust and Leaf-spot.



Lucerne Stems showing Galls at the Ground Level.

COWPEAS.*

The cowpea is a summer-growing annual, more closely related to the bean than to the pea. It is not a true climber, having no tendrils, but the long vines twine around any adjacent support and cling to it. Every year this plant plays a more important part in farming economy, and as a summer green manure it can hardly be excelled. It is grown as a forage crop, and either fed off, soiled, or mixed with other material and converted into silage. Though difficult to harvest and handle, yet it makes an excellent hay. The seed commands a constant and satisfactory price on the market.



Black Cowpeas ; yield, 14 tons 8 cwt. per acre.

Cowpeas are very tender, and are killed by even a light frost at any stage of their growth. During the summer and autumn they continue to grow and produce green pods (except in the case of very early varieties) until checked by frost or drought.

The plant thrives best under warm and moist conditions, and, while it readily adapts itself to dry weather, the weather must be warm or the plant will not develop. It grows well on the North and South Coast, and in favoured portions or under irrigation in the west.

Although sensitive to wet soil, cowpeas will grow on poorer soil or on a more acid soil than soybeans, but where the climate is suitable velvet beans will make better growth on poor soil than even cowpeas.

* The matter under this heading, together with that under the heading Soybeans, was revised from previous matter by Mr. H. Wenzholz, B.Sc.(Agt.), Inspector of Agriculture.

The land can be prepared in much the same way as for maize and other summer crops. Very early sowing is not to be recommended. Sowing should be deferred till the soil is warm enough to germinate the seed rapidly, as otherwise it is likely to become mouldy and rot in the ground. As a rule the crop is sown in rows 2 feet 6 inches to 3 feet apart, and the seed from 6 to 9 inches apart in the rows. Such a practice enables the crop to be cultivated, which is an important factor in the production of seed, or when grown in a dry district. It is also economical with seed—an important consideration when the crop is not a direct money crop, and every endeavour is being made to reduce expense. The amount of seed required per acre for sowing in rows 3 feet apart varies from 5 to 15 lb., according to the size of the seed of the variety grown.

When broadcasted or sown with a wheat drill using every run, considerably more seed is needed. There is an advantage, especially on weedy land, in broadcasted, because of the smothering effect. From 1 to 1½ bushels of seed are sown per acre, and this, especially with upright-growing varieties,



A Crop of Cowpeas.

greatly facilitates harvesting with a scythe or mowing machine. The seed drill, using the coarse runs, is undoubtedly the best machine for this purpose, as the seed is covered to an even depth. If, after broadcasted and merely harrowing in, heavy rain falls, a quantity of the seed may become exposed and not germinate. Moreover, sowing wide enough to allow of cultivation may be performed with the same drill, by sowing only through certain drills and blocking up the rest. It must be remembered that, with seed at 30s. per bushel, thick sowing means a considerable increase in the cost of production.

Cowpeas, in common with other legumes, are valuable in increasing the nitrogen in the soil, thereby largely reducing the expense of buying high-priced nitrogenous fertilisers for other crops. It is not infrequently found that the second and successive crops succeed better than the first, owing to the soil evidently being inoculated more thoroughly with the bacteria that carry out the fixation of atmospheric nitrogen. Dressings of about 1 cwt. superphosphate per acre will in most cases considerably increase the yield.

Varieties.

There are a very large number of distinct types of varieties of cowpeas. Of the large number imported at different times from India, America, and other places, a few only are in general cultivation. Of these the Black is the most popular, while the Poona, a variety introduced from India, has rivalled the Black at Hawkesbury Agricultural College. The following are the best varieties of the large number which have been tried up to the present by the Department:—

Black.—This, one of the best all-round varieties, is distributed more widely than any of the others. It is late maturing and semi-recumbent to recumbent in its habit of growth, and gives heavy yields of both green-stuff and pulse. The grain is large and black in colour, the pods from 7 to 8



A single plant of the Black variety of Cowpeas.

inches long, and easy to pick. One of its chief qualities is the even ripening of the pods, which necessitates fewer pickings than do many of the other varieties.

Poona is a very late-maturing variety, which does not mature its pods as evenly as the Black, but which equals, if it does not excel it in the production of green fodder. It is a distinctly upright-growing variety, thereby facilitating harvesting and cultivation, till the pods begin to form and the vines fall and block up the path between the rows. The seed is light brown and very small, the pods being only 4 inches long.

New Era is a medium early variety which produces a large bulk of green fodder and a heavy yield of seed. It is medium upright to slightly recumbent in its habit of growth, and the pods are very long and straight. The seeds are a bluish colour, marbled and dotted with brown. This is one of the best varieties for sowing among early maize, for, owing to its earliness, a quantity of seed can be picked before the heavy bulk of fodder is ploughed in.

Victor is the best of the new varieties. It is a little later maturing than the New Era, and makes a very good growth of fodder. It is the only variety of which seed is at present obtainable in the State and which is resistant to the attacks of eelworm, a troublesome pest on the North Coast. At Wollongbar Experiment Farm, in 1920, Victor easily surpassed all others. The seed is fairly small, of a brownish colour, with dark-brown marblings tinged with crimson.

As a Green Manure.

Cowpeas form a very valuable green-manure crop for orchard and general farm work. Their deep-rooting and nitrogen-fixing propensities especially adapt them for this purpose. A good deal of difficulty is experienced in ploughing the vines in, and the use of the mouldboard plough is only partially successful. It is the usual practice at Hawkesbury Agricultural College to roll the crop first, and then, after running over it with a corn-stalk chopper or disc cultivator, to plough it in with a single-furrow disc plough. The crop should be ploughed soon after the pods are set. At a later stage than this the stems become woody and are hard to deal with. If it is desired to collect some seed for the next year's planting it would be more satisfactory to allow certain rows to mature all their seed, rather than allow the whole crop to mature to that stage when it is ready for the first picking.

As a Fodder Crop.

Ploughing cowpeas under in this manner is sometimes a very wasteful practice. The crop has a very high feeding value, and if fed off on the ground where it is grown at least 50 to 75 per cent. of the manurial value will be returned, while the full feeding-value of the crop will also have been obtained.

The growth of such crops as maize, sorghum, and millets, with the cowpea is a very good practice. Such a mixture not only forms a better mixed ration for stock, but also increases the total produce.

The seeds of the legume and cereal are usually sown together in rows 2 feet 6 inches to 3 feet 6 inches apart, and there is a tendency for the cowpeas to climb the upright-growing crops—more particularly the sorghum and millet. These two crops can be broadcasted with cowpeas, and make a

good stand. The sorghum stalks are finer and more suited to dairy stock, while the cowpea vines keep off the ground better and are easier to harvest. The high price of cowpea seed is often a determining factor in the case, and where the rainfall is scanty and soil poor, crops grown in rows will give better results.

About the usual quantity to sow in rows is—maize 10 lb., sorghum 6 lb., and millet 3 lb. per acre, mixed with 8 to 10 lb. of cowpeas per acre. If broadcasted, about one-half to three-quarters of a bushel of cowpeas, sown with 7 to 10 lb. of millet, or 15 lb. of sorghum, are usually required. The variation in the size of these seeds makes the drilling of these crops rather difficult. With a wheat drill the millet can be broadcasted with grass-seed attachment, and the cowpeas with the drill. As such machinery is rarely available in dairying districts the crops would easily be broadcasted by hand.

A system that has proved very profitable on the North Coast is to sow the cowpeas down between the rows of early corn. They are sown with a maize dropper or broadcasted immediately after the last cultivation of the maize, which should not be later than January.

Cowpeas by themselves usually form an inferior sample of silage, often acid in character, poor in colour and smell, and more or less decomposed. Ensiled mixed with sorghum, maize, or millets, a much better product results.

Undoubtedly the best plan of utilising the green crop is by feeding it off. Pigs take to it more readily than cows, but the latter can be accustomed to it. If it has to be cut and fed to stock, either as green feed or as hay, a pea-vine harvesting attachment should be used with the mowing machine. The upright-growing varieties, such as Poona, especially when grown thickly, can be harvested with a scythe and sometimes with a mower.

The cowpea will make good hay, but although the hay is somewhat difficult to cure, it actually stands more rain during curing than many other hay crops. In the southern states of America cowpea hay is grown to a large extent as a substitute for lucerne hay, in a climate of abundant rainfall, similar to our North Coast.

Growing for Seed.

One drawback to any extensive cultivation of this crop for seed is the difficulty attending the harvesting of the pods. No machinery for this purpose has been perfected, and with present methods, the whole plant has to be harvested and threshed, or the pods picked by hand. Good pickers can harvest about 150 to 200 lb. of pods per day. About 250 lb. of these peas in the pod give, when threshed, one bag of peas weighing 180 lb.

Before threshing the pods are allowed to dry thoroughly, when the hull becomes brittle, and the seed separates quite easily. For small lots, a bag can be half filled with pods, and after tying up the mouth, threshed with a flail in the ordinary way. This saves the seed from being shattered, but is not so quick as threshing them loose on large sheets.

Pea hullers can be obtained on the market, but they seem to be only partially successful, their chief objection being cracking of the grain. The average retail price for cowpea seed is about 30s. per bushel.

SOYBEANS.

A crop which is grown to the extent of 190,000 acres in the United States seems surely to merit some place in the agriculture of New South Wales, which in many parts is climatically similar to America.

For many years soybeans were tried on the North Coast and in other warm districts on the western slopes, but without any sign of success. From this failure it has been wrongly concluded that the climate of New South Wales is wholly unsuited to the culture of soybeans. Evidence is now available to the effect that it is in the cooler climates of the State chiefly that soybeans will be generally most successful. On the North Coast, both velvet beans and cowpeas are too strong competitors as green manures or even as fodder crops, with perhaps the exception of one outstanding variety of soybeans. Though resistant to a certain amount of dry weather, soybeans are not sufficiently drought-resistant to stand the long dry spells experienced during the summer in the western districts, except in favoured localities on the slopes.

Although killed by heavy frost, soybeans will stand a considerable amount of frost without injury, and have been already successfully grown on parts of the Northern, Central, and Southern Tablelands. The seed does not rot in cold weather nearly as readily as cowpeas, and will germinate well even when the weather is wet and cold in the spring. It is stated that in America some varieties (particularly the black-seeded varieties) will lie in the ground all the winter and germinate in spring, while cowpea seed exposed in this way quickly rots.

The Utility of Soybeans.

The soybean is one of the most important crops in China and Japan, and from those countries a large quantity of soybean oil is exported, some of which finds its way into Australia. The oil is a semi-drying oil (contained in the kernels to the extent of about 17 per cent.), which is used chiefly in the manufacture of paint and soap.

It is not, however, as a grain crop for this purpose that it is likely to make headway here. Apart from its value as green manure (being a legume, it maintains or increases the nitrogen of the soil also), the soybean excels mainly—(1) as a grain crop for hogging down, on account of its heavy production of seed of very high protein and oil content and excellent feeding value, and (2) as an emergency hay crop on account of the high value of its fodder. As mentioned above, the hay is about equal in feeding value to lucerne hay, and superior to clover hay, and it has the added virtue of being able to produce good crops of hay on soils too poor or too sour for clover or lucerne.

Unlike cowpeas, the soybean ripens all its seed about the same time; on the tablelands the best varieties take about four months to reach the hay or fodder stage, and about five months to mature seed.

One feature of the soybean crop is its comparative freedom from attacks of insects and diseases. Even the seed in storage is not affected by the bean weevil which infests cowpeas and other beans badly. Rabbits are, however, very partial to the crop even when plenty of other feed is available, which may be taken as an indication of its high palatability and feeding value.

Planting.

The best time to sow soybeans is about the time maize should be planted, or better, slightly later. The growth is slow at first, and if sown too early weeds may grow faster than the crop and the soybeans will be injured, in the attempt to smother or otherwise deal with the weeds.

Soybean seed heats very quickly in storage (especially in a warm moist climate), and also loses its germinating power very quickly if kept for any length of time, especially over one season. When there is any doubt about the vitality of the seed a test of the germination should be made or the seed should be sown thickly.

Above all, care should be taken to plant the seed only at a shallow depth—not more than 2 or 3 inches. Many disappointments have been caused by deeper sowing.

The rows should be about $2\frac{1}{2}$ or 3 feet apart and the seed 4 to 6 inches apart in the rows, 5 to 12 lb. seed being required per acre, according to the size of seed of the variety. Sowing can be done with a maize-drill with a special plate, or with a wheat-drill by blocking up all but a few of the tubes.

The young plants have no ability to push through a crusted surface soil, and care should be taken to keep the surface loose by light harrowing before the plants come through.

Varieties.

Varieties of soybeans differ greatly in the length of time taken to mature, the nature of the growth, and the size, shape, and colour of the seed. As a rule the later maturing varieties grow more vigorously than the early varieties and usually give the best yields of fodder, though some of the earlier ones are good seed producers. For hogging down, dual-purpose varieties are required, namely, varieties that will produce good yields of both fodder and seed.

Of the varieties tried so far in New South Wales the following seem to be best:—

Otootan.—This is a very late variety, which takes nearly the full season to mature for fodder on the tablelands, but the production of the seed is somewhat risky there. On the coast, however, it gives a good yield of both fodder and seed, even rivalling some of the cowpeas for fodder or green manuring. It is easily the best dual-purpose variety yet tested on the coast. The seed is very small, black, and elliptical in shape, with flattened sides.

Hollybrook is a medium late variety, but nearly a month earlier than *Otootan*, maturing safely for seed on the tablelands, where it is a good dual-purpose variety, giving a good yield of fodder and a very good yield of seed. The seed is small, of straw-yellow colour, and elliptical in shape.

Mammoth Yellow.—This is a variety of about the same maturity as *Hollybrook*, giving a good yield of fodder, but not such a heavy production of seed. The seed is small, round, and yellow.

Haberlandt is a medium early variety of very good seed-producing qualities, but not so good for fodder. The seed is of medium size, round, and yellow.

As Hay or Fodder Crop.

It is as an emergency hay crop that soybeans are destined to fill a place in our tableland agriculture.

The chief qualities possessed by this crop which make it well worth consideration in the tableland districts are:—

1. The high feeding-value of the hay (nearly equal to lucerne hay and superior to clover hay).
2. The yield of hay obtainable in a short season of growth (1½ to 2 tons per acre being a fair average).
3. The distinct soil-improvement value of the crop when included in a system of crop rotation.
4. Its ability to make better growth on acid soils where clover fails.
5. Its emergency value in the utilisation of land; soybeans can be sown for hay after the best time for sowing clover or oats has passed.

The highest feeding value and the greatest palatability occur in soybeans just as the pods are forming, but when the pods are full grown nearly double the yield of fodder is obtained. The best time to cut for hay is when the seeds are about half developed. Some varieties have more persistent leaves than others, but in most varieties the leaves are usually shed completely when about half the pods are ripe, or a little later.

For seed, the crop should be cut when about three-fourths of the pods are ripe. If left later than this a quantity of the seed may be lost by shattering.

The ordinary mower can be used for harvesting the hay and also for seed, though it is also possible in many cases to use the grain binder for the latter purpose. Threshing can be done with the ordinary grain thresher by making a few adjustments to avoid cracking the seed.

When soybeans are to be used for hogging-down or as a grain crop for use on the farm, they may either be sown alone or with maize. When sown alone an average yield of 15 to 20 bushels per acre may be expected. Yields have been recorded in America of up to 35 bushels per acre. Hogging-down maize is not practised here to anything like the extent that is done in America, but on the upper reaches of some coastal rivers where it is in vogue the planting of soybeans with maize would make the feeding value of the combined crops much greater than the maize alone. Planting soybeans in the same rows as the maize will not generally reduce the yield of maize appreciably, and any reduction may be expected to be more than made up for by the yield of soybeans. Alternate rows of maize and soybeans decrease the yield of maize still further, but counterbalance this by the increased yield of soybeans.

For many parts of the coast where pig-raising is conducted small areas of soybeans alone of the most suitable varieties are recommended for trial as a concentrated grain food (combined with the fodder for hogging-down) of extremely high feeding value, being exceptionally high in protein and fat. As a combination crop with maize for silage, soybeans are also becoming largely grown in America.

VELVET BEANS.*

The velvet bean is practically unknown in New South Wales as a farm crop, yet in the southern states of America it is very largely grown, and in South Africa it is stated to be "without exception, the most important crop introduced into Rhodesia."

On the North Coast, where the climatic conditions most suit this crop, one cannot but be struck with the extremely copious growth it makes, easily outyielding any of the cowpeas and soybeans, and being especially capable of making good growth on land too poor to grow cowpeas successfully.

When grown on an experimental scale this vigorous growth of the velvet bean has been observed more in the light of a valuable green manure or cover crop, and little is apparently known of the plant here as a fodder crop. In the other countries mentioned velvet beans are valued very highly as a palatable and nutritious stock feed—especially for cattle and pigs.

Valuable Winter Pasture.

It is as a winter pasturage that the velvet bean excels. Even with the cold winters experienced in America it is stated that velvet beans will remain in the field all through the winter, weather conditions having such little harmful effect on the vines, leaves, and pods. With the shortage of feed during the winter, particularly in the specialised dairying districts on the far North Coast, where paspalum is chiefly relied on and where little winter fodder is grown, velvet beans seem destined to fill a place as a cheap winter feed for cattle, especially with the appeal they make on account of their ease of handling as a winter grazing crop. Leguminous fodders should be welcomed here on account of the shortage of protein in the usual farm-grown feeds, and the recognised necessity for its purchase in the form of bran, oil-meal, &c., and the velvet bean is well worthy of a trial.

The usual practice in the southern states of America is to sow velvet beans in the maize crop. Owing to the immense growth made by the velvet beans, sowing at the same time as maize in the same rows, is undesirable owing to the velvet beans pulling down and smothering the maize stalks and rendering the harvesting of the maize difficult or impossible. After fifteen years' experience, the Massachusetts Experiment Station found that the ideal method was to sow two rows of maize 3 feet apart to one of velvet beans sown six weeks later than the maize. By this means the best of the maize can be pulled with little trouble when mature, leaving the nubbins and the velvet bean fodder for winter grazing.

The amount of grazing afforded depends on the growth of the velvet beans and on the amount of maize not harvested, but the Massachusetts Experiment Station states that it is the custom to allow one-third or one-half acre per month per cow. A good picking for pigs is also afforded from the trampled vines and beans if they are allowed to follow the cattle.

Velvet Beans for Seed.

Only on the North Coast is it possible to get velvet beans to mature a good crop of beans, and the value of these as a concentrated feed entitles them to some consideration.

Seed may be harvested from the field sown with maize, as mentioned above, before stock are turned in, or a separate small field may be sown

* H. Wenzholz, B.Sc.(Agr.), Inspector of Agriculture.

specially for seed. If the latter method is adopted the beans may be planted in rows $3\frac{1}{2}$ or 4 feet apart, and 15 to 18 inches apart. This will require 12 to 15 lb. seed per acre. The average yield of seed is about 1,000 to 1,500 lb. per acre. The weight of unthreshed seeds in the pod will be about double this.

For feeding purposes the seed need not be threshed from the pods, the usual method of feeding being to use pods and all, either soaked for twenty-four hours or crushed into velvet bean feed or meal.

Velvet Bean Meal.

It seems possible that for the average farm the soaked pods will be the best form in which to make use of the high feeding value of the seed at the least expense. Considering the fact that large quantities of bran are bought to supply protein at present by North Coast dairymen (particularly in the far North Coast—the big scrub country), the composition of velvet bean meal and the results obtained from its use in America and other countries should be of interest.

The following comparison with wheat bran is given:—

	Asb.	Crude Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Velvet bean meal ...	4.5	20.3	16.5	54.5	4.4
Wheat bran ...	7.0	17.8	10.7	59.6	4.9

It will be seen that the chemical composition of velvet bean meal resembles that of wheat bran. It is slightly higher in protein, but contains a little more fibre.

As the result of feeding experiments at the Massachusetts Agricultural College, where digestion studies were also made, velvet bean feed was found to contain about 130 lb., or 11.5 per cent., more digestible nutrients per ton than wheat bran, and in two feeding experiments cows receiving a velvet bean ration produced an average of 5 per cent. more milk than on a wheat bran ration.

At the present time some tests are being conducted at Wollongbar Experiment Farm as to its feeding value compared with wheat bran under our conditions, and the results of these will be awaited with interest. The yields obtained per acre and the cost of harvesting will determine whether it is more profitable to feed a home-grown concentrate like velvet bean meal (or soaked beans) than to purchase wheat bran.

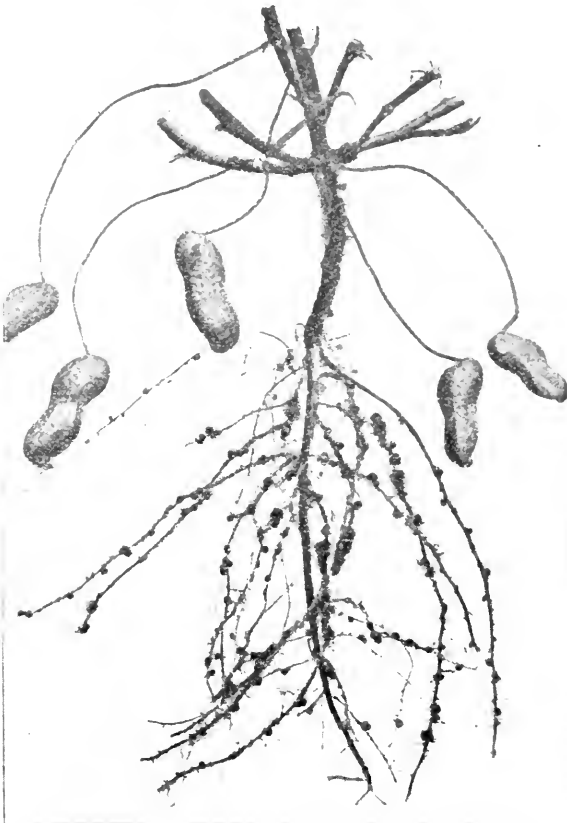
Value for Soil Improvement.

The value of the velvet bean for soil improvement also must not be overlooked. The increase in the nitrogen and humus content of the soil is reflected in better yields in the various crops. In America an increase of 12 bushels of maize per acre is recorded after velvet beans, while up to 20 bushels increase per acre has been made in Rhodesia after green manuring with velvet beans. Appreciable increases in the yield of the subsequent crops should also follow after velvet beans are utilised for winter grazing. Velvet beans are also suitable for sowing with maize for ensilage.

The Chinese variety is the best of those tried up to the present in this State.

PEANUTS.

Practically nothing has been done on a commercial scale with regard to the cultivation of peanuts in Australia. In New South Wales the first introduction of American varieties by the Department of Agriculture was made in 1912, since



The Peanut Plant showing bacterial nodules.

which year they have been given a thorough trial and have proved beyond doubt that they are eminently suitable for our climate and soils. Excellent yields have been obtained, and when their commercial value is thoroughly realised and the proper labour-saving implements have been obtained, &c., there should be a big future for the crop in New South Wales, Queensland, and Victoria. We should at least endeavour to produce the £30,000 worth of nuts annually imported from China and Japan to supply the local domestic demand.

Although peanuts are usually regarded only as the roasted article, this is only one form in which they are used. They feature very extensively in the manu-

facture of confections and food products. It is, for example, one of the most important of the world's oil products, the United States alone utilizing nearly 1,000,000 gallons annually in the manufacture of oleomargarine.

As a farm product it is of considerable importance, for the entire plant is almost a balanced ration, being rich in protein, carbohydrates, and fat. Again, it is a legume and its rootlets contain tubercles of various sizes. These tubercles or nodules contain myriads of microscopic organisms (rhizobia), which have the power of collecting the free nitrogen of the atmosphere and storing it within the tubercle, where it can be utilised by the plant or may supplement the nitrogen content of the soil. For this reason the peanut is a most desirable crop for soil renovating or improvement.

Climate.

The peanut will thrive under a wide range of climatic conditions, but that best suited to the production of profitable crops is one in which maize will grow luxuriantly. Ideal climatic conditions are an early spring, a moderately hot summer of even temperatures with light rainfall, and a comparatively dry autumn, so that harvesting may take place with the minimum of injury to the nuts and vines. The crop is very susceptible to frost; a climate in which there is a season of five months free from frost is necessary.

That portion of our own State which most nearly approximates the ideal climatic conditions for the peanut is the North Coast. There are, however, other districts where it could be grown with a similar measure of success, particularly for oil production and for feeding to stock. The Department's experience indicates the Murrumbidgee Irrigation Area and the North and Central Coast as climatically suitable districts, but it is exceedingly likely that the establishment of the peanut in those localities will lead to its profitable production in most parts of the State, with the exception of the highlands and southern slopes.

The Soil, and its Preparation.

The class of soil that will produce the most marketable nut for roasting is a light, sandy, calcareous loam, greyish in colour, and with a well-drained clay subsoil.

Although a sandy soil with a moderate amount of humus and rich in lime is regarded as ideal, the largest nuts and often the heaviest yields are obtained on clay soils containing a high lime content. Practically any soil that can be reduced to, and kept in, a friable condition will grow peanuts.

The factors chiefly influencing the preparation of the soil are its physical nature, the climate, and the time of sowing. The object is to have available at sowing time a deep, friable seed-bed, with 5 or 6 inches of well-worked soil.

The ploughing should be deep (6 or 7 inches), but the subsoil must not be brought to the surface. After ploughing, harrows and cultivators should be employed to work the soil, which can be allowed to lie idle until sowing time, when, if it has been set by rain, it should be cross-ploughed to a depth of 4 or 5 inches, harrowed and sown. If it is still in a fairly loose condition, it will only be necessary to cultivate to prepare for sowing, using the spring-tooth or disc cultivator.

A proper system of rotation should be followed with peanuts as with other crops. To retain the soil fertility—which is dependent on so many factors—unimpaired, it is necessary to follow a rotation suited to the soil and climatic conditions.

Varieties.

The best varieties are Spanish, Valencia, and Virginia Bunch. Of these the former is the more suitable for oil manufacture, and the two latter for the roasting or confectionery trade. At present, seed of these varieties is obtainable only from the Department's Experiment Farms.

Sowing.

Peanuts are planted in the spring of the year, but not until all danger of late frost is over and the soil is warm. If the ground is cold, germination will take place slowly and irregularly.

To sow an acre, 27 to 35 lb. of unshelled nuts, or 8 to 10 lb. of shelled nuts, are required. The quantity depends chiefly on the variety, the distance apart in the rows, and the width of the drills.

The method adopted in small areas is to mark out the ground in drills with a hand plough, drop the seed by hand, and cover with the plough or rake. On extensive areas, where the peanut crop has taken a permanent place in the rotation of the farm, and is, perhaps, the chief source of revenue, the use of machines becomes necessary. The land is marked out in drills, as for maize, but not so deeply, using an ordinary plough or one of the special drill ploughs on the market. The distance apart of the drills will depend upon districts and on varieties. In typical districts, drills 3 feet apart and seeds every 18 to 24 inches in the drills is sufficient for the strong-growing varieties.

The seed should be covered to a depth of $1\frac{1}{4}$ inches in sandy soil and 1 inch in heavier soil if it is in a fine moist condition. Slightly deeper covering will be necessary if the soil is inclined to be dry at the surface.

After-cultivation.

Cultivation between the rows must be thorough and frequent, from the time the plants appear above ground until the blossom falls and the nuts begin to form or "peg," as it is termed. The land must be kept scrupulously clean, and under no circumstances must the weeds be allowed to grow unchecked; they will not be difficult to control if the soil has been properly prepared at the outset.

To conserve the moisture during the dry summer months, the cultivator must be employed after every rain of any magnitude to restore the mulch and prevent evaporation.

Harvesting.

If the season has been favourable and the cultivation thorough, the vines in two to three months from sowing will have met between the rows, and the whole field will have the appearance of a mass of dark green foliage. Later on, it gradually assumes a yellowish appearance—a sure indication that the pods are reaching maturity and that the time of harvesting is approaching. Under normal conditions the maturity of the plant ranges from 120 to 170 days. After the lifting implements have gone through the crop, the vines are pitchforked into windrows, where they are left for a few hours to wilt; then stacked until cured, which may take from 15 to 25 days, and finally the nuts are picked from the vines and marketed.

Summary.

The factors which would seem to indicate that the peanut industry could be placed on a profitable basis in this State may be summarised as follows:—

1. There are large areas of suitable land.
2. The climatic conditions are favourable.
3. There is an extensive market for nuts of good quality for roasting and confectionery, and for nuts of second quality for oil manufacture.
4. Large quantities of edible and crude peanut oil are imported annually which could be produced locally.

5. The leading importers are prepared to use locally grown nuts if the quality is equal to the imported article.
6. The protection afforded by the import duties of 4d. per lb., and 6d. when shelled, on nuts, and 2s. per gallon from United Kingdom, and 3s. from other countries on edible oil, with the possibility of increased duty when the area of production warrants it.
7. Excellent machines for handling in all stages of the industry are procurable from overseas.
8. The uses to which the peanut is put are ever increasing, and the demand greater each year.
9. The plant is of considerable value on the farm holding as a soil-renovating crop and a quick-fattening fodder for all classes of stock.

FIELD PEAS.*

These crops deserve more extensive cultivation than they have received in the past. As a fodder for sheep, pigs, and other stock they have been found excellent. For several reasons, however, they are more frequently grown with wheat, oats, or barley, forming a very palatable and well-balanced fodder.

The most suitable soils are loams and clay loams of an open nature. Sandy soils give but poor results, partly on account of their general lack of plant-food, and partly because of their tendency to dry out rapidly and become warm during a spell of hot, dry weather. On such soils it is advisable to use farmyard manure whenever obtainable, and many stock-yards where manure has accumulated for years could be sweetened and very profitably used by growing peas in combination with oats or barley for green feed.

In most of the river districts of the North Coast large areas of field-peas are grown each year for feeding milch cows. Besides producing a rich milk-producing food, the refuse is ploughed under in the spring, and the soil considerably enriched for the summer crop of maize.

A method of sowing field peas that has come into some prominence on the North Coast, where maize-growing, in conjunction with dairying, is practised, is to sow the peas between the rows of late maize just prior to the last cultivation. Very little growth is made until the maize ripens, when the dying leaves allow free ingress of light and air, and causes a quick growth of succulent forage. When the maize is pulled the dairy cattle are turned in, and an immediate increase in milk yield is the result. In addition, this system prevents the growth of weeds, and, most important of all, helps to maintain the fertility of the soil by reason of the power peculiar to this group of plants of enriching the soil with nitrogen.

Field peas may be sown from February to May. If a succession of sowings be made every fortnight or so the crop can be utilised much more economically, as there is less waste.

* The matter under this heading, together with that under the heading Vetches and Tares, has been revised from previous matter by several officers of the Field Staff.

For fodder purposes peas may either be grown in rows or broadcasted. In the former case the rows are drilled 2 feet to 3 feet apart, and the seed sown at the rate of 15 to 30 lb. per acre, the exact quantity depending on the size of the seed and the luxuriance of the variety. When broadcasted, the seed is sown from 1 to 1½ bushels per acre. In a good season this produces a thick stand of succulent but nourishing fodder. Until nearing the flowering stage the vines grow fairly upright, and are easy to harvest. At a later stage this operation is more difficult, but the full feed value of the crop is obtained.

When grown for pigs the vines are allowed to bear pods, and when in the dough stage are eaten off. The pigs will harvest the pods and eat at the same time a good quantity of the greenstuff. If the vines are dead ripe trouble is often experienced from the pigs eating the hard grain, and consequently suffering from digestive troubles.

Field-pea hay is of excellent quality, but very difficult to make. This is especially so when the vines are allowed to reach that stage when they contain their full nutritive value.

A question of importance in broadcasting is to bury the seed sufficiently deep, which in normal soils will be 2 to 3 inches. Harrowing it in on freshly-ploughed ground will often act satisfactorily, as the seed mostly falls between the crowns of the furrows. Seed should not, on any account, be sown on smooth land with the intention of only harrowing it in. If the land needs a second and a shallow ploughing, the seed can be broadcasted in front of the plough.

Drilling is recommended where possible instead of broadcasted, as 1 bushel of seed per acre will be sufficient, with $\frac{1}{2}$ to 1 cwt. superphosphate. The seed can be buried at a more uniform depth, and less seed is necessary than with broadcasting. As the seed is expensive this is worthy of consideration. Farmers are advised to grow their own seed.

Peas will stand a great deal of dry weather, but, on the other hand, will suffer from too much rain. If the soil does not go out of condition during the growing period they will yield heavy crops on a medium rainfall, and leave the land in fine working condition.

Caution should be observed in feeding a succulent growth of field-peas to cattle, particularly if hungry, owing to the liability of "bloat" or hoven.

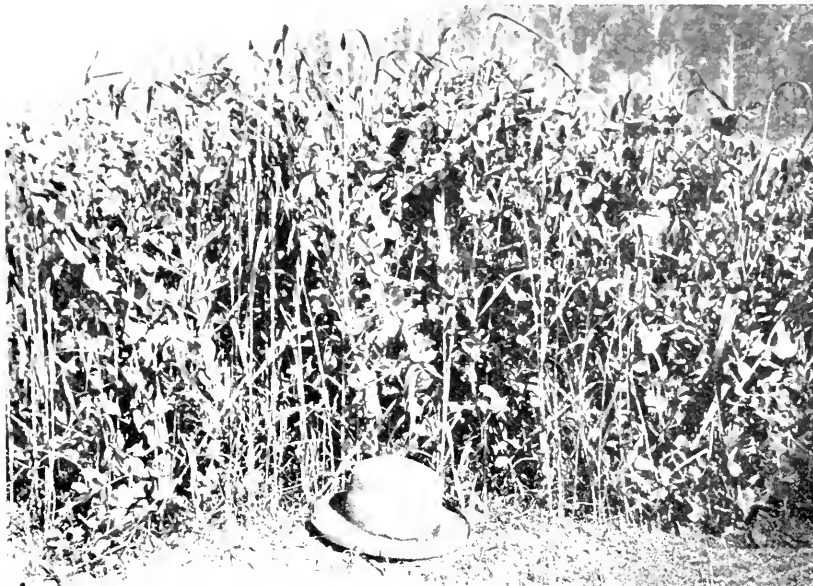
Field-peas are specially valuable in districts where trefoil and clover are scarce in the natural pastures, and in their adaptability for mixing with cereals.

Field Peas Combined with Cereals.

In addition to the combination with maize already mentioned, field-peas can be grown with any of the winter cereals. The mixture of peas and oats is a well-recognised and valuable combination where these crops will grow, although the yield from wheat and peas has given decidedly better results on the North Coast.

As a green manure, peas can best be mixed with either barley or rye. Especially on poor sandy soil, the rye combination gives a mass of greenstuff which is of great value in improving the texture of the soil. The

peas should be carefully drilled, or broadcasted on rough land, so that they will be covered to a fair depth. The cereal can be broadcasted and harrowed in afterwards, or the two crops may be sown together. The difference in the size of the grain, and the different depths at which they should be sown, make it somewhat inconvenient to mix the seed.



Grey Field Peas and Huguenot Wheat, showing how the Peas are supported by the Wheat.



Grey Field Peas and Rye for Green Manuring at Hawkesbury Agricultural College.

From one and a half bushels of the cereal, and one half to one bushel of peas per acre are usually sown. It may often be found advisable to alter the proportions, and this can be settled only by trial.

Experiments have been conducted at various centres on the North Coast for the purpose of comparing wheat alone against wheat in combination with field peas and with vetches.

The following are the results of the experiments:—

Locality.	Tatham.			Kyogle	Dorrigo.	Bellingen.	Uki.	Burrapine.																				
	1920.			1921.	1921.	1920.	1921.	1920.	1920.																			
Season.	t.	c.	q. lb.	t.	c.	q. lb.	t.	c.	q. lb.	t.	c.	q. lb.	t.	c.	q. lb.													
Wheat and Peas	14	2	0	11	13	15	0	0	10	0	0	0	9	3	2	15	9	4	1	4	8	16	3	0	17	18	0	10
Wheat and Vetches	13	16	1	20	11	7	3	12	13	14	2	0	8	16	3	0	9	10	0	0	8	0	1	0	.....	.....	.....	.....
Wheat alone	7	8	1	11	7	12	1	0	7	18	1	0	6	7	2	12	6	8	3	0	7	6	2	0	10	18	2	8

Of varieties, Huguenot, Thew, Warren, Firbank, Florence, Clarendon, and Bomen are suitable rust-resisting wheats, and Algerian and Sunrise are suitable oats for these combination crops of cereal and legume for coastal districts. Rye gives heavy yields, and affords good feed while young, but it should not be allowed to mature, as it becomes unpalatable.

Cape and Skinless barley are excellent fodders, but on account of their early maturity are not altogether suitable for sowing with peas or vetches.

Varieties.

The varieties which have been most successfully grown are the Grey field pea and the Blue field pea.

The Grey field pea invariably gives the heaviest yield of greenstuff. It is later than the others, and is a very hardy and vigorous grower. In comparative trials at the Hawkesbury College the yields were as follows:—

Grey Field Pea 9 tons 15 cwt. per acre.

Blue Field Pea 4 tons 14 cwt. per acre.

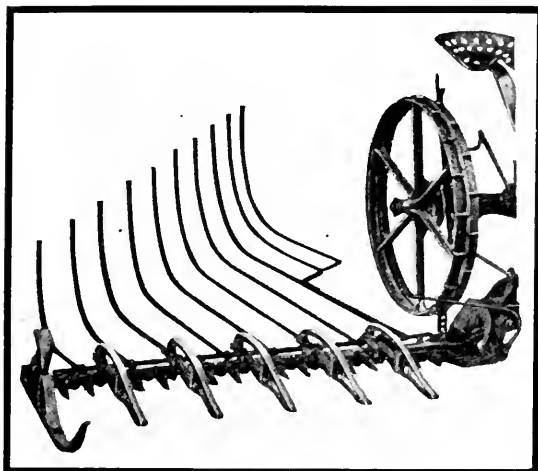
The Blue pea is largely grown in Tasmania and other cooler parts for the production of seed. For fodder purposes it is hardly to be recommended, as the yield is not great, and the variety is not very hardy.

Several earlier varieties than the Grey and Blue peas are being tested, some of which will be more suitable for the inland districts, but even for the coast earlier varieties are often required. Canada and Suntop are the best of these varieties.

Harvesting for Seed.

A special pea-harvesting attachment for the mower, which will lift the vines from the ground in front of the mower blade, can be obtained from most implement firms. A windrowing attachment is also desirable to prevent trampling by the horses and the consequent loss of seed. The crop

should be mown when about half the peas are ripe. A flail or a pitchfork should be used for beating out the seed, and a tarpaulin spread underneath. In dry weather the vines are soon fit for threshing, and it is best to do the work in the field; carting to a shed causes loss of a quantity of seed. The peas may be cleaned by passing them through a winnow, or, if the quantity is small, by pouring into a bag from a large dish, using the wind to winnow. When growing quantities of seed for sale the peas should be carted from the windrows to a thresher, the drum of which should be set rather open, as the peas readily crack.



A Type of Pea-harvesting Attachment for the Mower.

VETCHES AND TARES.

The vetches for the most part are slender climbing plants, producing numerous tendrils at the ends of the leaves. Their habit of growth is recumbent, and to facilitate harvesting they require to be grown with a cereal crop. To most farmers the terms vetches and tares are synonymous, and are used indiscriminately to include all varieties of this crop. Correctly speaking, there is a botanical difference between the tare (*Vicia sativa*) and the vetch (*Vicia villosa*). The difference, however, does not seem to be taken into account by the seed merchants, and is therefore of little practical importance.

Vetches may either be used as a fodder or as a winter green manure. If for the former, they are usually mixed with oats, barley, or rye, and give a heavier yield and a better balanced ration. If as a green manure, they may be sown alone or in a mixture. Such varieties of wheat as Huguenot are to be strongly recommended. The strong and upright growth is better able to support the vetches, and they seem to do better with wheat than with oats. Algerian is the most popular variety of oats, especially along the coast where rust is likely to cause considerable damage.

The crop is probably grown more extensively along the Macleay River than on any other coastal river. In that district it is used as a dual-purpose crop, the greater bulk of the growth being used as a "soiling" fodder and the residue being turned under for green manure. It is this procedure that to a large extent keeps up the fertility of the land. Maize is the chief crop grown, and to crop continually without a change, as vetches, soon has a marked effect in decreasing its yields. Vetches are more highly valued by mixed farmers as a fodder crop than any other legume, excluding lucerne, and they are easily grown. During the last year or two, however, their growth has not been satisfactory, owing to a "damping off" occurring when the plants are about 6 inches high. This is more in isolated cases than the general rule, and is probably caused by the very wet autumns and winters.



Black Vetches and Huguénot Wheat.

Along the Manning River the vetch is chiefly used mixed with oats, wheat, or barley as cow fodder. Used in this manner it is preferable to field peas, which are not always relished by cows. It has often been noticed that where vetches have been included with a cereal the latter invariably has a richer colour than when sown alone, thus showing the value of the vetch as a soil renovator early in its growth.

This crop can be grown in most parts of the State where there is a fair rainfall during the winter. In the moist coastal districts it grows very luxuriantly in the cool weather, and produces a valuable fodder during winter and early spring.

The soil best suited to vetches is a loam or clay loam. Sandy soils are not generally suitable, although vetches will do better than peas on such soils, and, given a good season, they do moderately well on the poor sandy soil at the Hawkesbury Agricultural College.

Seeding may commence about February, and continue till May. When sown with a cereal, about 30 lb. of vetches and 40 to 60 lb. of oats, barley, or rye, will usually give a good stand. The seed can be mixed and sown broadcast or with a wheat drill. If sown alone in drills with a maize-dropper and sorghum plate, a much smaller quantity of seed will be required. Besides this, the crop can be cultivated for a limited period before it spreads across the rows. The seed is difficult to harvest and consequently somewhat high in price, averaging about 12s. per bushel. For this reason the use of smaller quantities of seed may be found to be more economical.

The value of maize stalks as a winter fodder can often be enhanced by sowing the seed of vetches between the rows of late maize after it has received its last cultivation. This should be some time during or after February. Seedings before this month can be made more satisfactorily with cowpeas.

The difficulty attending the harvesting of this crop prevents it from being of much value as hay, although the quality of the fodder thus preserved is said to be very good. When mixed with cereals the growth is more upright, and correspondingly easy to harvest. The pods, when dry, shell very easily, and if allowed to mature, seed is scattered about, and the plant is likely to become a nuisance. This is especially the case where wheat is grown for the seed gets harvested with the wheat, and it is not easily separated by grading. When grown with barley, oats, or rye, it rarely has an opportunity of seeding, since the cereal is ready to be fed off before the vetch has commenced to flower.



An average plant from a crop of Tares grown for green manure at Wagga Experiment Farm.

This crop makes demands on the soil similar to other legumes. It enriches the soil considerably in nitrogen, hence its value as a green manure. Under such circumstances it is advisable to encourage as much growth as possible, and manures can often be more effectively used by applying them to the green-manure crop rather than to the main crop, or to the fruit-trees.

Golden vetch or tare is the most popular variety grown, and the one most commonly quoted by the seedsmen. The Hairy vetch is a more vigorous grower, and a much later variety. It is remarkably hardy and drought-resistant, and care has to be taken that the seed does not spread, as self-grown plants may give trouble later.



Hairy Vetches (*Vicia villosa*).

CLOVERS.*

Clovers are leguminous plants belonging to the genus *Trifolium* (three leaves). They are distinguished from other legumes by the flowers being clustered in a head and by the seed pods being scarcely longer than the calyx of the flower. Again, the seed pods do not open, and often fall off the plant when the enclosed seed is quite ripe.

Clovers are very common throughout the world, and although there are over 200 species, comparatively few are found growing in any abundance. For example, as far as this State is concerned, the following are the only species found growing spontaneously in pastures in any quantity:—White clover (*Trifolium repens*), Hop clover (*T. minus* and *T. procumbens*), Hare's Foot clover (*T. arvense*), Ball clover (*T. glomeratum*), and Woolly clover (*T. tomentosum*).

These legumes have long been recognised as some of the most useful plants to grow as (1) an adjunct to pastures, (2) a rotation or green manure crop, and (3) a hay crop.

* J. N. Whittet, Agrostologist.

As an Adjunct to Pastures.

As an adjunct to pastures clovers are of inestimable value in this State. In the coastal districts White clover has increased the productiveness of couch, paspalum, and other grass pastures to a very great extent. The manner in which it will grow on the poorest of soils is particularly noteworthy, while on the rich volcanic soils of the northern rivers it provides the necessary supplementary constituent to complete a ration. In the interior, particularly in the south-west and Riverina, Ball and Woolly clovers are very abundant, often dominating the situation. Their capacity to fatten lambs in the spring is well known.

As Rotation and Green Manure Crops.

The value of clover as a rotation and as a green manure crop has long been recognised, but practically little work has been done in this direction in this State; some striking results, however, were obtained at Bathurst Experiment Farm by following a wheat crop on Scarlet clover. The advantage of growing Scarlet clover as compared with maize and wheat as previous rotation crops to wheat is well shown by the following table. The crop sown was Cleveland wheat.

Previous crop.	Manure per acre.	Seed sown per acre.	Yield of hay.			Yield of grain.	
		lb.	t.	c.	q.	bus.	lb.
Scarlet clover	Superphosphate 1 cwt.	28	2	10	2	37	40
Wheat	do do	28	1	2	2	10	39
Maize	do do	28	0	11	1	6	45

Red clover has been used as a rotation crop at Glen Innes Experiment Farm for many years with satisfactory results.

Clovers, in common with other legumes, possess the property of obtaining nitrogen (more than they need for their growth) from the air. It has been ascertained in Canada that a vigorous crop of clover will produce as much nitrogen, phosphoric acid, and potash as can be obtained from an application of 10 tons of ordinary barnyard manure per acre. The exact figures are as follows:—

Clover:—

Nitrogen	100 to 150 lb. per acre.
Phosphoric acid	30 to 45 lb. „ „
Potash	85 to 115 lb. „ „

Barnyard Manure (10 tons per acre):—

Nitrogen	100 lb. per acre.
Phosphoric acid	50 lb. „ „
Potash	90 lb. „ „

The significance of clovers and other legumes as rotation crops has not been thoroughly realised. For example, many of the best wheat-farmers in the south-west and Riverina adopt the method of fallowing for two or three

years, and then throwing the land out of cultivation for a couple of years, allowing it to run to grass. The resultant grass includes a very large proportion of legumes, such as *Medicago denticulata*, *M. minima*, and Ball clover (*Trifolium glomeratum*). The increased yields in the succeeding crop of wheat, after ploughing in such humus, laden with nitrogen, is very marked. The result could, however, be obtained much more quickly if the seed of such legumes as Ball clover and Burr trefoil were sown instead of allowing them to come spontaneously, and probably one year's rotation would suffice if such treatments were adopted.

Clover Hay and Silage.

Clover, particularly the Red, Crimson and Berseem varieties, makes excellent hay, rich in protein and very palatable to stock. It has been ascertained that 1 ton of well-cured clover hay is worth, for feeding purposes, nearly half as much as a ton of bran. Clover hay, fed with cereal or grass hay, provides an ideally-balanced ration, particularly suitable for young stock and dairy cattle. Care, however, has to be exercised in curing the hay, as over exposure to the hot sun produces extreme brittleness in the leaves.

Clover also produces silage of fair quality. Investigations as to the comparative values of clover hay and clover silage have resulted in the following conclusions* :—

1. The most important chemical changes occurring during the ensiling of Red clover are an increase in the percentage of moisture, a disappearance of the reducing sugar, a loss in the nitrogen-free extract, and a slight gain in fibre.

2. When clover is cured as hay there is a significant loss in protein, a considerable gain in nitrogen-free extract, and a slight loss in ash, crude fibre, and ether extract.

3. The results indicate that when Red clover is ensiled there occur changes in the proteins which result in a noticeable lowering of the co-efficient of digestibility for this, the most important of food constituents.

Clover under Irrigation.

That clovers under irrigation are distinctly promising for western districts is shown by the trials at Yanco Experiment Farm. Short-lived clovers like Subterranean, Crimson, and Egyptian, gave high yields for the season, and may therefore be particularly useful as rotation crops. The following are the acre yields obtained in the 1915 trials :—

Variety.	Yield.			
	t.	c.	q.	lb.
Subterranean clover	3	8	3	0
Crimson or Red clover.....	4	0	1	12
Chilian clover.....	3	9	2	16
Egyptian clover.....	8	11	1	20 (3 cuts)

* Montana Agric. Exper. Stn., Bul. 117.

The Soil.

Clover requires fairly good soil. Those of a clayey nature, such as stiff clays and loams, give good crops: light loams also prove satisfactory. Rich alluvial flats are eminently suitable, and usually give splendid crops. Sandy soils are unsatisfactory, and good crops are rarely obtained from them. An abundance of potash and phosphoric acid encourages its growth, as does also lime. This last is essential as a plant-food, but its chief value to the clover crop appears to be that it increases the amount of soluble potash in the soil. It is noticeable that where lime is applied to clay soils clover appears spontaneously in the pasture. It rarely so appears in sandy soils, except perhaps to a limited extent.

The land must be worked down to a fine, level, firm condition. Deep ploughing should be given, and the harrow and roller used until the right degree of fineness is reached. The seed should not be covered deeply.

Manuring.

Fairly liberal manuring is required on poor soils. Lime is beneficial, and can be applied at the rate of one ton per acre. Wood ashes and gypsum also form good manures; they can be applied at the rate of 10 cwt. per acre.

Nitrogenous manures are not usually required, but in some cases may be necessary. The plant should be encouraged to obtain its nitrogen from the air, through the agency of bacteria. At the same time a small amount of nitrogen may be helpful until the plants are able to gather it from the air.

Feeding the Crop.

Clover can be fed either as a green feed, hay, or pasturage. For green feed or hay it should be cut when about one-third of the bloom is out. The hay is a little difficult to cure, but if the methods recommended for lucerne are followed, good hay will be obtained. Care should be taken in feeding green clover, as it is liable to cause bloating. Stock should be accustomed to it gradually, and given some other feed in addition. Clover hay is equal to lucerne hay, and, like it, improves the feeding value of green maize or silage.

TYPES OF CLOVER.

There are three distinct kinds of clover, viz., annual, biennial, and perennial, and there are several varieties of each.

All the clovers of the interior, including Ball clover (*Trifolium glomeratum*), Woolly clover (*T. tomentosum*), Hare's Foot clover (*T. arvense*), Spotted clover (*T. maculatum*), are of an annual nature, and in addition most of the medicago family, generally termed clovers, such as Burr clover (*Medicago denticulata*), Woolly Burr clover (*M. minima*), and Snail or Button clover (*M. orbicularis*). These valuable nutritious fodder plants occur spontaneously in pastures, and provide a considerable amount of feed in the spring months. Owing to the manner, however, in which they quickly disappear under the hot summer conditions, practically 70 per cent. of their growth is wasted unless utilised as silage or hay.

In addition to these varieties which are grown inland there are many annual clovers which could be grown on the coast, or in the cooler parts of the State. The most important are:—

EGYPTIAN OR BERSEEM CLOVER (*Trifolium alexandrinum*).

This is a clover best utilised for hay, which is highly palatable and nutritious. It has proved its capability to do well in the coastal districts and under irrigation in the interior. To obtain the best results it requires to be sown early—in March, at the rate of 12 lb. of seed per acre. In a good season it is possible to obtain as many as three good cuts. It is a valuable rotation to employ between two summer fodder or grain crops.

CRIMSON OR SCARLET CLOVER (*Trifolium incarnatum*).

This clover is well adapted to the coast and tablelands, though many failures have been reported owing to faulty germination of the seed, which must be fresh in order that a good stand may be obtained. It also suffers severely in a dry spell. Owing to its slow growth under very cold conditions



Crimson Clover (*Trifolium incarnatum*).

early sowing is essential, as otherwise the winter weeds, especially herbage, will quickly smother it. The principal use of this clover is as a rotation crop—the first cut being utilised for hay, and the aftermath ploughed in to provide humus.

SUBTERRANEAN CLOVER (*Trifolium subterraneum*).

Probably the most successfully grown annual clover under irrigation, or in districts with a fair winter rainfall, Subterranean has proved an excellent clover to have in winter pastures at Yanco, and is doing so well on the south-east tableland that it is spreading rapidly through the pastures. Quite a lot of it can be seen around Hölbrook and Culcairn. In Western Australia

and Victoria, where considerable areas are grown, it has proved to have a considerable fattening and carrying capacity for dairy cattle. Owing to the manner in which the runners set their numerous seeds under the soil, it re-seeds itself even under heavy stocking, and maintains practically a permanent character.

Biennial Clovers.

There is only one biennial clover of any importance, and it is not really a clover, although the term Bokhara or Sweet clover is now permanently fixed. Its scientific name is *Melilotus alba*. There is a big scope for this clover throughout the coastal and wheat-growing districts and very good results have been obtained from growing it on the coast, in the New England district, at Orange, Bathurst, Cowra, and on the Murrumbidgee Irrigation Area.



Sweet (Bokhara) Clover (*Melilotus alba*).

The most valuable characteristics of Bokhara clover are:—(a) It provides excellent pasture for sheep and large stock; (b) it makes very fine hay; (c) it is very drought resistant; (d) it is a very efficient soil renovator, owing to its deep root system and its property of acquiring abundant nitrogen-gathering bacteria; and (e) it is a valuable crop to grow preparatory to laying down a lucerne paddock. It can be sown in early autumn or early spring at the rate of 8 to 10 lb. of seed per acre. The seed must be sown on a well-rolled seed bed, and lightly harrowed in, otherwise a faulty germination will ensue.

The growth should be pastured or cut before it becomes too woody. By allowing the crop to seed in the second year a permanent pasture is practically guaranteed. On the coast and in New England this clover does well when mixed with cocksfoot. The combination provides an ideal ration for dairy cattle.

Perennial Clovers.

The perennial varieties seem to do best in the cooler districts of the State—on the coast and tablelands—in fact temperate conditions are essential to their growth.

PERENNIAL RED AND COW GRASS CLOVER (*Trifolium pratense perenne*).

The difference between these two clovers is that the former has a solid, and the latter a hollow stem. The Cow Grass clover appears also to be more permanent and vigorous than the ordinary Red clover, which formerly did not set seed, and generally soon disappeared in a pasture. Latterly, however, it hardly ever fails to set seed, and for this reason is steadily improving its popularity. For coastal and elevated tableland pastures it should be included in every mixture of Cocksfoot and Perennial Rye at the rate of 4 lb. of seed per acre, or it can be used as a rotation crop, when 12 lb. of seed per acre should be sown.



Chilean Clover (*Trifolium pratense perenne*).

An improved strain known as Chilean clover is recommended as being more permanent and more drought-resistant than the foregoing.

WHITE OR DUTCH CLOVER (*Trifolium repens*).

This well-known clover occurs spontaneously in coastal and tableland pastures, and it should be combined with most grass mixtures at the rate of 4 lb. seed per acre. It appears to be the only clover which will grow successfully with Paspalum, and it should always be added to the latter, as by this means a balanced ration is obtained.

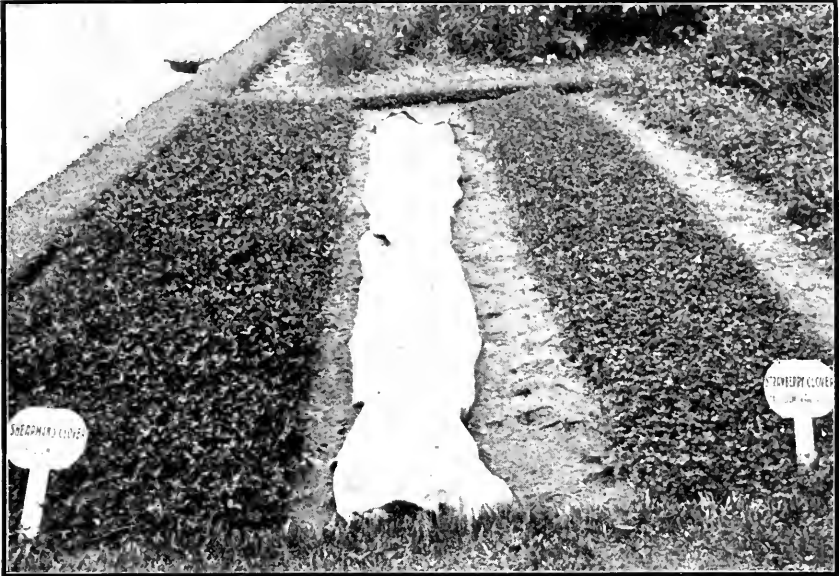
An undoubtedly improved strain of White clover is Ladino clover. This variety has a much wider leaf and produces fully three times the growth of the ordinary strain.

ALSIKE CLOVER (*Trifolium hybridum*).

Particularly suited to the Monaro and New England districts. This is a good clover to have in pastures on good soils in cold districts generally.

SHEARMAN'S CLOVER (*Trifolium fragiferum* var.).

Shearman's clover has been authoritatively identified as a hybrid from Strawberry clover, and was first discovered by Mr. J. Shearman, of Stockton. It is undoubtedly superior to Strawberry clover in moist situations,



Shearman's Clover (on the left) and Strawberry Clover (on the right), as grown at the Botanic Gardens, Sydney.

Note the similarity in habit; Shearman's clover, however, is much more vigorous.

and Mr. Shearman carries four head of dairy stock per acre on this crop alone. It makes its best growth in the warmer months of the year, and is highly recommended for swampy or marshy soils. Root planting is necessary, as so far it has failed to set seed.

MEDICS, TREFOILS, AND CROWFOOTS.*

To the grazier and pastoralist in this State the most important representative of the *Medicago* family of plants is the well-known *Medicago sativa*, or lucerne. Together with *Medicago lupulina* (English trefoil), which is also a perennial, it is the only member of the family cultivated to any extent. Many others, however, are extremely important owing to their value in pasture land and to their possibilities under cultivation, and several of the more important are discussed below.

The Medics are legumes with leaves like clover, but characterised by having pods curved or spirally twisted. Certain species have their pods provided with spines and are called Burr Medics or trefoils, while the pods of other species, *e.g.*, *M. orbicularis*, are not provided with spines.

* E. Breakwell, B.A., B.S.

Burr Medics or Trefoils.

The Burr Medics or trefoils are very heavy seeders, and owing to the manner in which the burrs are carried about by sheep are now distributed throughout the length and breadth of the State. Again, as the burrs contain up to eight seeds in a pod, the plants form a dense mass of vegetation under conditions satisfactory for the germination of the seed. The tough pod acts as a protection to the enclosed seed and supplies the necessary moisture during the germination period. Although sheep have now become accustomed to the Burr trefoils in the wheat-growing districts, exceptional cases of "bloat" have been known to occur. Bloat is most likely when the plants are wet, and when the stock are hungry. Pastoralists who are desirous of introducing the Burr trefoils in their pastures sometimes encounter difficulty in getting the seed to germinate satisfactorily. Such faulty germination is due to the hard nature of many of the seed-coats. Most of these seeds will, however, eventually germinate, though the time taken to do so will vary. It is also necessary that the soil should possess the requisite bacteria for the growth of the plant. When these are absent in the required proportion inoculation of the soil is necessary.

ENGLISH TREFOIL (*Medicago lupulina*).

This variety is also commonly called Yellow trefoil, Hop trefoil, or Black Medic. It is found growing spontaneously in pastures and fallowed lands throughout the State, but is only abundant on the cold tablelands. In New England it is perhaps more common than elsewhere, and provides a fair amount of winter feed. It is well adapted to heavy rich soils in cold districts, and provides good bottom herbage where other clovers are not too good. It is much better adapted to grazing than mowing, and can only be recommended for cold localities where other clovers will not thrive.

BURR TREFOIL OR BURR MEDIC (*Medicago denticulata*).

This plant is most commonly called trefoil or Burr trefoil, but sometimes Burr Medic and Toothed Burr clover. It is one of the commonest and most abundant plants growing in New South Wales, and often succeeds in dominating the whole of the vegetation in the wheat-growing districts during the cool months of the year. Its distribution practically coincides with the progress of the plough, and outside the wheat-belt it becomes scarce. It will not grow well where the winters are too long, or where the mean temperatures of September and October are below 52 and 60 degrees Fah. respectively, and its best growth is on the stiff or alluvial soils of the flats. On river flats and on the black-soil plains this trefoil has entirely displaced the original native pastures. Such country is often termed "trefoil country." The growth of such trefoil in the warm months of the year is so abundant that the ordinary number of sheep carried on the farm cannot keep it eaten down. If all this feed were properly utilised there is no doubt that it would more amply serve the grazier's needs than the original native pastures. The trefoil, however, has a short life. Under ordinary conditions it commences growth in the autumn, and seeds about September or October. After this burrs are left in great abundance on the ground, sometimes as many as 1,500 per square yard, and these burrs provide the main source of feed during the summer months on ground often absolutely destitute of vegetation. If the trefoil were conserved as ensilage much more could be obtained from it, and probably less trouble would ensue from "burr" wool.

SPOTTED TREFOIL (*Medicago maculata*).

This is an annual trefoil or medic, not nearly as abundant as *M. denticulata*, being confined to the colder districts of the State. It is very abundant on the Southern Tablelands, particularly at Moss Vale and at Goulburn. When grown as a pasture grass stock do not take too kindly to it at first, but later develop a liking for it. It is also used as a hay crop to a certain extent, but plants should be cut as soon as the blooms are abundant, as the plants fall down if left too long.

The Spineless Medics.

The advantage which the spineless trefoils possess over the Burr trefoils is obvious, and as they possess all the good qualities of the latter, they deserve every possible encouragement. The more important species are briefly mentioned.

BUTTON CLOVER (*Medicago orbicularis*).

This species is most abundant in the north and north-western portions of the State, but does not appear to thrive in the very cold localities. It is badly affected by dry conditions; but has made promising growth under irrigation at Yanco Experiment Farm.

SNAIL CLOVER (*Medicago scutellata*).

This species has been found growing spontaneously in pastures at Molong, and has done well under irrigation at Yanco. During winter and spring the plants make good growth, throwing out stems about 18 inches long. The stems are very branched and carry a large amount of foliage. The plants remain green for some time after the pods have fallen, and the clover itself lasts longer than the other annual medics.

The Crowfoots (*Erodium* sp.)

There are three species of crowfoot commonly found in this State, namely, *Erodium cygnorum*, *E. moschatum*, and *E. cicutarium*.

The crowfoots are very abundant on the lighter soils throughout the wheat-growing districts. Such country is called "crowfoot country" as distinguished from "trefoil country" on the flats or heavy soils.

Native crowfoot (*E. cygnorum*) is confined mostly to the warmer parts of the State, such as the north-west and far west. West of Parkes right through to Condobolin it can be found in great abundance. On the black soils of the north-west it will grow to a height of 5 feet in a good season. It is a very rapid grower, its period extending from late autumn to early spring. The mature growth is seriously affected by heavy rains; owing to the succulent nature of its growth it falls prostrate, its leaves fall off, and only a mass of dry stalks remains. All classes of stock do exceedingly well on the green growth. So luxuriant is its growth in a good season that thousands of tons go to waste. It does not make good ensilage unless mixed with coarser plants, such as grasses or cereals.

Musky crowfoot (*Erodium moschatum*) is very abundant in the cooler parts of the State. It is generally associated with *E. cicutarium*, but owing to its more vigorous habit of growth, is generally more abundant than that plant. In the very cold districts, where the mean winter temperatures range between 55 degrees Fah. and 62 degrees Fah., it partakes of a rosette habit.

Erodium cicutarium is thought very highly of in this State. Although it does not produce the body of feed that Native Crowfoot does, its growing period is longer and it is capable of being closely grazed. When it takes possession the plants are invariably prostrate. This crowfoot is also credited with being a first-class bee plant.

SECTION VIII.

Miscellaneous Crops.

BROOM MILLET.*

From time to time inquiries are received by the Department from different parts of the State for information regarding the cultivation, harvesting, and marketing of broom millet. In recent years the price has fluctuated considerably, according to the supply and demand, and in the seasons which follow an unusually high market many farmers attempt to grow this crop who have but a slight knowledge of the requirements of the plant, and of the practical details from the selection of the seed to the harvesting, curing, baling, and marketing of the brush. The result is that the market is glutted with millet of inferior quality, and the returns give little, if any, profit to the grower. Besides this, manufacturers, in order to obtain the quality necessary for making their best goods, are compelled to import a large proportion of their supplies. We have in New South Wales soil and climate fully capable of producing the very best quality, and it is significant that those growers, whose practical knowledge teaches them to produce only the very best, are handsomely repaid for their outlay.

At the present time there is a Federal duty of 8s. per cental on broom millet, and with this protection there is no reason why we should not only produce enough for our own requirements, but become exporters as well.

The following table will convey an idea of the area under cultivation since the season 1910-11 :—

Season.	Acres.	Weight of Fibre in cwts.	Average Yield of Fibre per acre in cwts.
1910-11	4,467	39,451	8.9
1911-12	2,647	22,579	8.5
1912-13	1,828	11,154	6.2
1913-14	1,970	12,044	6.2
1914-15	2,027	10,400	5.1
1915-16	2,422	15,168	6.3
1916-17	1,721	8,795	5.1
1917-18	1,918	9,261	4.9
1918-19	3,019	13,883	4.6
1919-20	4,220	16,703	4.0
1920-21	1,453	8,126	5.6

* Compiled from articles by G. Marks, Manager, Grafton Experiment Farm, and J. M. Pitt, Inspector of Agriculture.

Fully 90 per cent. of the millet produced in this State is grown on the rich alluvial lands of the North Coast; and on several of these rivers—notably the Hunter, Manning, and Richmond—the industry may be looked upon as lucrative and permanent. Many farmers have reported their success with this crop, and would not think of reverting to the far less remunerative occupation of maize-growing. The raising of millet need not be confined to these districts, as, with the necessary care, and the aid of a few home-made contrivances, any land which produces 40 or more bushels of maize to the acre will yield profitable returns. The experimental cultivation of broom millet on the irrigation areas in the western districts has been attended with fairly satisfactory results. It is advisable, before entering extensively into the production of broom millet, to ascertain from agents or manufacturers the probable requirements of the trade, with the view of obtaining an idea of the prices likely to be obtained during the season. At the same time, should the prices fall after the crop is harvested, the millet may, if properly cured and baled, be stored for a considerable length of time without injury.

Requirements of the Trade.

In the manufacture of brooms, three classes of brush are required, which are popularly known as “inside,” “cover,” and “hurl.”

“Inside” millet is used for forming the inside of the broom, and is generally not more than 17 inches long.

“Cover” is the class used for covering the inside and also for forming the shoulders. It is longer than the former and must be from 17 to 20 inches in length.

“Hurl” is the longest brush, ranging from 20 to 25 inches. It must also be fine and straight, and forms the outside covering of the broom. To give a nice finished appearance, only prime hurl can be used.

About $1\frac{1}{2}$ lb. of brush are required to make an ordinary broom, and the three grades are used in about equal proportions.

The soil, climate, and methods of cultivation determine largely the quality of the brush, but in an average season there would be sufficient of each produced to satisfy the requirements of the trade. When grown under exceptionally favourable conditions, a larger proportion of long brush is produced. It may be used as covers, but owing to its length a certain amount has to be cut off, so that its use for this purpose causes unnecessary waste. On the other hand, a dry season will have the effect of stunting the growth, producing a large percentage of “inside” millet, which can only be worked in the inside of brooms. Manufacturers have consequently to purchase elsewhere to satisfy their requirements.

Condition of our Supply.

A great deal of dissatisfaction often exists amongst purchasers concerning the manner in which locally-grown millet is placed upon the market—so much so that the export trade has been injured, and the attention of the Federal authorities has been drawn to certain dishonest practices with the view of bringing broom millet under the provisions of the Commerce Act.

Whilst a large number of producers grade and bale their millet in a manner that compares favourably with the imported article, it is to be regretted that a certain section pays very little attention to these details. The chief faults may be divided into two classes—1st, those the result of ignorance and carelessness; and, 2nd, those which are brought about by unscrupulous individuals with the sole object of obtaining an unfair and undue advantage over the manufacturer. Those of the former class may be summarised as follows:—

1. The millet is not graded. All classes are packed indiscriminately in a bale.
2. The seed is not removed, or only partially so.
3. Broken, bent, or coarse brush is mixed with the good.
4. The cut is not uniform. Some are cut close to the brush; others have 10 or 12 inches of stalk.
5. The colour is not uniform.
6. Bales badly packed and pressed. Many are irregular in size and shape, and not bound with a sufficient number of wires to stand ordinary handling.
7. Brush destroyed by being packed before it is properly dried, causing it to develop moulds of various descriptions.
8. Absence of distinguishing numbers or marks signifying the quality and weight.

A few of the faults of the second class may be mentioned:—

1. The use of heavy billets of timber in bales.
2. Watering the interior of bales when packing with millet that has been properly dried.
3. Placing in the bales bundles of stems and leaves, useless brush, bagging, scrap-iron, sweepings of floors, quantities of unripe seed, &c.
4. Dressing the outside of bales with prime hurl and the middle with inferior material with the seed left on.

The following information may enable beginners in broom millet-growing to avoid some common mistakes, and to neglect none of the important operations which are essential to success.

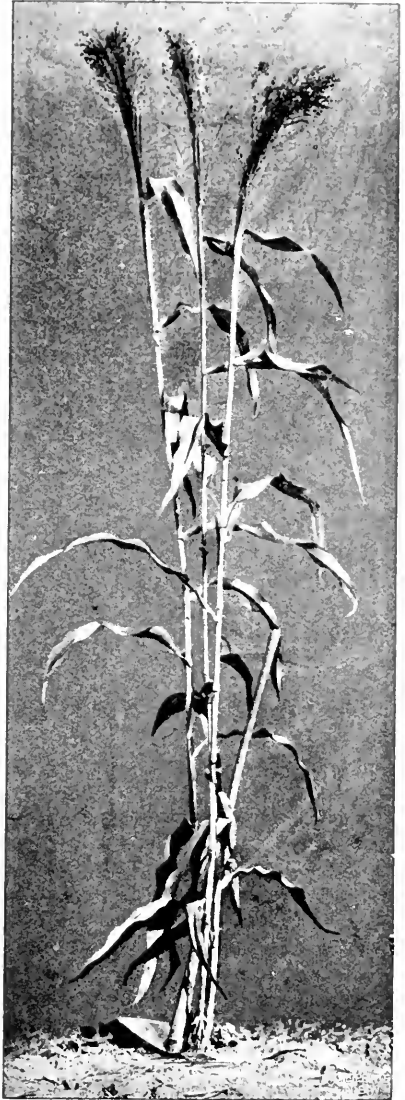
What Broom Millet is.

Broom millet is a non-saccharine variety of sorghum. It is an annual, somewhat similar in appearance to maize while young; but it has thinner stems and narrower leaves, and, instead of having male and female flowers on separate parts of the plant, they are both found together in the brush at the top. The flowers are of two kinds—perfect and imperfect.

The former are set directly upon the branch, and are accompanied by some of the latter, raised upon little stalks. The fine stems of the panicle or brush are the valuable portions; the other parts are incidental. The brush should be composed of seed-stems, uniform in size, length, elasticity, and toughness, and of a nice bright colour. The soil and general methods of cultivation will largely affect the character and quality of the product, even though good seed be used. By long and careful cultivation and systematic selection certain desirable qualities have been developed and fixed, which remain only so long as the conditions which brought these changes about are reasonably observed. When a plant is grown for a particular purpose it should be the cultivator's aim to keep improving it in the direction most profitable to him. This necessitates a careful study of the plant and its requirements, and the conditions which make for its proper development. In broom millet it is not desirable to obtain a heavy yield of seed, a large development of stalk and leaf, or a sap full of saccharine material, but a special and unusual development of the long, thin stems of which the brush is composed. It makes very little difference whether a large plant is produced or a heavy crop of seed is obtained, provided these stems are long and fine.

Class of Land required.

The soil requirements of broom millet are similar to those of maize. The best results are obtained from the deep, rich, well-drained alluvial lands of our rivers. It is, however, capable of adapting itself to a variety of conditions, and with proper care and attention, sandy and even gravelly soils, if thoroughly drained, will produce fair returns. Undrained lands make the working and cultivation more difficult; the growth is generally slow and uneven, and there is always the liability of the crop becoming stunted and diseased. To ensure evenness in ripening a soil uniform in character and fertility is essential.



A Broom Millet Plant, White Italian Variety
—one of the best kinds grown in
New South Wales.

Place in the Rotation.

In the general rotation on the farm, broom millet takes the same place as maize. It is not advisable to adopt the practice of growing it in the same piece of land continuously under any conditions. Neither should broom millet follow sorghum. No sorghum or broom millet crops are known to be free from the Red Stain disease which lives over in the soil from previous crops. It has been found, however, that in dry seasons, broom millet does not thrive as well following millet as where the previous crop was maize. The reason of this appears to be that, being more drought-resistant, the millet continues to grow and thus exhausts the soil of its supplies of moisture and plant-food, when maize would probably cease growing. Where possible, broom millet should follow a leguminous crop like lucerne or field peas.

Preparation of the Land.

To obtain the best results, the land must be properly prepared and brought to a fairly fine tilth before sowing. The previous treatment should be such as would destroy weed seeds. The presence of weeds in the early stages seriously interferes with the growth and cultivation of the young plants. Deep ploughing is recommended. This not only ensures greater feeding room for the roots, but it also has the effect of increasing the moisture-carrying capacity of the soil—a fact which must always be remembered, especially in those districts where the rainfall is limited and irregular.

Ploughing operations should be commenced a couple of months before sowing time. This not only allows the land to sweeten by exposure to the weather, but all vegetative growth turned under is generally well decomposed by the time the second ploughing takes place. In early spring the land should be well fined down by means of the harrow, disc, roller, &c.

Sowing and Cultivation.

Sowing should not take place until all danger of frost is over and the soil is thoroughly warmed, so that the seed will germinate at once. September, October, and November are usually the best months. On the Northern Rivers excellent yields are obtained by sowing up to the end of January. In these districts, frosts, if they do occur, come late in the season, and after the millet crop is matured. If planted too early, there is not sufficient heat in the soil to cause the seed to germinate, and it will either rot or the young plants will be so weak that the weeds will very quickly outgrow and smother them. It may be sown about the same time as maize, or two or three weeks later, with advantage. Drills 4 or 5 inches deep are struck out with a plough (a double mouldboard one is preferable) about 3 or 3½ feet apart, and the seed planted along these by hand or machine. The latter is preferable, as it sows more uniformly; and by using a fertilising attachment, chemical fertilisers may be applied at the same time. An ordinary maize seed-drill with a sorghum or broom millet plate, which sows and covers the seed in the one operation, is one of the best for the purpose. During hot or dry weather the seed should be sown soon after the drills are opened, and before the soil has had time to dry. When this system is adopted, hilling can be dispensed with and a great deal of evaporation from the soil prevented by the exposure of a smaller surface. Besides this, the plants, having their roots deep in the soil, have plenty of support, and are not so quickly affected by dry weather.

In districts having a good rainfall, and where at sowing time the soil is very moist, the seed may be sown by the machine direct, and without opening out drills with the plough.

The practice of broadcasting broom millet cannot be recommended. The chief objections are that cultivation operations—so essential for good results—cannot be carried into effect, and also that the harvesting and curing cannot be carried out so expeditiously.

On big areas the ordinary wheat drill can be used for planting by merely stopping up the openings of a number of the seed tubes so as to leave free those that would sow at the requisite distance apart. In a similar manner these machines can be used for distributing fertilisers also, closing all but those which correspond with the seed-sowing tubes.

The amount of seed required varies from 3 to 6 lb. to the acre.

When the plants are 6 inches high, they should be thinned out to 5 or 6 inches apart for rich soil, and more space allowed each plant in poorer soil. With good, clean, and evenly-graded seed, the sowing may be adjusted so that very little thinning is necessary, thereby saving a tedious and rather expensive operation. *The quality of the brush is affected to a very large extent by the manner in which this thinning is carried out.* If too much space is allowed, the plants grow very strong and vigorous and produce brush which is coarse and unsuitable for market. On the other hand, if crowded too much, they become very fine and weak. To obtain an even crop, it is essential to have uniform sowing and germination, and later on to thin the plants to a uniform distance.

Some growers prefer to sow the seed in "hills," 15 to 20 inches apart in the drills, leaving from three or four stalks to each. The seed should be covered from $\frac{1}{2}$ to 1 inch deep, the depth depending upon the character and condition of the soil. If it is dry, deeper covering is more necessary than would be the case if the soil were in a good moist condition.

Where labour is scarce, several sowings should be made in succession to enable the grower to deal with his crop at regular intervals, and not have the whole area mature at the same time. Rolling the land as the seed is planted ensures a quicker germination and a better stand, particularly if the soil is a little dry. When drilled, the roller at the rear of the machine is quite sufficient. Should heavy rains fall after sowing, and before the seed has germinated, a light harrow should be used as soon as the condition of the soil will admit. When 6 inches high, the crop may be harrowed to keep the soil loose and to gradually fill in the drills, and thus destroy any young weeds. Broom millet makes rather slow growth for the first couple of weeks, and the cultivator should be kept going every fortnight or three weeks to keep the surface soil loose and friable, to conserve moisture, and prevent weed growth, and in every instance after rains. For large areas, a two-horse spring tine cultivator may be used. When the crop is half grown, under favourable conditions cultivation may cease; in any case the surface roots must not be disturbed by cultivating too deeply. In moist and exposed situations the crop may be lightly hilled, as an extra support is necessary. It is during the early stages of growth that the cultivator is of greatest value, as the soil may then be loosened fairly deeply. The most critical period is when the heads are forming. If dry weather should set in then, the brush will be short and stunted. It may be necessary in some districts to sow early or late in the season so that the crop will not come into flower during such trying conditions.

Where irrigation is practised, it is essential to plant in suitably graded land and convey the water by means of open drills between the rows. After each application of water, and as soon as the nature of the soil will allow, the soil must be well cultivated to prevent caking and to conserve moisture.

Fertilisers.

Experiments with fertilisers have shown little or no increase in yield on good land, but some growers use 1 cwt. superphosphate per acre as a means of encouraging quicker growth in the young plants.

Harvesting.

While it is admitted that the best-coloured and finest-textured brush is obtained from the heads when the seed is immature, many farmers prefer to wait until the seed is quite firm. The brush has then, of course, lost its prime colour, and is a little inferior in quality; but they maintain that in normal seasons this quality sells quite as readily as the prime, and they have the seed, which, since all poultry foodstuffs are dear, is in greater demand by poultry-farmers than formerly. Besides making up for the reduced quality of the brush, the value of the seed is sometimes sufficient to cover the harvesting of the whole crop.

The actual harvesting should be carried out in warm, dry weather; otherwise the whole season's work may go for nought. "Tabling" is the first operation. Millet harvesting, owing to the plants averaging anything from 10 to 14 feet in height, would be rather a strenuous undertaking were it not for this. Hence it is that bending the plants over to bring the brush within reasonable distance of the knife is practised. The former method of bending in one or two places and bringing the brush to within a couple of feet of the ground (heads hanging downward) has been superseded by a more rapid and effective method; two rows are bent at the one time, and placed diagonally across each other, forming a latticed table about 3 feet from the ground. The work is simplified if the operator faces the direction of tabling. He is then in a position to accurately place the heads near the outside edges so that they are easily accessible for cutting.

The final operation of cutting is carried out by walking along the passages between the tables, and removing the head with about 6 inches of stalk, with a butcher's or some other suitable knife. The sheath enclosing the stem is removed at the same time. Beside hastening the process of drying, the removal of the sheath allows the reddish discoloration to dry out better, and it also deprives aphids of shelter. The heads are then placed in moderately thin layers on the "table" to dry, which usually takes from thirty-six to forty-eight hours according to the weather and the maturity of the crop. They are finally carted to the shed and placed neatly 9 to 12 inches deep (or more if advisable) on shelves. The crop is then ready for hackling.

Hackling.

The most widely-used hackler is a locally-produced hand machine with a spiked drum. With the addition of extra fly-wheels, intermediates, and other makeshifts, gas engines and horses have been used satisfactorily for the driving power—considerably reducing the cost and saving time. At least three "hands" are necessary for hackling—the feeder, an assistant who arranges the bundles and hands them to the feeder (occasionally two are thus employed), and a help, who keeps up the supply of brush, removes the cleaned brush back to the shed, and clears the seed away from beneath the hackler.

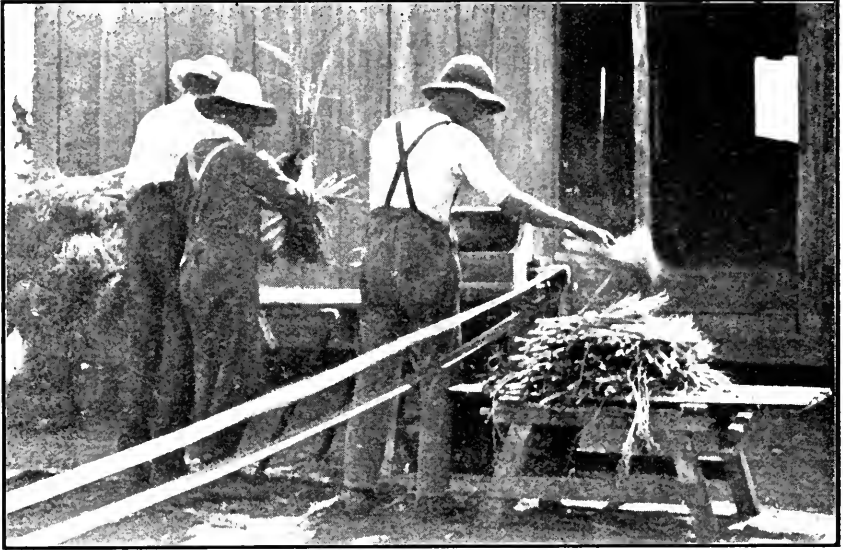


A section of a crop tabled.

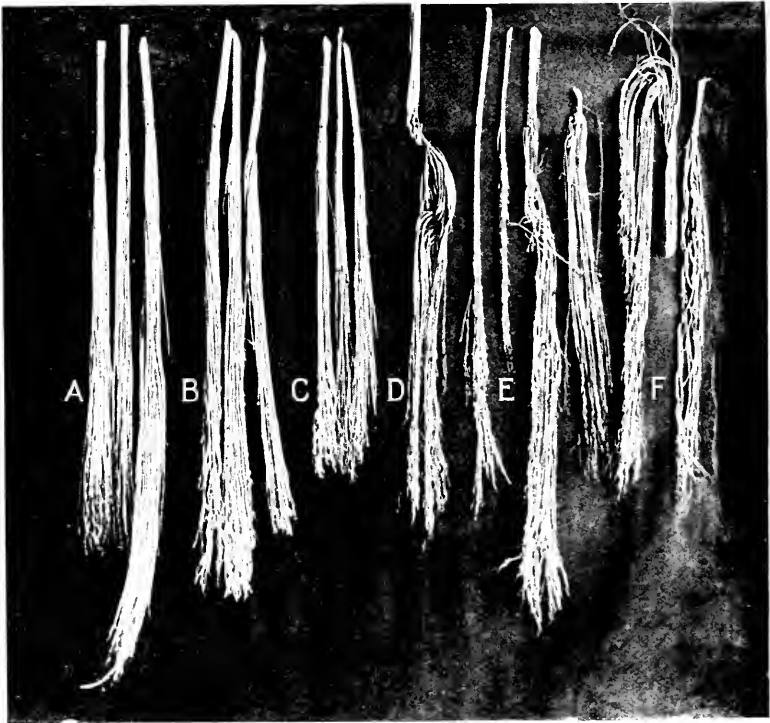
Note the difficulty that would otherwise attach to harvesting the heads of the standing crop.



Brush cut and laid all one way on tables to field cure.



A hackler driven by an oil engine.

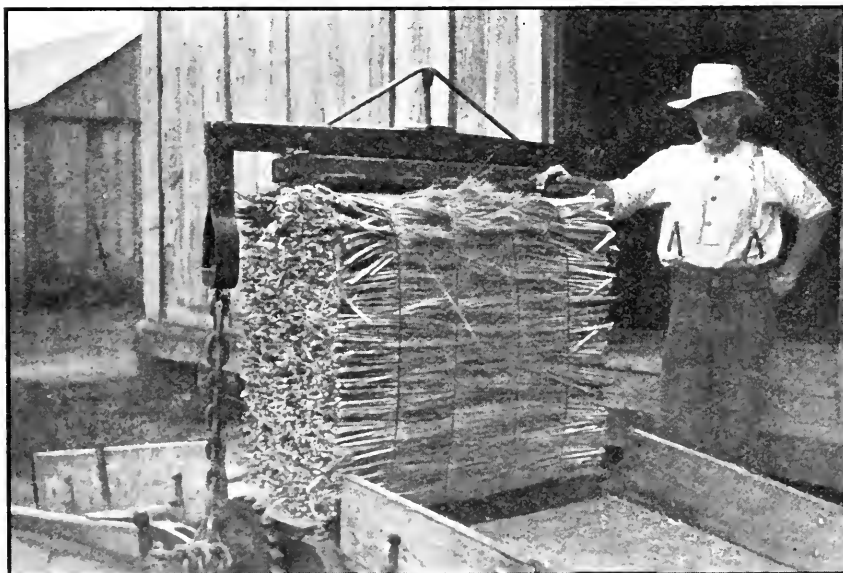


Samples of Millet Heads, from prime (A and B) to rubbish (D, E, F).

First the millet is brought from the shed and placed on the receiving table with the heads facing the assistant, the small bundles, with eight to twelve heads in each, being more easily separated from the bulk when placed in this way. As it is the seed that is to be dealt with, these parts are bunched together and the bundle placed in the feeder's left hand. Holding firmly, he places the heads on the fast revolving spiked drum and turns the bundle so as to bring all the seed in contact with the spikes, transferring it to the right hand when treated and thence to a table at the right of the machine, and receiving, as his left hand becomes free, another bunch from the assistant. The help at intervals removes the cleaned brush back to the shed and there packs it on the shelves, usually deeper than before, and with all butts level. Here it is allowed to cure until baling time. The brush is more easily handled when being removed to the press if the butts are level, and it also binds better in the bales if packed while curing.

Baling.

Very few farmers give this operation the attention it deserves. Grading is very seldom practised, most of the millet being pressed into self-working bales, composed of all grades, covers, hurl, insides, and bent and inferior heads in various proportions. Farmers contend that grading into separate bales not only necessitates extra labour and loss of time, but that the extra price received for the graded article is not sufficiently encouraging to warrant such treatment; also that the self-working bale sells readily enough.



Bale pressed, doors dropped, and bale ready to be removed.

Several types of press are brought into use. They are mostly hay presses fitted with makeshift contrivances to suit the work. The most satisfactory type is the box-press (an implement somewhat resembling a wool-press), which keeps the butts even, makes an attractive bale, and is simple to operate. A bale weighing approximately $2\frac{1}{2}$ cwt. is the usual size.

Yield.

The yield ranges from 10 to 15 cwt. of clean marketable brush, and 25 to 30 bushels of seed per acre. The price of broom millet fluctuates considerably with the season; the general average may be set down at £30. Should the prices, however, be somewhat low when harvesting takes place, the millet may be stored for any length of time without deterioration, and disposed of when higher prices are obtainable.

Second Crops.

In the warmer parts of the State, particularly the Northern Rivers, where the rainfall is good, good second crops can sometimes be obtained from a field of millet by cutting off the stalks close to the ground immediately after the first crop of brush is harvested. As the plant is still in a green sappy condition at the time the brush is harvested, the warm moist conditions favour a suckering or stooling from the old roots. Immediately the old stalks are cut and removed, the soil between the drills should be well stirred and cleaned by thorough working of the cultivator. With the early-sown crops it not infrequently happens that a second crop of brush is obtained that yields more heavily than the first or main crop. In these localities the season is sufficiently long to permit of the second growth maturing. Even if the cooler weather does not produce the finest haul, a good crop of short millet can generally be depended upon, which is just as essential as the other for broom making.

With late-sown crops a second cutting cannot be considered, and the plough should be brought into use as soon as possible after the crop is harvested.

Selection of the Seed.

Special attention must be given to the selection of the seed. That obtained in the process of stripping should not be used for sowing. The practice of using such would speedily lead to deterioration, and the production of inferior brush.

Good reliable seed can only be obtained by sowing in special areas and allowing the plants to mature their seed naturally. Individual plants may be allowed to ripen their seed in an ordinary field, but there is always a danger of them being hybridised by pollen from plants having inferior brush. In any case, seed should be obtained from those which produce the best heads, and which have not been cross-fertilised with degenerated millet, or have been grown near areas of stock-feed varieties of the sorghum family.

Of late years there has been a marked deterioration in the quality of the broom millet grown on many farms. This is accounted for by the fact that on these farms millet is planted alongside or in close proximity to areas of sorghum, such as Planter's Friend, grown for stock-feed. The varieties readily cross where they flower at the same period, and it can be easily understood how such conditions lead to rapid deterioration of broom millet. The short stunted brush, with the panicles growing out at right angles from the main thickened stem along its full length, and its general straggly appearance, are largely attributable to this practice.

By proper cultivation and selection the quality and yield of any variety may be improved. Where seed-eating birds are troublesome, it may be necessary to cover the heads with some light material, such as muslin, when the seed is



Broom Millet.

- A—Italian Hurl, showing how it is put up in bundles of uniform quality.
B—Samples of brooms made from same.
C—Samples of brooms made from New South Wales millet.

commencing to fill out. The ends must be tied loosely round the stalk so as not to interfere with the free circulation of the sap. After harvesting, the heads are thoroughly dried, threshed, cleaned, and kept in a place secure from weevils and damp.

Where the conditions for saving seed are not suitable, it is best to purchase from reliable seedsmen. There are several varieties on the market, but so far White Italian has given the best results in this State.

By-products.

The object of the grower should be to produce brush of the best quality; consequently all other uses of the plant must give way to this. In former years millet was allowed to develop a fair proportion of seed, but the diminished value of the brush was not compensated for by the value of the seed obtained. The finest green brush is usually obtained while the seed is in an immature condition, but in the production of good golden-coloured millet, a fair proportion of the grain is more or less developed. Growers who insist upon ripening their seed will secure brush of an inferior quality, which brings a low price upon the market, and if exported injures the trade.

The Seed as Stock Feed.

From time to time spasmodic attempts have been made to utilise broom millet seed as a grain food for stock, but beyond a little use being found for it on farms no serious attempt has been made to place it on the market as a feed grain until the high prices that have ruled in recent years for maize, wheat, and other grains, have drawn attention to it as a neglected asset. There is no doubt that broom millet seed has a high value, but its most serious drawback is the uncertainty of its safe storage under ordinary conditions. It does not seem as if, owing to the conditions necessary for dealing with the broom millet crop, any practical method can be evolved which will avoid a high moisture content in the seed when first stored. Some treatment must therefore be given to ensure the quick drying of the stored seed.

Where stock are kept the value of broom millet seed is, in most cases, greater on the farm where it is grown than when marketed. On account of the small size of the grain and its hardness, it is advisable to grind or crush it before feeding, except for sheep or poultry.

For farm horses, many farmers on the coast have found it an excellent substitute for maize, being nutritious and palatable when ground, but there should be no hint of damage by heating, or trouble will be experienced. With lucerne hay, which makes up for its deficiency in protein, the ground seed can also be fed to cattle.

For pigs the grain is improved by soaking—especially with skim milk, which helps to balance it as a ration, particularly for young stock.

For sheep it will not require crushing, but should be fed in a trough, as the grain is too small to be picked up effectively from the ground like maize.

For poultry it can be substituted in part for wheat or maize, and can be fed whole. This is the use it is most largely put to on the average farm where it is produced. Mr. Hadlington, Poultry Expert, suggests that a good

way to use the broom millet seed is to grind it to a meal and use up to 10 per cent. in the morning mash. Taking into consideration the factor of palatability when used in this way, it might be advisable to start with a smaller percentage at first.

Stalks and leaves.

The plant cannot be recommended as a particularly useful one for feeding purposes. While young, a certain amount of sugar exists in the sap, but this soon disappears, and by the time the brush is cut the stalks are more or less dry and pithy, and contain a large proportion of fibrous matter which is unpalatable. For this reason very little use is made of them beyond turning stock in after the harvest to feed upon the leaves. The refuse should afterwards be cut up with a heavy disc harrow, or cornstalk cutter, and ploughed under for manure.

Prospects.

As the demand for broom millet in the Sydney market is limited, it is not wise to undertake the cultivation of extensive areas, unless the product is properly prepared and suitable for export. For this purpose, prime brush only should be baled; and if the necessary details in harvesting and curing have been observed, there is no reason why millet should not be exported in a wholesale and profitable manner. On almost every farm the implements to plant and cultivate the crop are found. It will not pay any farmer to obtain the necessary apparatus to treat his brush unless he intends to grow the crop for a number of years. When prepared to do this, and he produces and sends to market millet of the best quality only, it will be found a very remunerative undertaking.

Those interested in the subject of broom-making on the farm may be referred to Miscellaneous Publication, No. 1,753, copies of which are obtainable free of charge on application to the Under-Secretary and Director, Department of Agriculture, Sydney.

SUGAR CANE.*

For profitable production, sugar cane requires a deep rich soil that is capable of supporting a heavy vegetative growth for a number of years, a warm atmosphere, and a substantial rainfall. The soil should be porous and friable without being sandy, and it should be thoroughly well drained, either by reason of a suitable subsoil or of the natural fall. The temperature should not only be mild, but there must be freedom from frost, and the rainfall should be well distributed throughout the year. The belief that sugar cane flourishes best near the sea because the saline particles conveyed by the wind are congenial to the plant may be well founded, but perhaps better reasons for the exuberant growth near the sea are the moisture that accompanies a sea breeze even in the driest weather, and the freedom from frost that the sea ensures.

* Condensed from Farmers' Bulletin, No. 139, "The Culture of Sugar Cane," by A. H. Haywood, Manager, Wollongbar Experiment Farm.

The North Coast of New South Wales affords all these conditions, frost being the chief controlling agent and responsible for much of the contraction in area that took place in years gone by. The beautiful broad sheets of water of the Clarence, Richmond and Tweed rivers, as they approach the sea, combine with their many creeks and channels to modify the temperatures and thus prevent frost, and at the same time to afford cheap freight for a bulky crop that otherwise might be costly to handle.



Sugar Cane at Chatsworth Island, Clarence River.

A heavy crop of Badila.

Costs of Clearing, Planting, and Harvesting.*

Before proceeding to deal more fully with the methods of cultivating sugar cane, it would be useful perhaps to give some idea of the cost of clearing land in those districts where new areas are being brought under the crop.

As to the tea-tree forest that stretches from Pimlico to Ballina on the Richmond, some idea is afforded by the experience at Wollongbar Experiment Farm, where partly cleared country that still carried some green timber cost £14 per acre to clear for the plough. On the heavier tea-tree timber further up the river, clearing would not be done for less than £20 per acre.

* The prices quoted were compiled in 1921, and are subject to variation.

An approximation of the initial outlay and probable return is afforded by the following figures which were made available by a farmer who had cleared and planted an area of rough virgin scrub land, where all the work had to be done by hand:—

Felling	£3 per acre.
Burning off	5 „
Holing	4 „
Plants	4 „
Planting	2 „
	£18 „

Thus, the crop planted had cost this farmer £18 per acre. Pursuing his figures, we may add the following:—

Weeding (four chippings)	£12 per acre.
Cutting (7s. 6d. per ton for 40-ton crop)	15 „
Hauling cane to punts (5s. per ton)	10 „
	£37 „

The total outlay on the crop at this stage was £55, against which must be set a return of 40 tons of cane at £2 per ton—or £80 per acre. Such a stand would, of course, be left for a ratoon crop, and the outlay, in view of the second cut, would be:—

	£ s. d.
Chipping	10 0 0
Cutting (7s. 6d. per ton for 30-ton crop)	11 5 0
Hauling cane to punt (5s. per ton)	7 10 0
	£28 15 0

The 30-ton crop at £2 per ton would leave such a grower in a good position as to his sugar cane, and a second ratoon crop would further improve matters, as the following shows:—

	£ s. d.
Chipping... ..	10 0 0
Cutting (7s. 6d. per ton for 25-ton crop)	9 7 6
Hauling cane to punt (5s. per ton)	6 5 0
	£25 12 6

With £2 per ton for 25 tons per acre, the farmer now shows a reasonable return for his outlay and labour, which we may present thus:—

<i>Dr.</i>		<i>Cr.</i>
	£ s. d.	£ s. d.
Felling timber, clearing land, and planting cane	18 0 0	First crop, 40 tons per acre at £2
Cultivating, cutting, &c., on first crop	37 0 0	80 0 0
Cultivating, cutting &c., on first ratoon crop	28 15 0	First ratoon crop, 30 tons
Cultivating, cutting, &c., on second ratoon crop	25 12 6	60 0 0
	£109 7 6	Second ratoon crop, 25 tons
		50 0 0
		£190 0 0

The above makes no charge for the interest on the capital value of the land, or for the farmer's salary as manager, though, of course it includes any labour he may have supplied himself.

THE CULTIVATION OF THE CROP.

Deep and thorough working of the soil is an essential preliminary to the planting of sugar cane. Not alone is this necessary because the plant is of deep-rooting habit, but a plant with such a strong vegetative growth and a capacity for producing in a few years two or three crops, often totalling over 100 tons, must in the very nature of things be provided with ample soil in friable, cultivated condition, in which the roots can forage for plant-food. The first ploughing should therefore be not less than 8 or 10 inches deep, and if the subsoil is stiff, subsoiling should be effected with a plough designed for the purpose, or with a plough of ordinary construction, from which the mouldboard has been removed. If the land is not too well drained, care must be taken not to bring sour soil to the surface.

This initial ploughing is best done late in the autumn or early enough in the winter to allow a fallow period of some four or five months before planting in September. The effect is twofold. It exposes the soil to atmospheric action, allowing sun, frost, and rain to ameliorate the physical condition, and affords the soil bacteria opportunity to elaborate plenty of plant-food in readiness to maintain vigorous plant life later on.

• A second ploughing in the spring is necessary further to pulverise the soil and insure a loose, friable condition, and this must be followed by work with surface-working implements that will prepare a suitable seed-bed. A third ploughing is preferred by some farmers, and no doubt is necessary in stiffer soils. The cane plant is a particularly delicate one in its early stages, and if it is to earn the maximum of profit for the farmer, it must have thoroughly favourable soil conditions. No amount of after cultivation will overcome careless preparation of the seed-bed, and when it is considered that the plant is to last for four to six years, and to carry two or three heavy crops of top-growth, it is apparent that thoroughness is quite worth while. It can be added with justice that for the most part the New South Wales grower understands and appreciates this, and lays a good foundation in this respect.

Planting the Sets.

The methods of planting the sugar cane crop necessarily differ with the conditions. A great many growers in this State prefer to plant on the square, so that intercultivation can be carried out both ways, and two conditions favour them in doing so—the nature of the soil and the varieties they grow. On the stony ridges of the Cudgen, drill-planting is the only thing to be thought of. Of varieties, one like Innes 131—erect in habit and a poor stooler—requires comparatively little room. Usually the seed is planted 18 to 24 inches apart in running drills that are 5 feet from one another.

Square planting is, however, much the better system. It affords the roots more space and permits of thorough cultivation both ways while the crop is growing, and that by medium of horse implements at a minimum of expense throughout the life of the crop. It is one of the reasons advanced by advocates of the square system that the ratoon crops are heavier by reason of the intercultivation that it makes possible.

Some variation is found, of course, in respect to the distances between the plants, from 4 feet 3 inches square to 5 feet being variously used. As before, this depends somewhat upon the soil and the variety, but 4 feet 6 inches may be accepted as a useful medium for average conditions.

It is a prime doctrine of cane-growing that you should "plant deep, but cover lightly." The apparent contradiction is explained if it is added that a furrow 8 inches deep is opened in the prepared soil, the plant or set is put at the bottom of the furrow, and 2 or 3 inches of soil drawn in, after-cultivation being allowed to fill in the furrow as the plant grows. Early in the season the covering may be on the lighter side, but at no time should it be heavier than indicated.

The opening of the furrow is generally effected with the mouldboard plough, which is used twice (once in each direction), but some farmers use a double mouldboard implement for the purpose.

The dropping of the sets is usually done by hand, farmers generally preferring that method, on the ground that they can place the sets according to their own desires, and then cover them lightly with a hoe.

Some importance is attached to the position in which the sets are placed; it would appear reasonable to expect that with one eye on each side as the set lies in the drill the germination would be quicker than where a shoot had to make its way from underneath the set to the surface, but there are many who hold it a matter of indifference, averring that the plant will come through quite as quick under the latter as the former condition.

"Get it up quick; that is the main thing," said one farmer, thus tersely expressing the general opinion that an early and vigorous start is of first importance.

Good Drainage an Essential.

Where the ground is apt to be waterlogged or flooded from time to time, some success has been obtained by throwing up ridges and planting the sets along the tops, so that the roots strike downwards to the water, and follow flood-waters down as they subside.

"Improvement will begin with the observance of two things," said the Colonial Sugar Refining Company's officers at Broadwater mill in a conversation lately. "The first is the selection of sets from disease-free canes, and the second is good drainage." These gentlemen are in constant contact with the necessity for good drainage, for on the Richmond some of the very best land is the poorest drained, and therefore lightest in yield. There are farmers with whom drainage should be the first consideration of all, but with whom it still occupies a quite indifferent place.

The Sets to Use.

The selection of the sets has a most important influence upon the plant. Vigour, stooling habit and freedom from disease, and, of course, adhesion to varietal characters, are elementary considerations; others might be mentioned, but if due regard were paid to these there is little room for doubt that sugar cane would be more attractive than it is ever likely to be under present conditions. Here again the experienced North Coast grower gaily acclaims the soundest principles and as gaily goes forward on his own happy-go-lucky lines. One-year old cane of first ratoon crop, or at the least twelve months' cane from a plant crop, is no doubt universally used, and rightly so, for there lies healthy vigour and activity. Every grower knows, too, that while the butt shoots provide hardier and stronger plants, they also make slow-growing ones, similarly every grower knows that the top shoots provide the quickest growth, but the tenderest—even the weakest plants. Thus enclosed, the grower proclaims the advisability of using only the

middle portion of the cane—but then cane is worth £2 per ton, and perhaps a bonus to boot; and what thrifty grower would think of sacrificing half a ton per acre of good cane for the doubtful advantage of a better crop two years hence? Perish the thought! Use the whole length; it makes little difference after all! And so the crop that might be better than its progenitor, and that might become the progenitor of better still, is sacrificed once more, and the grower remains in the sphere to which his methods condemn him.

If anyone considers the situation is exaggerated, let him think about it once more. Let him ask himself how much serious selection he practices in relation to freedom from disease. Obviously debilitated and diseased plants are no doubt avoided, but there is reason to fear that even this is not consistently done. What is wanted is a knowledge of the earlier indications of the presence of disease—in other words, what especially to avoid in this connection.

The soundness of this doctrine of selection for freedom from disease is dealt with later on.

The seed or "sets" vary somewhat in size, according to the ideas of the grower, but two or three eyes per plant seem to be the best. Long sets of several eyes are apt to be disturbed by cultivating implements, and this is particularly injurious to the young plant, for it is very tender in the earlier stages and intolerant of rough treatment. One farmer on the Clarence lately affirmed his belief in sets of one eye each, holding that they come up quickest, and that it takes less cane to plant a given area. A crop that he planted on these lines will be watched with interest, but on the whole a longer set seems to have the sanction of experience. Groenewege, discussing the occurrence of gumming in Java, makes the remark that "cuttings with one node only should never be used."

Damage is often done when the canes are being cut, the ends being shattered and split in such a way as to allow of the entrance of fungi when the sets are placed in the soil. In the early days of the industry this was a matter of small consequence no doubt, but land that has grown cane for many years is now well stored with fungi of various kinds that take advantage of every means of entry. Dr. Cobb found this a most important point in the cane-sick lands of Hawaii, and it may yet acquire significance here.

Change of Seed.

Change of seed seems to be desirable with sugar cane as with many other crops, and no doubt this has been one reason for the numerous varieties that have followed one another across the path of the grower. It is universally accepted that sugar cane of one variety should not be followed on the same land with another plant of the same variety, and doubtless experience points definitely that way. Let it be interpolated, however, that if any farmer imagines that change of variety complies with the principles of rotation as good husbandry, he is quite in error. The practice absolutely fails on that score, valuable as it may be for other reasons.

It is perhaps not out of place to remark here that there is no reason why every variety should "run out" in time and follow the course of those that have "run out" before it. "Run out," it is to be feared, is largely the consequence of farmers' own crude methods of selection and neglect of the sound indication of virility and freedom from disease. In other words, it is

the result of successive plantings with little regard for the characters that should be perpetuated, and for those that should be eliminated or controlled. "Run out" is not an essential of the industry, and a recognition of this might yet see some excellent old varieties that growers are inclined to bemoan coming into favour again.

Intercultivation.

The working of the land under a young cane crop is generally on the lines of flat cultivation in the earlier stages the objects being (1) to prevent the loss of moisture and (2) to control weed growth. Cane-farmers appear to be well aware of the value of a loose surface as a means of conserving soil moisture, and also to realise that the quantity of plant-food available in the soil at any one time is limited, and that if weeds are allowed to take an ample supply for themselves, then the more valuable cane plant is deprived of essentials to its development.

The harrow is usually employed while the plants are still small, successive workings filling in the plant furrow until the crop becomes too tall to be treated in this way. A Planet Jr. horse-hoe, fitted with narrow tines for scarifying purposes is used by many as the plants grow. A few farmers even open up the ground on either side of the plants when they are two or three weeks above ground, leave it so for a few hours—perhaps for a day—and then break the middles, thus throwing the soil back upon the plants. The effect is no doubt to aerate and warm up the soil while yet it is possible to get close to the plants; later on as the roots spread this would be impossible.

For later cultivating operations, the disc cultivator seems to be favoured by many farmers. It is largely used on the coast by maize-growers, having a raised frame that enables it to be used until the crop has attained a height of 3 feet 6 inches; this frame can be lowered and the discs reversed to convert the implement into a disc harrow. With this or some similar implement the rows are inter-cultivated and the drills hilled up, the work being continued as long as possible, especially in a dry season. Where square planting permits, inter cultivation is carried out first in one direction and then the other; in drill planting this is impossible and the hard condition into which the soil gets where the implements cannot reach is one of the great disadvantages of that method. Hand chipping is no doubt possible, but it is a very laborious and costly matter, and the drill-planter must satisfy himself by going as close as he can without damaging the plants. Presently the cane covers the ground completely and further cultivation is unnecessary.

Stripping and Cutting.

Trashing or stripping, which consists of the removal of the dead or dying leaves as the cane grows up, is an operation that is variously regarded. Its effect is to expose the cane to the maturing influences of light and air, and on the whole there seems to be reason to consider that the effect is to increase the sugar content. On the other hand, injudicious and careless stripping is very liable to leave wounds through which fungus diseases may obtain an entrance. Dr. Cobb made the remark that "when cane is stripped, care should be taken not to remove any of the leaves that have a living connection with the stalk, as this results in wounds that are likely to admit disease. . . . It is better to remove too little than too much!"

The operation of trashing is practised by very few on the Richmond, but on the Clarence the majority of farmers attach some importance to it. As already stated there are those who specially value it as a means of ensuring

good ripe cane for the purpose of sets, on the ground that the buds are developed by the light and air admitted, but Dr. Cobb in particular regards the natural covering as beneficial to the eyes, except when certain insects are present that shelter between the leaves and cane.

The cane crop is removed between July and December, according to whether it was planted early or late and to the conditions that have obtained during growth. Occasionally a plant crop matures with unusual rapidity, but on the whole it is the first ratoon crop that is cut earliest in the season. The experienced grower does not need to be told that the cane must be cut as close to the ground as possible; not only is the maximum weight of cane obtained in this way, but also the part of the cane in which the sugar content is greatest and to which, therefore, the greatest value attaches.

Harvesting has become a well-organised operation, upon the details of which it is unnecessary to linger.

Burning the Trash.

The first operation that follows the harvesting of the cane is the burning of the trash. The dead and dying leaves that remain on the ground after the crop is cut and removed must run into several tons per acre, and it is impossible to avoid the regret that so much vegetable matter must be destroyed. Might it not be allowed to lie on the surface until it can be ploughed under, and thus returned as humus to the soil that produced it? The idea looks attractive, but the trash harbours much in the way of fungi and insects, and the practice would almost certainly be attended by an increase in the number of enemies with which the ratoon crop would have to compete. Where a stand is being ploughed out it might be permissible to allow the trash to remain on the surface and plough it under when breaking up the cane stools: but even there the practice has the obvious objection that if the land is to be replanted at once to cane, the young plants will have plenty of enemies waiting them in the soil. If some other crop, such as maize, or a renovating crop such as cowpeas, is to occupy the ground for a year before the land is replanted to cane, no doubt the interval would be sufficient for the spores of the fungi to be starved out, and in such cases the trash might be turned under with a measure of safety, but the practice cannot otherwise be commended.

Where the crop has been cut very early in the season, and there is danger that frost may catch the tender shoots of the following ratoon crop, it is better to let the trash lie on the surface until the risk of frost is past, for the young plant is exceedingly tender, but even this must be with the reservation that any fungi present will become busy at the first improvement of the weather, so that the firestick must be put in as early as possible.

Cultivating the Ratoon Crop.

The trash being thus disposed of, the farmer must set about the cultivation of the stools in view of the ratoon crop. In the sugar-cane districts of New South Wales, farmers look to get at least two cuts of cane from a stand—one "plant" cane and one ratoon—but quite frequently the stand is good enough to yield three ratoon crops (or four cuts in all).

The first operation on behalf of the ratoon crop is a thorough deep ploughing between the drills to open up and aerate the soil, working close to the stools with some disc instrument that will act as a root-pruner. Distinct advantages lie in thoroughly opening and exposing the stools to light and

air for a short time. A good many farmers still prefer to plough on to the stools at this stage, but others among the most successful growers find that ploughing away from the plants cuts off the old roots that have fulfilled their function, and encourages the formation of a new and more vigorous root system on the sides. Thus invigorated, the stools have a firmer hold on the ground, and from the roots send up better canes than if the lower remaining nodes of the canes lately harvested are allowed to shoot again.

The methods of effecting this root-pruning vary a great deal, a few carrying it out on all four sides, others doing it on three sides out of four, and others again two out of four sides, contenting themselves by "ploughing on" on the remaining sides. The implement used is generally a mouldboard plough with disc couler attached.

Shaving the ratoon crop stubble just below the surface has a very stimulating effect on cane, but it is an operation that has so far been done by hand, and cane-growers are still awaiting the introduction of a horse power implement to perform the work economically.

It is interesting to add that farmers have observed that where tram lines have been laid for the removal of the cane, those stools that have to be trimmed hard in levelling the track are often the best in the whole crop.

Where this root pruning does not form part of the farm practice, it is usual to give a thorough working. The after cultivation in both methods is with the disc cultivators until the growth of the cane again puts an end to all such work.

Rotation.

It is convenient before turning to discuss the varieties of sugar cane grown in this State, to say a few words on a subject to which allusion has been made several times in this article, and to which we are assured farmers will be compelled as time goes on to devote more and more attention.

Rotation of crops lies at the very basis of good farming. In certain countries (chiefly countries where farming has been followed for many years) a systematic rotation is specifically prescribed in the mortgages and leases under which land is commonly held, so well do owners and tenants recognise it as an essential part of good husbandry. New land may yield profitably under one crop for a few years, but do so indefinitely it will not. Sooner or later a change becomes imperative.

Continuous cropping brings with it depletion of the vegetable matter in the soil and declining fertility, and it permits the invasion of diseases and pests that increase in the vigour of their attacks as the strength and virility of the crop declines. Postpone its effects in various ways we may attempt to do, and even with a measure of success, but deliver ourselves from this law of nature we cannot. Wheat farmers have learned it; so have maize farmers: Americans with all their resourcefulness have not been able to avoid it; the patient farmers of civilisation thousands of years old have bowed to its dictates, and the cane-growers of our northern rivers cannot claim exemption.

We have already indicated that this is a phase of things not unknown on the Clarence, Richmond and Tweed, but the theory—excellent thing that it is—has yet to be put into common practice. No doubt legumes are grown from time to time and ploughed in between two cane stands, but the complaint "that we do not get the yields we once did" has but one answer.

The cane-grower is in the fortunate position, too, that crops suitable for the purpose and capable of returning a reasonable profit without undue loss of time, offer themselves. Maize, for instance, can be sown after the stools

have been ploughed up, and harvested early enough to allow a short fallow before the next cane crop need be sown. We have indicated at an earlier stage, too, that many cane-growers have found that the land can be profitably sown with grasses and clovers, or even allowed to lapse into couch grass pasture and devoted to dairying for a few years. The effect is the renovation of the soil, and the starving out of fungi that have established themselves, and the crops of cane obtained when the land is returned to the main crop are instructive as well as profitable.

The possibilities of change of crop are thus considerable, and should be attractive.

It is opportune, however, to urge upon farmers the use of legumes more extensively. If the fertility of the soil is to be maintained under such conditions as sugar cane demands, it can only be by the growth of crops with the specific object of maintaining humus. How efficient legumes are for this purpose our growers of cane already well know. How little they make use of them we have already indicated. Yet, excellent legumes offer themselves for each of the rivers. On the Clarence and Richmond, for instance, cowpeas produce heavy crops of foliage and of seed in summer, and vetches do well in the winter. On the volcanic soils of the Tweed, Florida velvet and Lablab beans make vigorous growth in summer, and vetches have proved their ability to make good growth in the winter.

Manures and Fertilisers.

Fertilisers are not extensively used. Trials have been conducted by different farmers in their own ways, but properly arranged experiments are required before anything definite can be said. Appearances seem to indicate that provided the fertility of the land is well and properly maintained, the only utility of the fertilisers is in connection with the ratoon crop. Some farmers favour bonedust with a little blood added, others again have had fair results with a complete fertiliser, and yet others again have been well pleased with their experience of nitrate of soda. It can be said with some certainty that fertilisers are likely to be profitable when used on the green manure or rotation crops, and they should not be omitted when maize is sown.

THE QUESTION OF VARIETIES.

The importance of plant improvement, in relation to sugar cane, is so fully recognised in Louisiana—where the production of sugar is perhaps as large as anywhere in the world—that cross-breeding and improvement by selection go on as regular features year after year. Results encouraging as to both total yield and sugar-content have been obtained, and the work is now on an extensive scale. In one year, it is recorded, at least 1,805 varieties were under test—many of them being worthless, of course, but a few being promising. Cane-growers in Louisiana are much interested in the work, and already varieties have been produced that are expected to put a very different aspect on the industry there.

At the same time, there has been, and perhaps still is in Australia, a disposition to regard new varieties as so many talismans for the solution of all cane growers' troubles. The notion is obviously unsound. What is wanted is the best variety for the conditions, quite apart from whether it is new or old, and at the same time the consistent selection of seed from vigorous and disease-free plants. That there is a good deal to be known on

this subject of varieties is apparent from the statement lately made by a well-informed man that at the present time some fifty or sixty varieties are being grown on our rivers. Having regard to the fact that soil and climatic conditions under which sugar cane is grown in New South Wales might roughly be divided into say half-a-dozen groups, in respect of each of which perhaps, one or two varieties could be named as most suitable, it would appear that less than a dozen varieties would be ample for all ordinary requirements.

It is not so much new varieties that are needed as an ampler knowledge of the comparative usefulness of existing varieties, together with systematic testing of any others that seem likely to be useful here.

New Guinea No. 16.—This is the variety that is perhaps most extensively grown in New South Wales. It occupies nearly 80 per cent. of the area on the Clarence, is second in favour with growers on the Richmond, and is also sown on a fair area on the Tweed.

It is a purple cane, fairly erect, and of leafy habit, throwing a lot of flag, which tends to keep down weeds; not a high-testing cane, but a good cropper, standing dry weather well and responding at once to rain; a slow grower the first year, and therefore properly a two-year cane; "arrows" in certain years on the Tweed. In at least one case in the past season the yield was estimated at 70 tons per acre. *New Guinea No. 16* cannot be recommended for rich land on account of its rank growth and poor quality, but it is specially adapted to light and medium soils, and to land that has been under cultivation for a number of years.

Badila.—On the Clarence one-tenth of the area under cane is planted with this variety; on the Tweed it is largely grown on account of its preference for wet conditions, and on the Richmond it also has many partisans, being specially adapted for new rich land and for well cultivated land of good quality. Notwithstanding its somewhat delicate character and its liking for moisture, it crops well in a dry season, and at all times responds well to good cultivation methods. Being of a spreading and leafy habit, it is a good frost-resister. The sugar-content of the cane is high, and the yields at times as much as 40 and 50 tons per acre; during the past season at least one crop of approximately 70 tons per acre was found.

Mahona.—This variety was at one time very popular, but latterly it has been attacked by fungus pests, and the area under it is now much smaller than in years gone by. It seems particularly liable to leaf scald, a disease that has lately made its appearance on the Richmond, and that in some instances has wiped out whole crops. There are plenty of healthy crops of *Mahona* yet, however, on the Richmond, and it is quite possible to save it if good methods are adopted and if diseased crops are avoided for seeding purposes. It occupies 40 to 50 per cent. of the cane-lands on that river, being highly adapted to the heavy land between the river and the sea. Apart from its liability to disease, its greatest faults are its soft skin (which makes it liable to the attacks of rats), and a disposition for a percentage of the canes to lodge and to be snapped off when the ground is being cultivated. It is a quick grower, and most likely of all to provide a crop at one year, and it is useful as a good cow cane.

Malabar.—This is an old-time favorite that has long ago been given up on the Clarence, but that does particularly well on indifferently drained areas on the Richmond. It is a very erect, strong, grower, with a strong, broad leaf that affords plenty of protection to the cane, and it is generally so

vigorous in habit as to escape many of the troubles of other canes. At least one crop estimated to run 80 tons to the acre was last season to be seen on the Richmond. Gummy, so generally associated with want of drainage, does not seem to affect Malabar to the same extent as some other varieties, but in sugar-content it is rather weak, especially if not allowed to mature fully. Its vigorous habit makes it somewhat of a favourite on the stony lands of the Cudgen area, but growers should take care that they plant only from sound stock. Drill planting is preferable with Malabar, and sets are generally dropped 2 feet apart in the row.

Imis 131.—This variety is grown to a limited extent on the Clarence, while an occasional crop may be seen on the Richmond. It is a very erect grower and a poor stooler, and hence should be planted in drills. For sandy ground it is, perhaps, the best of all varieties at present grown in New South Wales, and it has the recommendations that it weighs well at the mill and is rich in sugar, but for the most part there are more profitable sorts.

D 1135.—At one time this variety was extensively grown, but it became susceptible to Fiji and other diseases, and only a few crops of it are now to be seen. It is fairly well suited to the poorer classes of soils, and under conditions favourable to it, matures rapidly; but where it has been growing for a number of years the introduction of one of the newer canes might be said to be imperative.

1900 Seedling.—This is a cane of high quality that yields some good crops on well-drained lands, but it is very susceptible to Fiji disease, and, consequently, the sets should be carefully selected.

No. 14.—This is still regarded by farmers as one of the best canes ever grown on the rivers, but it became badly affected with Fiji and other diseases some years ago, and has been dropped. It is only mentioned here as a variety that might be well worth attention in plant improvement work, a direction in which opportunities do present themselves to observant farmers.

Louisiana 511.—Coming first into prominence in the country of its origin in 1908, Louisiana 511 has since maintained a reputation for high sugar-content. It is tall and erect in habit, and has been observed at Coimbatore sugar-cane breeding station in India to carry an extremely short top—an indication of early maturity. It is under trial at the Department's Duck Creek farm, and has been found to produce as much as 6 feet of cutting cane. In common with one or two other varieties which have been produced in Louisiana, this cane is regarded as beginning a new era in the production of sugar. It is one of the conspicuous examples of the possibilities that systematic plant improvement offers, and is in itself an encouragement to someone to take up the matter in this country.

The Diseases of Sugar Cane.

The diseases to which sugar cane is liable in this State are not numerous, but, as has been indicated in the earlier articles, they have had a marked effect on the areas devoted to the crop and on the profits derived by the growers. As with many other classes of produce, the cane-farmer is disposed to regard somewhat lightly the appearance of disease until the effects have become manifest and serious loss has been entailed. Then there is a hurried resort to some new variety, and perhaps an injured appeal to the Department of Agriculture for assistance.

Incidental reference has already been made to the influence of clean cultivation, combined with judicious selection of the variety and the seed as means of prevention, and it can only be repeated now that these measures—

cheaper than all others are also the most effective. The grower must, however, first know how to recognise each disease and how its spread may be prevented.

The following notes on the four diseases most common in New South Wales are supplied by Mr. D. S. North, plant pathologist to the Colonial Sugar Refining Company, Limited, who has done valuable work in this sphere.

Gumming.

Gumming is most surely detected by the tiny yellow spots of gum which ooze out on to the cut ends of the canes. These spots quickly appear without treatment in severe cases, but in mild cases suspected canes freshly cut into short lengths should be enclosed in a tight can (*e.g.*, a billy-can) to sweat for two or three hours before looking for the gum spots.

At quite an early stage of gumming, peculiar narrow streaks, spotted with yellow and orange, turning into yellow streaks towards the leaf tips, appear on some of the older leaves. Special attention should be given to these leaf-streaks, because frequently they will draw attention to the presence of gumming in an otherwise healthy-looking field of cane. They may even be found before it is possible to detect any gum spots, although these can usually be obtained eventually by choosing and sweating a number of the most likely-looking stalks.

In advanced stages, numerous signs of ill health appear, including white-leaves, dead and dying canes, gum cavities in the stalks near the tops, &c., &c.

All of the present approved varieties are likely to be attacked, although they are resistant compared to some grown in the past. Malabar is the most highly resistant, and therefore the safest variety to plant on farms where the disease is present. No immune variety is known.

Leaf-scald.

Two distinct phases occur in this disease. In one phase, whole stalks, sometimes whole stools, suddenly wither and die. In the other, white or withered streaks appear in the leaves and all the buds on the stalk sprout into side-shoots; the leaves sometimes turn partly white, and show a tendency to wilt and to wither at the tips. Either one of these phases may occur without the other, or both may appear together in the same stool.

The peculiar streaks in the leaves provide the best symptom for its definite recognition. They are usually straight, narrow, even, well defined, whitish streaks, one or several in a leaf, and may either run throughout the entire length of the leaf-blade and leaf sheath, or only part of this distance. Towards the leaf-tip they sooner or later turn into a withered streak. The discovery of a streak in one single leaf is sufficient to diagnose the disease.

Where the withering phase occurs alone, sometimes no characteristic symptom indicating leaf-scald as the cause of death can be discovered. But frequently peculiar small, sickly shoots (suckers) bearing the typical leaf-streaks may be found by searching at the base of the stool.

In the other phase, the leaf-streaks may readily be found, both in the ordinary leaves of the stalk and in the leaves of the side-shoots and the small suckers.

Of present approved varieties, Mahona alone becomes badly affected: N.G. 16 may be attacked in isolated stools, as also may most other varieties, but to still smaller degree.

Fiji Disease.

Fiji disease shows itself in short, stunted growth with small, deformed, wrinkled leaves, on some of which scorched patches occur. Later, the buds on the stalks sprout and numerous small suckers spring from the ground.

Peculiar galls are found on the underneath side of the leaves, in the form of small, elongated lumps or ridges, both on the midribs and on the leaf-blades. These galls provide the best means for diagnosing the disease, especially as they may be found in its early stages while the cane appears otherwise healthy, as well as in all later stages.

Where it has gained a good hold, this disease has proved difficult to deal with, because all varieties are attacked by it. Mahona and Badila have proved to be rather more resistant than D 1135, N.G. 16, and most of the other varieties grown.

Yellow Stripe Disease.

This is also known as "Mottling" or "Mosaic" disease. It is recognisable by a peculiar mottling of the leaves, by which their green colouring is reduced to a lighter, more yellowish tint. In the more advanced stages, similar mottled markings may also be seen on the rind of the stalks.

These are the only evidences of disease to be found. Far from being destroyed, affected canes appear to the casual observer to have nothing wrong with them. Yet this disease causes severe losses of crop by reducing the vigour of growth, producing thinner, shorter stalks, fewer stalks per stool and generally a much lower weight per acre of cane. Further, its effects are cumulative, becoming more and more severe with each successive planting of diseased stock.

Many cases of the so-called deterioration or "running out" of varieties have undoubtedly been due to this disease.

All of the present approved varieties are liable to its attack. Of these N.G. 16 and Mahona appear most resistant, while Immis 131, Malabar, and 1900 Seedling are rather susceptible.

Controlling these Diseases.

As already stated, clean cultivation and the planting only of healthy cane are the methods of control that the farmer should regard as most practical and effective. These methods may be summarised thus:—

1. Selection of healthy cane for planting.
2. Eradication of disease in the young crops.
3. Dealing with badly diseased crops.
4. Avoidance of knife infection.
5. Attention to drainage.

1. *Selection of Healthy Cane for Planting.*—This is of first importance, because, in the case of these four diseases, infected cuttings—if they grow—invariably produce diseased stools.

It has been found that a portion of the cuttings may prove diseased when they are taken from the healthy-looking stools in fields where disease is present. This is especially the case with gumming, leaf-scald, and Fiji disease. When healthy canes become infected by these diseases, they undergo a prolonged period of incubation, varying from a few weeks to twelve months or more, before any decided symptoms appear.

On this account, selection of healthy plants becomes more a matter of selecting healthy fields than of excluding diseased cuttings or stools.

It has been found unsafe to take plants from fields in which even traces of either gumming or leaf-scald can be discovered. Where not objectionable for other reasons, the planting of clean plants of a resistant variety, such as Malabar, on farms where gumming occurs, or any variety other than Mahona in the case of leaf-scald, is the safest course, for this also minimises the risk of the disease spreading to the newly-planted clean field from an adjoining diseased block.

In the case of Fiji disease we have no highly resistant varieties from which much aid may be expected. But selection of the cleanest fields, followed by careful exclusion of any diseased stools in those fields, has proved adequate for its control, without a change of variety.

Yellow stripe disease, on the other hand, has a short incubation period of two to three weeks, and is infectious at certain seasons only. Healthy plants may therefore be selected from diseased fields without undue risk being incurred, and change of variety on its account is not necessary.

2. *Eradication of Disease in the Young Crops.*—It is found in practice that odd diseased cuttings sometimes creep in in spite of every care being taken in selection of plants.

As most of these usually develop definite symptoms of disease during their first three to four months growth, they can be detected and removed, and their places filled with healthy plants at little expense, provided that only a small number be present.

This method of "cleaning up," to supplement selection of plants, is especially useful with Fiji disease.

When cultivation is completed and the cane laid by, further eradication becomes laborious, and usually does not pay. If further diseased stools appear, they may be dealt with when cultivating the young ratoons after the plant crop has been cut for the mill.

3. *Dealing with Badly Diseased Crops.*—Where the proportion of disease is too high for the eradication of individual diseased stools, the whole crop should be ploughed out as soon as possible, although it usually pays to leave it until cut for the mill. Its further ratooning would usually be undesirable, even though a payable crop might be expected, because the crop would breed infection for dissemination to any healthy cane in the vicinity.

4. *Avoidance of Knife Infection.*—It has been shown by careful trial, in the case of both gumming and leaf-scald, that cuttings from healthy plants may be infected by being cut with a cane knife previously used to cut diseased cane.

The risk may readily be avoided by disinfecting the cane knives while in use, by dipping them into disinfectant solution or into boiling water, on the principle of the surgeon who sterilises his knives to prevent blood poisoning.

Disinfection of knives is of most importance when stalks are being cut into cuttings, but it should also be used whenever cutting cane which it is intended to ratoon, on farms where even traces of these diseases are present.

5. *Attention to Drainage.*—Defective drainage favours diseases generally. This is especially the case with gumming, which may spread with great rapidity and kill most of the cane on badly-drained areas, whereas it makes little or no headway where drainage is really good.

INDIAN CANE.*

As is the case with all plants of economic value, Indian cane has its limitations, and it is feared that many farmers, not thoroughly conversant with it, are attempting to grow this plant in latitudes not favourable, or in situations not conducive to the best results. It is a variety of sugar-cane (*Saccharum officinarum*), though not grown here for sugar production, and it is not, as has been erroneously supposed, one of the sorghum family.

Prior to the introduction of this variety, sugar-cane had been in cultivation for many years on certain areas adjacent to the Tweed, Richmond, and Clarence Rivers, and the value of sugar-cane as a fodder had long been known to farmers. During the cane-cutting season, which usually extends from July to December, the leafy tops that are cut off in preparing the cane for the mill form almost the sole food for the horses or bullocks that are employed in hauling the loads. They do well, stand the work as if fed on a grain ration, and finish the season in good condition and with sleek coats. On most of the cane farms, portions of standing cane are usually reserved for winter feed, and on account of the somewhat hard and woody nature of the canes, the usual practice is to chaff them prior to feeding.

With the advent of the dairy industry, and the gradual stocking up of the farms, it soon became apparent that something would have to be done to counteract the shortage caused by the failure of the *paspalum* pastures to maintain their reputation during the winter months. Sugar-cane was tried, and although it could not be stated that it improved the milk flow, it kept the animals in condition; and in dry and severe weather, that in itself was of immense value. Similarly, cane was fed to pigs with equal benefit, and gradually cane came to be planted on many farms expressly for stock.

Later, the introduction of Indian cane provided farmers with a variety more suitable for fodder purposes, and it is now highly esteemed as a valuable stand-by in times of drought. Dairymen must not grow it for the express purpose of stimulating milk production, or they will be disappointed, though used with regard to the nature and composition of stock foods generally—in other words, as part of a properly balanced ration—it has its place on the average dairy farm, and may be one means of preventing many of the losses that unforeseen circumstances or want of forethought sometimes incur.

In a memorandum, Mr. A. H. Haywood, when Manager of Grafton Experiment Farm, compared "cow cane" with Indian cane, and referred to the true utility of the latter in the following sentences:—"I obtained some cuttings of cow cane from Wollongbar Farm three years ago, and still have a small patch on the farm. I never enlarged on this, as it did not come up to its reputation, and is infinitely inferior to Indian cane. Cow cane is slow in growth, is not any easier for stock to manipulate, is more subject to frost, and does not adapt itself to different soils and climates like Indian cane.

"Indian cane is a splendid fattening food, especially when chaffed, and is very useful for feeding in conjunction with lucerne to dairy stock, dry cows, and calves. It has been subjected to a lot of abuse, because it has not been used with discretion by dairymen who expected it to stimulate milk production and were disappointed. It was never meant to be used alone for that purpose, and the dairyman should feed it in conjunction with other foods rich in protein. For maintaining condition on all classes of stock it is most valuable."

* George Marks, Manager, Grafton Experiment Farm.

The Range of Indian Cane.

Indian cane has proved itself in its adaptability to a variety of both soil and climatic conditions to be suitable for growing over a great portion of the North Coast. Excellent results have been obtained as far south as Gloucester, and in a few well-sheltered situations on the Hunter. It is a perennial plant, which is propagated by "sets" (portions of cane having several eyes or buds), and grows to a height of from 10 to 14 or 15 feet, according to situation. The stem or cane is composed of a series of joints or nodes, at each of which is a bud or eye. Under normal conditions these buds do not sprout unless the canes are broken down and come in contact with the soil, or unless the dead leaves which encase them are kept moist for an unusual length of time. As the plant grows the lower leaves die and many fall off, or, as is usually the case, they are kept supported by the mass of other leaves and numerous stalks that come from one root. The stems are usually somewhat yellowish in colour, slender, and much softer than those of the average variety grown for sugar. At the same time the outside casing is somewhat hard and woody, and this fact must be borne in mind when much of it is fed to stock. At the top of each plant are to be found several pairs of long, narrow pale green leaves.

The canes and leafy top form a valuable stock food. Unlike maize and other crops that die off upon reaching maturity, cane always remains green, so that if at any particular time of the year it is not required to be used it may be allowed to stand without danger of deterioration.

It prefers a deep, rich, well-drained soil, situated in a locality where there is abundance of heat and plenty of moisture. The steamy conditions which are so prevalent on the coast suit it admirably. At the same time it will succeed well on hill lands situated some distance from the rivers, provided it is protected from undue exposure. Though the cane is able to stand a fair amount of frost, it must be distinctly understood that it will not stand very heavy or continuous frosts. Slight frosts will probably do little more than check the growth, but heavy frosts will kill the leaf development, whilst a continuance of very heavy frosts will completely destroy the plant. Cases have occurred where cane which has been growing in exposed situations subject to severe frosts has been checked in growth and completely killed out, while in sheltered localities no harmful results were noticeable.

These facts should be borne in mind when selecting land to be planted, particularly in the southern districts. The plantings should be kept in the higher lands if possible, and special care taken to avoid depressions or hollows that are frequently met with on our alluvial farm areas. Numerous instances have come under notice where cane was completely killed in such depressions by frosts, while that adjacent to it on land only a few feet higher was scarcely affected. In hilly situations preference should be given to easterly, north-easterly, or northerly slopes, so as to obtain the maximum of heat and the necessary protection from fierce cold or dry westerly winds. Any little consideration that can be given in this direction will be amply repaid by increased returns.

Preparation of the Land.

The land should be ploughed at least 10 or 12 inches where practicable. Cane is a gross feeder, and as one planting occupies the land for a number of years, more attention should be given to this operation than for a crop that matures in a few months. Its drought-resisting qualities depend in no small measure upon the development of a deep root-system, and this

development should be encouraged in every possible manner, by having the land in good heart and properly prepared.

In timbered areas, such as are found in the soft-wood scrubs or in partially cleared areas, it is advisable, after brushing and felling the scrub, to get a clean burn, and then planting can be proceeded with, using the mattock, a specially-constructed grubbing hoe, or an old adze to make the holes to receive the sets.

On stony headlands or spurs, hand labour has also to be resorted to, and it is surprising how the cane thrives in such situations, provided, of course, that there is reasonable depth and quality of soil.

Time to Plant.

Cane can be planted at any time during the spring and summer, from, say, September till January, but it is preferable to have the planting done during the first hot month, usually October. If planted earlier, the somewhat cold nature of the soil does not admit of quick sprouting, and the spring showers favour a more rapid weed growth. It must have plenty of heat in order to promote quick growth, for during the early stages the plant is always more or less sluggish. Late plantings do not admit of the plant making enough headway before the cold wintry conditions set in, and being more tender at this stage, it is not able to withstand such adverse conditions as could be borne by an older plant.

Planting.

Cane is propagated by "sets." These are portions of the cane containing several eyes or buds. In the choice of sets, due regard should be paid to the selection of well grown stalks having large and well developed buds. There should be at least four sound buds to each "hole." The buds are arranged alternately on the nodes, and the roots of the future plant start out from all round the nodes. During growth these buds are protected by the dead leaves which may not have been removed, but it is not absolutely necessary to remove these at planting time unless it be to examine the buds. Otherwise such leaves afford protection from any injury that may occur in the ordinary handling and planting of the sets.

The sets should be planted fairly deeply, but only covered with a light layer of fine soil, so that they will get the full amount of heat to start sprouting. As the plants grow, the earth can be gradually drawn in around, and brought to the level of the surrounding soil, which will also smother any weeds at the same time. Shallow planting is not favourable to free stooling: droughty conditions affect the crop more readily, and it is more likely to break down with its own weight, or the effect of winds and storms. Hilling can be carried out to remedy some of these evils in affording the necessary support, but in naturally open or porous soils, or those situated on hillsides, this practice cannot be recommended.

The distance at which the sets are planted varies with different growers, and a good deal depends upon the situation and fertility of the soil. Close planting tends to develop longer and thinner canes than wide planting, and is of some importance when the product is not chaffed before feeding. In general practice, however, it is found that the best results are obtained by planting the sets 4 feet 6 inches or 5 feet apart each way.

On level land free of obstacles, it is advisable to plant on the square system. This is done by laying the land off in checks, 4 feet 6 inches or 5 feet apart each way, by striking out shallow drills, working up the soil at the intersection of these drills with a hoe, and planting the sets. This method enables the land to be cultivated or ploughed each way afterwards.

Regular and constant cultivation is required while the crop is young, particularly to keep down weed growth, and also to bring about those favourable soil conditions that proper and systematic cultivation ensures. After a few months' growth the leaves of the rows should overlap, the soil between is completely shaded, and the crop looks after itself.

Cutting.

With an October or November planting, the crop should be fit for feeding to stock by the following winter, when there should be no difficulty in getting from 20 to 30 tons per acre. In particularly favoured situations, as high as 40 tons may be obtained from twelve months' growth.

It is most important that the crop be properly cut. The future growth and life of the plant is influenced to a very large extent by the manner in which this work is carried out.

The canes should be cut with a sharp implement (preferably a cane knife) slightly below the surface of the soil. Breaking the canes or cutting with blunt instruments damages the base of the stalks, and the surfaces do not heal as quickly as they should, whilst in addition the bruised or split portions favour the introduction of moulds, &c., which set up decomposition.

Some people actually turn stock into cane and graze it off. This is undoubtedly done with the object of economising labour, but the practice is one that cannot be too strongly condemned, and nothing is calculated to destroy a plantation quicker than this trampling and constant nibbling. If the crop is not required for present consumption it can be allowed to stand.

A number of inquiries have been received regarding the suitability of Indian cane for converting into silage. Good silage can be made from it, either by itself or in combination with other crops, but as cane always remains green it is neither necessary nor desirable to go to this extra trouble and expense.

Later Crops.

In the ordinary course of harvesting, most of the dead leaf or "trash" will have been removed. The land should then be ploughed between the rows, or well loosened with the cultivator early in spring. As soon as the warm weather sets in the roots will stool again, young stalks starting from the buds at the base of the old canes. These will increase in number after each cutting, but will become gradually weaker. The first crop, termed "plant" cane, is usually the heaviest and best, whilst the succeeding cuts, known respectively as the "first ratoon, second ratoon," and so on, become gradually lighter until it is necessary to plough the whole area out. However, with ordinary precautions, a good crop of cane will last many years before it has to be replanted.

When the cane has been planted in recently fired scrub lands, it is advisable to fire the refuse or trash. This will enable a large quantity of dead timber and stumps to be got rid of, and also destroy many forms of borers and other insects that are harmful to cane. Where vermin such as hares, rabbits, paddymelons, &c., are plentiful, it may become necessary to enclose the plantation with wire-netting.

The Limitations of Indian Cane.

As stated previously, Indian cane is being grown extensively throughout the North Coast, and quite a number of dairymen, whose spirits were buoyed up on the reputation of this plant, have been disappointed, and in a few instances have condemned it, but only because the crop was not understood. Cane contains a large amount of saccharine matter, which tends to fatten rather than to stimulate milk production. For the milking herd it is essential that foods rich in protein, such as lucerne, clovers, vetches, peas, &c., should be given.

At the same time, if other fodder is not available cane is far better than nothing, and if it does nothing else than pull animals through a somewhat severe winter in good condition its value should not be overlooked. In any case, young or dry stock can be fed on this fodder, while any milk-producing foods that may be grown can be reserved solely for the milking herd.

Feeding to Stock.

Indian cane is specially suitable for working bullocks. In the timber districts the country is not usually of the best for grazing purposes, and it not unfrequently happens that through a scarcity of ordinary or even rough herbage many teamsters are compelled to turn their teams out for a rest during winter months. At such periods the weather conditions generally favour good roads, so that the teamsters are compelled to lose valuable time. The cultivation of cane in favoured situations in many of these localities enables the animals to be fed, and with the wonderful powers of endurance thus obtained constant and profitable work may be engaged in. In a similar manner horses will also work well, but, of course, it is preferable, if very heavy work is being performed, to include a little grain.

In the feeding of this fodder to stock, however, there are certain dangers which must be guarded against. All well matured cane ought to be chaffed. Though much softer than many varieties of sugar-cane, there is a fair amount of hard or woody fibre, which has a very bad effect upon the teeth of stock. Chaffing minimises this danger to a very large extent. Probably no deleterious results would be noticed in feeding small quantities over two or three years, but, on the other hand, liberal feeding of unchaffed cane over lengthened periods does injure the teeth and otherwise impair the health and comfort of animals.

Instances have been recorded where stock have been killed through eating cane. *Post mortem* examinations have revealed the presence of large accumulations of undigested fibre. Similar troubles occur in drought times in other districts where animals are forced to subsist on nothing but dry foods. This raises another point of considerable importance regarding the feeding of stock, and that is, that endeavours should be made when feeding large quantities of dry foods, or fodder containing much dry matter, to have also a liberal supply of succulent material, such as green crops or silage. A mixed diet is always preferable to a single food.

There is another danger associated with cane. There is always a risk of fire from the presence of so much dead leaves or trash. For that reason care should be exercised in the selection of sites, so that they are not situated too close to scrub or other material that may be burnt, or to forest areas that are periodically raided by bush-fires. In harvesting the cane also, lighted pipes should be prohibited.

SUDAN GRASS.*

Sudan grass is a member of the sorghum family, of which the two most important economic species are Johnson grass (*Andropogon halimifolius*) and the ordinary sorghums, including Sudan grass (*Andropogon sorghum*). As is well known, Johnson grass is a perennial possessing rootstocks; Sudan, on the other hand, is an annual (rarely perennial), and has no rootstocks. Owing to the fact also that Sudan grass has a much finer leaf and stem than the cultivated sorghums, and because of its well-marked stooling characteristics, it has been classified as a variety of *Andropogon sorghum*, and is botanically called *Andropogon sorghum sudanicus*.

Sudan grass is a native of Anglo-Egyptian Sudan, North Africa, where it is cultivated under the name "garawi." It was first introduced into the United States in 1909 and tried under cultivation, when its success was so pronounced that the demand for seed soon far exceeded the supply. One big seed firm in 1912 catalogued the price of the seed at 8s. per lb., while Sydney seedsmen recently quoted it at 9d., a fairly conclusive indication of the extent to which the cultivation of this grass has been extended. It was first tried in New South Wales in 1913 at Yanco Experiment Farm, when the first supply of acclimatised seed was obtained, and cultivation has since extended throughout the length and breadth of the State. The Department has always used its own supply of seed, so that any seed issued or sold to farmers bears the hall-mark of acclimatisation since the year 1913.

Characteristics and Possibilities.

Sudan grass is adapted to any part of New South Wales except localities with an elevation of over 2,500 feet; while it thrives best under irrigation and on the coast, high yields having been obtained from it as far west as Nyngan. Being very sensitive to frosts, no growth at all is made in the winter; but the manner in which it will thrive on a small rainfall and "hold on" over dry periods is one of its most prominent characteristics. During the phenomenal drought of 1918-19, reports were received from all over the State testifying to its remarkable drought-resisting qualities. At Bathurst Experiment Farm it was fed off right down to the ground, and yet produced a crop of 400 lb of seed to the acre on a rainfall, extending over a period of six months, of only 6 inches; while at Nyngan Experiment Farm it grew 5 feet high and matured seed on 387 points of rain. No native grass at the experiment farms has succeeded in growing and retaining its succulence under dry conditions in the same degree as Sudan grass. It is very rapid growing, maturing ten to twelve weeks after sowing; cuts are obtainable from it at intervals of eight to ten weeks in an ordinary season.

Sudan grass may be grown for pasture, hay or ensilage. As a pasture grass, it is characterised by palatability and nutritive quality of a high order, while its stooling qualities are considerably improved by grazing. Both sheep and dairy cattle are extremely fond of it. It will carry a cow to the acre for at least five months of the year on the coast and under irrigation, and at least a sheep to the acre on the slopes and tablelands, so that the laying down of a paddock of it for pasture each summer undoubtedly pays. At the present time farmers in wheat-growing districts depend, during the summer and autumn months mostly on stubble, native pastures, and herbage on

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fallowed land for their sheep, but judging by the experience of the manager of Bathurst Experiment Farm during the drought of 1918-19 the Sudan grass pasture during the summer months was a most valuable asset, and paid handsomely.

The utility of Sudan grass as a rotation crop in wheat-growing centres is another of its possibilities. A rotation trial consisting of—1st year, wheat; 2nd year, fallow and Sudan grass in spring and summer; and 3rd year, Sudan grass in autumn and then fallow, to be again followed by wheat in the fourth year is being carried out at Nyngan Experiment Farm.



Sudan Grass, Hawkesbury Agricultural College.

The mixed farmer who has an objection to the laying down of Sudan grass as an annual pasture has the alternative of using it as a cover crop in a permanent pasture. In a mixture such as Rhodes grass, lucerne, and Sudan grass, the last checks weed-growth, shelters the young plants of Rhodes grass and lucerne from the hot summer winds, and provides a large amount of pasture during a critical time of the year. Such a mixture has been very successful at Wagga Experiment Farm.

Horses are particularly fond of Sudan grass as a pasture, and according to Mr. C. Oliver, of Coonamble, who is well informed on the subject of stud horses, they prefer it to any other.

Up to the present time Sudan grass has been grown mostly for hay. In this respect it has completely outclassed millets throughout the State, with the exception of one or two isolated localities on the South Coast. Under

dry conditions it has given nearly double the yield of Japanese millet at Hawkesbury Agricultural College, while under ordinary conditions it has given much heavier yields than Manchurian or Hungarian, both at Grafton and at the College. Very frequently millets will outyield Sudan grass in the first cut, but millets will usually only produce one cut, whereas four cuts have been obtained from Sudan grass during a season. Yields of 7 tons of green fodder and 2 tons of hay per acre from the grass are common on the coast, while yields of 1 ton of hay per acre have been obtained from it as far west as Nyngan. Under irrigation, the yields are, of course, much higher. The palatability of the hay and of the chaff made from the hay have been favourably reported on from all quarters, working horses being particularly fond of it and doing well on it.

Sudan grass should make good ensilage. Reports from the United States of trials with ensilage-making have been summed up as follows:—"The principal difference between maize and Sudan grass silage is in the quantity of fibre. The Sudan silage was somewhat bulkier than maize silage, was a light-brown colour and had a faint acid odour. The silage was fed to sheep and, while providing a good feed, did not appear to be relished by the animals as well as maize silage. It appears to be quite as palatable, however, as silage from grain sorghums, and was relished much more in this form than as cured hay."

Cultural Methods.

Sudan grass seed should be sown fairly early in the spring, as the seed germinates in much colder soils than in the case of sorghums or *paspalum*: by sowing early, the grass is well established by midsummer and better able to stand adverse conditions in January and February. By sowing late, say, in December, the grass has a severe struggle to establish itself, and is likely to prove a failure. In the north-west, west, and North Coast, sowing in September is recommended; elsewhere October is the best month.

The grass may be sown broadcast or in drills, but the latter method is much to be preferred, as it enables cultivation to be carried out in the early stages, thus suppressing weed-growth, conserving moisture and encouraging the stooking properties of the plant. The land should be prepared as in the cultivation of sorghum or wheat. In sowing broadcast, 12 to 16 lb. of seed per acre has been found to be a satisfactory seeding. In sowing in drills—the easier and preferable way in districts of the interior—the seed should be put in every third drill, which makes the rows about 1 foot 9 inches apart—a sufficient interval to allow for cultivation. For drill sowing 8 lb. of seed per acre is sufficient for the drier localities of the western plains, and a little more should be used under irrigation or on the coast. The drier the district the lighter should be the seeding, and the more vigorous the inter-row cultivation for conservation of the necessary moisture. The grass can easily be cut for hay with the ordinary reaper and binder.

The best stage at which to cut is when the flowers are well showing and before the seed is formed. Owing to the succulence of the plants, practically as much time is required for stooking and drying as for ordinary wheat, and a week is not too long for the grass to remain out in the field.

For seed-production, American authorities recommend the first cut, but in this State the best results have been obtained from the last, which should be regulated so as to allow the seed to mature before the cold weather sets

in. If the final cut for hay is made about the middle of March in districts on the tablelands and slopes, the seed should mature in May. On the coast, the cut could be left until April.

The seed can be stripped from the standing crop by an ordinary wheat harvester, but owing to the irregular manner in which the seed ripens and to the manner in which it clings to the plants, a great deal of choking and waste is occasioned by this method. A simpler and more effectual one is to cut the grass with the reaper and binder, and after it has been thoroughly dried in the stack to thresh it with the ordinary wheat header. Yields of 400 lb. of seed per acre are common in the interior of the State. The seed weighs about 32 lb. per bushel.

Fertilisers and Soil.

Sudan grass responds very readily to fertilisers. At Tallawang (Mudgee) with an application of 1 cwt. of superphosphate per acre, the yield from the first cut was 1 ton 18 cwt., as against 1 ton 2 cwt. on the unmanured plot. The addition of potash further increased the yield. The results from the addition of fertiliser are just as marked on irrigable land. An application of 1 to 2 cwt. of superphosphate per acre is therefore recommended in sowing Sudan grass.



Cows depastured on Sudan Grass and Japanese Millet, Yanco Experiment Farm.

Sudan grass will grow on practically all classes of soil. Even on the poor sandy soils of the coast, by the application of fertiliser, good results have been obtained. The best yields so far appear to have been obtained from the granite soils of the wheat-growing districts and elsewhere on the black soils (alluvial or basaltic).

Natural Crossing and Variation.

Sudan grass crosses very readily with the sweet sorghums, and for this reason should not be grown near a sorghum paddock. Although good results (particularly an increase in vigour) may be obtainable as the result of such a cross, a patchy crop is sure to follow when the resulting seed is

subsequently sown. Special care should also be exercised that Johnson grass is not in the vicinity where the Sudan grass is grown, as on the northern rivers. On close examination, the seeds of the two grasses are fairly distinguishable, the seed of the Johnson grass being much redder in colour and much smaller than that of Sudan grass, but an ordinary grower can readily be deceived. To introduce such a pest as Johnson grass further into our coastal paddocks would be a calamity for which the beneficial results obtained from Sudan grass would hardly be sufficient compensation.

A great deal of variation is noticeable in a field of Sudan grass among the individual plants, some tending to have wide leaves and big stems, while others are of a finer habit, containing sometimes over 100 stems to a plant. These variations are very important from a selection point of view, and it has already been proved that a considerable increase in yield can be obtained by selecting and isolating from a superior type of plant.



Sudan Grass at Yanco.

Feeding Value.

The feeding value of Sudan grass is extremely good. In determining a well-balanced ration, the albuminoid ratio—that is, the proportion of protein or albuminoids to carbohydrates and fats (ether extract) is of vital importance. In this connection Sudan grass compares favourably with Hungarian or Japanese millet, and is superior to most of the grasses, including *Paspalum dilatatum* and Rhodes, green maize or sorghum.

The palatability of this grass cannot be questioned: all classes of stock eat it greedily. It was noticed at one centre that cattle preferred it to lucerne, for, on being placed in a paddock containing both crops, the animals

remained on the Sudan grass for three days, eating it closely to the ground before touching the lucerne, and returning to it periodically, keeping it closely grazed and refusing isolated lucerne plants growing amongst it. Horses are known to prefer Sudan grass chaff and hay to either the best oaten and wheaten. Digestibility—one of a feed's paramount necessities—is not lacking in Sudan. Not only do cattle fed on it milk exceedingly well, but horses work well and sheep fatten.

Sudan Grass Poisoning.

Owing to the close relationship of Sudan grass to the sorghums, the question of prussic acid poisoning naturally crops up. Investigations by the departmental Chemist, confirms American reports, that prussic acid poisoning by Sudan grass is a possibility. This fact, however, should no more prevent farmers growing Sudan grass than it prevents them growing sorghum, as a few simple precautions will safeguard them from loss. Farmers should remember:—

- (a) Sudan grass is most likely to be harmful to cattle when immature or stunted through drought.
- (b) If cattle are put on to Sudan grass, care should be taken that at first they are only put on to it for a short time.
- (c) When cut and dried it is very unlikely to be harmful.
- (d) So far as prussic acid is concerned, Sudan may safely be grazed by horses or pigs, and is unlikely to be as dangerous to sheep as to cattle. It is only on isolated occasions that sufficient prussic acid will be present to make the grass harmful.

Sudan Grass under Irrigation.

Sudan grass is undoubtedly an excellent summer fodder when grown under irrigation conditions. Its ability to produce a maximum yield in the minimum of time on various classes of soil, together with its high feeding value, palatability and succulence, marks it as an ideal fodder for farmers engaged in dairying or sheep-raising on the irrigation areas. Further, when cured it makes a hay relished by all classes of stock, especially horses, which are known to work well and retain condition throughout the trying summer months when fed on it alone.

The grass is essentially a warm-climate plant, producing maximum growth in a long season, and continuing to grow until the advent of frosts. Being such a rapid maturer, it is available at a period when natural pastures are scarce, and before the millets, maize and sorghums are fit to cut. In comparison with the millets it is far superior, and will, no doubt, replace them to a large extent. Data is not yet available as to the perennial nature of Sudan grass under irrigation.

Cultural Operations—The initial preparation of the soil requires to be thorough, and the best results will follow when the land is ploughed during the winter, allowed to lie in the rough till the spring, and then worked down to obtain a friable seed-bed.

Owing to the fact that hot winds prevail during the sowing season (October to January), it is a wise policy to irrigate and cultivate prior to this. No reliance can be placed on the natural precipitation to promote

a satisfactory germination, and the practice of flood irrigating is strongly discountenanced owing to the soil setting hard. If a patchy germination follows planting, and irrigation by flooding is found necessary, harrowing to break the crust formation is essential in order to allow the seedlings to push through. These are important points to consider, and must receive special attention. The rate of seeding is governed largely by the width of rows employed, and the proportions set out in the following table are recommended :—

Width between Rows.	Seed per Acre.
36 inches	4.5 lb.
30 "	6.8 "
21 "	10 "
14 "	12-15 "

Both the wheat drill and the maize dropper may be employed for sowing. The former should be set to sow the lowest quantity of dry wheat, blocking up the hoppers not required. With the maize dropper a sorghum plate should be used. When broadcasted, 12 to 15 lb. per acre is sufficient, and this quantity can be controlled by sowing with some fertiliser through the manure box of a wheat drill. A rotation of sowings in small areas up to 3 acres is advocated, this resulting in the complete control of the soil moisture, and the ensuring of a good germination and subsequent growth. If larger areas are planted at one period, difficulty will be experienced in retaining sufficient moisture to germinate the seed. Concerning planting depth, on no account should the seed be set deeper than 2 to 3 inches. The moisture content of the soil controls this factor to a large extent, but germination is considerably retarded if planting is carried out at too great a depth. The aim should be a depth of from 1 to 2 inches.

Irrigation Practice.—When once established, Sudan grass will thrive well with abundance of moisture, but care must be exercised with irrigation during the early stages of growth. This is most necessary when flood irrigation is practised, as the young plants are susceptible to scalding.

When it is intended to irrigate by flooding, the erection of check banks $\frac{1}{2}$ to 1 chain apart is recommended. These banks are easily constructed with a plough, but the furrows on either side should be filled in, otherwise the water will be directed to these channels and ineffective irrigation will follow.

Maximum yields are obtained from furrow irrigation, with rows 3 feet apart and cultivation after each irrigation, but where it is intended to use the grass for grazing purposes, flooding is generally advised.

Fortnightly irrigations are essential during the summer months to produce maximum growth, and the grower should, if possible, apply water prior to cutting, as it encourages an early start in the succeeding growth, and thus obtains the highest possible yield for the season. On no account, it is important to remember, should stock be allowed to graze until the land is sufficiently dry to carry them.

Fertilisers.—Increased yields are obtained from the application of chemical fertilisers, and experiments have shown that 1 to 2 cwt. of superphosphate per acre or a mixture containing equal parts of superphosphate and bonedust can be used with profit. The effect of manure is most apparent in the first growth, as a rule, increasing the percentage of flag, succulence, stooling propensities, and height of stalk.

Harvesting Stage.—Experience has shown that the maximum yields are obtained when Sudan grass is cut in the flowering stages; its succulence is then much more pronounced and its feeding value higher. If allowed to remain any longer, much energy is spent in the production of seed, young growth commencing from the stools is cut back, and the following growth is considerably retarded and yields lowered. For grazing purposes, the grass may be fed off when 2 feet high, allowing close grazing seven to eight times during the growing period. In the warm months it can be grazed every two to three weeks, its growth being at the rate of approximately a foot per week, providing the necessary attention is given.

Cultivation.—Heavy soils have a strong tendency to set hard after irrigation, and unless due attention is paid to cultivation during growth, evaporation is accelerated and yields are considerably reduced. The practice of harrowing or cultivating with the rigid tine or spring-tooth cultivator has everything to commend it, not only when provision is made for inter-row cultivation, but also across a broadcasted crop.

ELEPHANT GRASS, OR NAPIER'S FODDER.*

Elephant grass is a native of tropical Africa, being confined to the area between 10 deg. north latitude and 20 deg. south latitude. Within this immense area it occurs mainly along watercourse and in marshy depressions, but also enters the bush and forests where open spaces afford sufficient light. Under favourable conditions it forms extensive reed jungles, as for instance in the delta of the Zambesi. In the interior of Sierra Leone, it ascends nearly to 2,700 feet, and near its southern limit, in Rhodesia, to 5,500 feet. In rich marsh land it attains a height of 21 feet or more, while on drier soils, as in the savannas of East Africa, its stalks are hardly more than 6 feet high. In Togoland it has been called Elephant grass by the colonists, while in Rhodesia it is termed Napier's fodder, after Colonel Napier. The first mention of the grass was made in 1905, when it was stated to be a good fodder for cattle. Pigler in 1908 described it as one of the best fodder grasses. (Kew Bulletin, 1912)

The Rhodesian Agricultural Department commenced to take up its cultivation in 1910, Colonel Napier co-operating. The latter tested it under severe conditions, and became fully convinced of its economic value.

A parcel of seed was obtained by the Agricultural Department in this State in 1914, and only one seed grew. The resulting single plant became the origin of all the areas now established at the experiment farms, in addition to the thousands of roots that have been distributed to farmers.

Description.—Elephant grass (*Pennisetum purpureum*) belongs to the *Pennisetum* family, and is a near relative of Pearl millet (*Pennisetum typhoides*). It is a coarse grass, and characterised by extremely rapid growth. Under warm conditions it will attain a height of 20 feet in a few months. It grows in tussocks, and stools considerably. The leaves are 2 feet or more long when fully grown and somewhat coarse, being similar to those of maize. In young plants, however, and in the growths that follow grazing, the leaves are soft and succulent. There is a fair amount of variation in the hairiness of the plant, in some cases the stalks and leaf sheaths being

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practically glabrous, while in other, both are extremely hairy. This variation has also been noticed in Africa in the natural habitat of the grass. The stems, after reaching a height of over 6 or 7 feet, become hard and woody. It has been found by analysis, however, that the feeding value of the mature stalks is comparable to that of maize stalk roughage. In most localities the grass flowers on maturity, but seldom sets ripe seed. On the northern rivers and in Queensland ripe seed is formed to a small extent. The flower heads have the characteristic bristles of *Pennisetum*, and are 4 or 5 inches long.

Adaptability to Soil and Climate.

To date Elephant grass has shown itself adapted to the coast, tablelands, and the slopes, and in the far west it does well under irrigation. It will grow on all classes of soils, but gives the best results on alluvial, volcanic, or good sandy loams. As a proof of its wonderful aptitude for growing on poor country it may be mentioned that some coastal land just south of Newcastle, previously devoted to burrawang and useless scrub, has now Elephant grass growing there in abundance, providing a considerable amount of good feed.



Elephant Grass at Hawkesbury Agricultural College—before being eaten off.

Good results have also been obtained on barren soils at the mouth of the Manning River, and it should prove useful in bracken or useless scrub country.

Everyone who has grown Elephant grass has been impressed with the remarkable rapidity with which it develops. In the warm months of the year, if provided with plenty of moisture, it grows over 2 feet a week. Light frosts do not severely affect it, but continuous heavy frosts will kill the flag entirely, though without injuriously affecting the roots, for records from very cold localities show that it readily comes away again in the spring. In western districts it seldom reaches a height of over 6 feet, but stools

considerably, a single cutting producing forty or fifty stalks in a single season. As a consequence, it has produced at Cowra Experiment Farm a greater yield for the season than any other grass tried.

That this grass will stand a considerable amount of drought has been proved beyond all doubt at Hawkesbury Agricultural College, Cowra Experiment Farm, and in other localities. Hardly a plant was lost at the College



The same plot as that shown on page 631—after being eaten off.

during the great drought, and comparatively few were lost at Cowra during the same period. What Elephant grass will not endure are the hot winds and the extremely hot surface of the red soil plains in the summer months, and it is hardly worth growing west of Narromine.

Elephant grass responds to a good rainfall, the conditions most favourable to it being those of the northern rivers, but it does not like cold swampy subsoils.

Palatability and Feeding Value.

The appearance of Elephant grass is extremely deceptive. At first sight it looks unpalatable, but that it is not so is proved by official investigations under various conditions, and also by the numerous reports submitted by farmers. Elephant grass is not as palatable as many other well-known grasses, but that cattle will eat it and do well on it is beyond question. Its palatability appears to be greatest in its young, more succulent stages. When it reaches a height of 7 feet or over its woodiness is against it, though even under these conditions the softer ends of the stalks and leaves are readily eaten. Sheep appear to like the grass least of all when other grasses are about, but they will eat it and thrive on it when other feed is not abundant. This has been the experience at Cowra Experiment Farm. The illustrations showing the grass at Hawkesbury Agricultural College before stocking and after stocking speak for themselves.

How to Plant Elephant Grass.

Elephant grass can be raised from seed, but such seed should be sown in a nursery bed; and the young plants transplanted to the permanent paddock. Early summer is the best time for sowing.

The best method of propagation, however, is by planting rooted slips or cuttings. The former can be planted in spring or autumn and the latter in spring only. The slips and cuttings have wonderful vitality, and a case is on record where certain cuttings, having been kept for over a month, were soaked in water before being planted, and a 60 per cent. strike resulted.

Cuttings should be obtained from the fairly-hard portions, and should have three nodes. They should be planted in cultivated ground, a distance of 3 feet apart. The slips can either be inserted in the soil with two nodes in the ground and one out, or shallow furrows can be ploughed 3 feet apart, and the slips or cuttings dropped horizontally in the furrows, and the ridged soil turned back upon the cuttings by reversing the direction of the plough.



Elephant Grass showing a month's growth after being pastured close to the ground.

Carrying Capacity.

A fodder that will produce 70 to 80 tons of green feed per acre in a season must necessarily have a good carrying capacity. It is very difficult to obtain the actual carrying capacity of the grass, owing to it having to be fed off at intermittent periods. It may be said that when 6 feet high it requires to be very heavily stocked to ensure it being eaten down. The cows should then be removed until the grass has made new growth. In the winter months no growth is made, but during the summer Elephant grass will maintain ten to twelve cows per acre at periodical intervals.

Behaviour under Stocking.

As a rule stock eat the top leaves and stalks of Elephant grass, and from the joints below several tender shoots spring out, and these are always appreciated.

Owing to its rapid growth in midsummer Elephant grass often grows quicker than the stock can eat it, and when over 6 and 7 feet high it develops woodiness. Under these conditions a succulent growth can be induced by cutting the grass, not near the base, but a couple of feet above the surface of the ground.

The plants stool considerably, and in the second year it will probably be found that all available room is taken up. Experiments are now being conducted to determine the advantage, if any, of planting the roots at a greater distance apart, and filling up the spaces between with a vigorous creeping grass like Kikuyu grass.



Elephant Grass at Wollongbar Experiment Farm

Summary.

1. Elephant grass can be treated either as a fodder or as a pasture grass. As a fodder it is not recommended for situations where maize or other summer crops will grow, but it will produce most satisfactory results on poor soils.
2. Elephant grass should be cut or pastured before reaching a height of 6 or 7 feet: the succulence of the plant improves considerably under grazing.
3. Elephant grass produces greater fodder yields in our coastal districts than any other plant known.
4. It is an excellent grass to grow in our wheat-growing districts for summer feed.
5. Records from Hawkesbury Agricultural College, and also from the United States, show that cows maintain their milk yield when pastured on Elephant grass.

RAPE.

Rape (*Brassica napus*) is a cruciferous plant with small yellow flowers, belonging to the same natural order as the cabbage and turnip. In the early stages of growth it closely resembles the Swede turnip, but usually attains a greater height than the turnip, and the root is not bulbous.

It is best adapted to temperate climatic conditions. In the New England and other cool districts it will grow best during the summer months; but in the coastal districts, and in many of the wheat districts on the Western Slopes, it does better as an autumn-sown crop. It is very rapid in its growth, and in favourable seasons is ready for feeding in from twelve to fifteen weeks. The growth by May is very luxuriant and fleshy, and may be eaten down by sheep or pigs when it reaches 6 inches in height. The advantage of feeding the rape crop down this month (May) is that a vigorous second crop follows. This naturally depends to some extent on the class of soil and the abundance of moisture, and in the autumn we usually have favourable conditions. Sheep, when eating the first crop, are liable to eat it off too close. This can be avoided by turning them off when they remove the first lot of leaves. They generally eat those first, and return to more closely remove the lower tendrils, leaves, and stems. Horses and cattle will eat rape, but in doing so they injure the plant and retard the second growth. In every case very hungry animals, especially cattle and sheep, eat it greedily, and are liable to sudden attacks of hoven or bloating. It is advisable to break them into feeding it gradually, and after a week's attention allow them free use of the paddock. It is a good practice to feed all animals half on grass and the balance on rape. Hoven is more prevalent during wet weather or when heavy dews fall. Whilst on rape, cattle and sheep do best when given free access to rock salt. An average crop should feed ten to fifteen sheep to the acre, and fatten them for market in sixty days. The pigs proved to be more thrifty and in healthier condition when fed with rape than when fed with grain alone. Considerable saving in labour is effected in grazing pigs on rape. Moreover, the ground is enriched from the excreta of both sheep and pigs. Experience has shown poultry-farmers the need for a green feed of a heterogeneous character as a substitute for more expensive nitrogenous foods, such as bran and pollard, and rape is most valuable for the purpose, as repeated trials have fully demonstrated. Milking cattle should not be grazed on rape.

As a change crop in the wheat belt, and as an adjunct to fattening sheep in conjunction with wheat-growing, practical experience at Bathurst Experiment Farm has proved it to be a nutritious fodder for sheep. In moist seasons it may err in being over-succulent and thus induce scouring. Trouble in that direction may be minimised by feeding dry grass, chaff, &c., in conjunction with it. In the laboratory, analyses have shown that rape contains a fairly large proportion of nitrogenous substances.

As a sheep food it is extremely valuable, especially for ewes suckling lambs and for the topping up of broken-mouthed sheep. When the ordinary pastures are dry, the corrective effect of the rape is exceptionally desirable. In districts with temperate winters, ten to twelve sheep may be depastured per acre throughout the winter.

It also is a good cattle food, excepting for its liability to cause bloat and to taint the milk of dairy cows.

For pigs it is very desirable, as they are not liable to hoven. When fed in conjunction with grain for topping off, excellent results are obtained.

In all classes of poultry-farming it is valuable, and a run upon rape is very beneficial.

Value as a Soil Renovator.

Besides its value as a fodder, rape is extremely valuable as a soil renovator, and it may be ranked next to vetches as a green manure crop in orchards. Its vigorous root system penetrates the subsoil for several feet, and comparatively large air-channels are formed upon the decay of the tap-roots, which assist materially in the amelioration of the soil.

Rape, in common with other plants having broad leaves, obtains comparatively large quantities of carbon from the atmosphere which, when ploughed under, increase the humus of the soil, so essential to the beneficial micro-organisms of the soil that are indispensable to fertility. It also ensures the physical condition necessary to circulation of air. Soils deficient in humus readily get out of condition with heavy rains, and fail to exhibit that liveness which farmers like to see.

On account of the vigorous growth allowing numbers of stock to be carried for several months of the year, large quantities of readily soluble plant-food are returned to the soil in the forms of liquid and solid excreta.

After the crop has been grazed off, the land should be ploughed and the residues turned in. Humus is thus added to the soil, and this, together with the improved physical conditions, allows the soil bacteria free scope for the discharge of their functions. Plant food is thus rendered available to give the following wheat or other crop the fillip in the early stages that is so necessary to vigorous development.

Some indication of the quantity of feed that rape will supply is afforded by an experiment conducted at Hawkesbury Agricultural College. Five different plots were planted on the 30th March, and on 15th May, less than seven weeks later, various plots gave yields (computed) of 5 tons to 11½ tons per acre.

Suitable Soils and their Preparation.

The soils best adapted for rape are the rich, friable loams. Those which grow maize and potatoes profitably are very suitable, but with good cultivation rape does well on ordinary wheat land.

The land should be ploughed, whenever practicable, some time before sowing, to allow such necessary tillage as harrowing, &c., to be given. Areas cut for hay can be ploughed earlier, and time allowed for the proper preparation of the soil. Better still, however, is the devotion of a small portion of the fallowed land to rape growing. It can easily be understood that a crop of rape will do very much better on fallowed land than on non-fallowed land.

The surface should be worked down fine prior to seeding to ensure that the seed shall be covered uniformly from ½ inch to 1 inch deep. In addition to the thorough working of the land, a roller should precede the drill (especially in dry districts), so that a more even germination may result. The seed, being small, does not germinate when covered too deep.

In numerous experiments with different varieties, Dwarf Essex has in every instance given the best results from a fodder point of view, and it is the one that must be recommended to farmers.

Sowing and Manuring.

In the absence of a seed attachment to the drill the best results are obtained by mixing the seed with superphosphate and sowing through the manure box. Regular and thorough mixing of seed and fertiliser is necessary, as the seed is apt to work to the surface with the vibration, and the sowing to be uneven. For the same reason it is unwise to put in the manure box more of the mixed seed and fertiliser than will sow one acre at a time.

Where it is intended that rape shall be cut as green fodder and supplied to stock, it is advisable to make the sowing much lighter than where it is to be grazed by either sheep or pigs. The drills should then be made 2 feet 6 inches to 3 feet apart, instead of 7 inches, and 1½ lb. to 2 lb. of seed per acre sown instead of 4 lb. Everything being equal, drilled rape grows higher than broadcasted rape, which is an advantage in cutting the fodder.

Almost throughout the State, the end of February or the beginning of March is the best time to sow. In cold districts like New England a spring sowing may be made, and poultry-farmers near Sydney can sow a succession of small patches in the spring and again in autumn, but as a grazing crop in wheat districts early autumn is the most profitable season for sowing.

When grown in small areas there is nothing equal to ordinary farmyard manure for this crop. Unfortunately, this material is produced in limited quantities, and large areas, if manured, must be treated with concentrated fertilisers.

When rape is sown in rows better results can be ensured by keeping down all weeds by cultivating constantly between the rows. The effect is not only to remove the competition of the weeds, but to conserve moisture and enhance the growth of the crop.

Feeding-off.

If the season proves favourable, rape should be fit to graze in about eight to ten weeks after sowing. If there are several paddocks, they should be grazed alternately, one being grazed, say, for a fortnight, and the others



A Crop of Rape, Bathurst Experiment Farm.

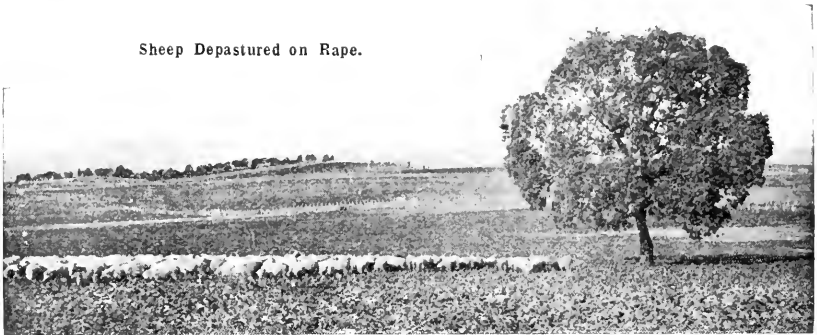
allowed to recover. Continuous hard grazing is not satisfactory. If there is only one paddock, it should be subdivided and treated as above. Wire-netting and stakes make an excellent temporary subdivision for sheep, and areas of any size may be operated upon, very little labour being entailed in shifting the fence.

Sheep or cattle should not be turned on to rape whilst hungry; they should be partially fed on other foods first. When hungry they eat ravenously, and hoven or bloat may be set up, and losses ensue. If it is necessary to depasture hungry stock on a rape crop, they should only be left on for a short time at first, and carefully watched until their hunger has been appeased.

To minimise this risk other foods should be available. It may be wise to have a crop of rye, barley, or wheat in one portion of the paddock, upon which they could graze in conjunction with the rape. Quick-growing ryes, oats, and barleys can be sown to advantage with the rape, 15 lb. of rye or other cereal and 3 lb. of rape being sufficient seed per acre. Care should be taken during moist, windy weather, as stock are more liable to bloat upon such fodders at such times. If any are bloated, Stockholm tar placed in the mouth, or bicarbonate of soda given as a drench are good correctives.

If scouring is induced by the over-succulence of the fodder, the stock should have access to a dry grass paddock, or be fed partially upon dry hay or chaff.

Sheep Depastured on Rape.



In cold districts growth may be suspended throughout the colder months. Upon clay soils in districts of heavier winter rainfall, the tramping of the stock would interfere with the satisfactory conditions of the soil for its growth. Under such conditions, the sandy friable soils would be preferable for winter grazing.

KALE.

The several varieties of kale belong to the same family as the cabbage, but do not form hearts like the latter plant. The open leaves and tender stalks possess considerable feeding value, whether used for soiling cattle or for grazing sheep. Kale is also an excellent feed for pigs and poultry, or as a green vegetable for humans. It thrives well in districts which are sufficiently cool and moist, but its cultivation is not recommended in the hotter and drier parts of the State.

A well-drained soil should be selected for the crop, and the land brought to a fine tilth. Seed should be sown in drills as soon as the frosts have ceased; or plants may be raised in a seed-bed and transplanted. The latter method requires less seed, but, of course, entails much more labour. Green fodder will be obtained from April to October of the following year. To avoid tainting milk, it should be fed to dairy cattle just after milking.

The best known variety is Thousand-headed. Jersey Tree is a tall-growing sort, and fairly well liked. Both these are preferable to Marrow Kale (*Chou moellier*), which has too large a proportion of stem to the leaf growth.

TOBACCO.*

A light, friable, sandy loam is the most suitable for the production of a good quality tobacco that will give the desired aroma, texture, and colour. The plant is, however, easily affected by climate and by the chemical and mechanical conditions of the soil. Bright-coloured tobaccos are usually produced on light-coloured soils, and dark leaf on dark soils.

The presence of clay has a great influence on the product, and it will be found that a proportion of eight to ten parts of sand to one of clay is most likely to produce bright or yellow tobacco. Large proportions of clay will produce a tobacco which cures out a dark colour.

The subsoil is another important factor. It is desirable that it should underlie the soil at a depth of about 12 to 18 inches, and that it should contain a larger proportion of clay than the soil above. It is found that where the subsoil is too near the surface the tobacco is inclined to cure out a darker colour. On the other hand, it must not lie too deep, for the sandy nature of the surface soil may allow moisture to get beyond the reach of the plants, which may thus suffer from insufficiency of moisture should a dry spell occur during the growing season. Thus the subsoil should lie neither too near the surface nor too deep, and within 18 inches of the surface is most satisfactory.

In new localities the suitability of the local and climatic influences should be determined by experiments before tobacco-growing on a large scale is attempted. It is not advisable to attempt to grow the crop within 10 to 15 miles of the coast, as the "burn" of the tobacco is injuriously affected by the presence of chlorides in the atmosphere and soil. The land should be well drained, and the soil as free as possible from weeds.

Preparation of the Ground.

The land should receive a thorough ploughing early in the winter, and as soon as weeds appear thereafter, or a crust is formed on the surface, the spring-tooth cultivator should be used. The operation will not only kill the weeds, but will conserve moisture and sweeten the subsoil. Shortly before the season for transplanting, a second ploughing should be given to a depth of 9 inches, and the soil harrowed to produce a fine tilth, so that the rootlets of the tobacco plants may be hampered as little as possible in their search for nourishment.

As tobacco should arrive at maturity in two to two and a half months after transplanting, the grower requires to give careful attention to the preparation of his ground. With anything like unfavourable soil conditions the rapid and healthy development of the plants is bound to be interfered with, and it should be the concern of the farmer to do all that is within his power to prevent such a state of affairs.

Working-up the Seed-beds.

In the growing of tobacco, care and trouble in the preparation and subsequent treatment of the seed-beds are amply repaid.

The last week in August is early enough to start sowings of seed, and this should be continued at regular intervals of a week or ten days up to the first week in November, so that the grower may be assured of a sufficiency of plants whenever the weather is favourable for their removal to the field after danger from frosts is past.

* C. J. Tregenna, Tobacco Expert.

The site chosen for the seed-beds should be in a position sheltered from prevailing winds, and the soil should be a well-drained, rich, sandy loam. First mark off beds 4 feet wide; then pile a quantity of timber and brush-wood on the surface, and start a fire on the leeward side, the intention being to raise sufficient heat to kill insect eggs and seeds of any weeds that may be present. Rubbish of any size should be raked off, but the fine ashes should be left, as these will act as a fertiliser when worked into the bed. Then the surface should be broken to a depth of 5 or 6 inches, and worked up to as fine a tilth as possible. The bed should be enclosed with a framework of wood. If squared timber is not available, straight logs about 6 to 9 inches in diameter will answer the purpose.

To Ensure Even Sowing.

To ensure even sowing, one level teaspoonful of seed is sufficient for a bed 4 feet wide and 25 feet long, and should yield enough plants for one acre.

Do not attempt to sow the seed without addition to its bulk, but get two buckets, one of which should be about one-third filled with fine ashes. Place a thin layer of ashes in the empty bucket, and sprinkle as evenly as possible a pinch of seed over it; add another layer of ashes, and mix well. Repeat the process until the quantity of seed it is desired to sow is used up, together with the ashes. Give it a good mixing again with the hands. The early morning will probably be found the best time to sow the seed, before the wind becomes troublesome. It is inadvisable to sow with a strong wind prevailing, if it can possibly be avoided, as the seed is so light that it will be blown away. The mixture of ashes and seed should be distributed over the bed as evenly as possible, and the colour will be a guide as to its evenness. The seed should not be raked in, but after sowing the bed should be gently firmed all over with a piece of flat board. Then lightly water the bed several times with a can that has a fine rose. Do not put on so much at one time that it will run in small streams, but moisten the bed thoroughly.

Raising the Plants.

It will now be necessary to cover the beds for protection against cold, the sun, and insects. A simple plan is as follows:—At each end of a bed drive one small post, leaving it about 12 inches above the ground level, and strain a length of No. 10 wire from one to another, so that it runs down the middle of the bed; place a few small posts along the bed to take up any sag. Attach to the wire white hessian or cheese-cloth. This may be stitched to the wire tightly with binder twine or string with the aid of a packing needle. The covering should be stretched tight and fastened to the sides by hooking over nails.

As it is advisable to have plenty of plants at the right stage when required, provision should be made for 50 per cent. more beds than are apparently necessary. One hundred square feet of bed is sufficient for an acre, but the bed will require to be pulled over a period of a few weeks, and the grower should not miss an opportunity of getting out as many plants as possible at one time when the weather conditions are favourable. Then, too, the danger from loss of plants by destruction by insects and other causes must not be overlooked. Over a number of years, the grower will find the average of 50 per cent. extra will amply repay him.

If the soil is inclined to pack after sowing, scatter over the bed very lightly some fine, well-rotted horse manure. If it is anticipated that the soil is likely to pack in this way, the manure should be incorporated in the bed before sowing.

In about one month the beds will be ready to be uncovered, and the seedlings to be hardened off before transplanting. This should be done gradually. For the first few days, if the weather is very hot, cover up in the middle of the day until the plants can stand the direct heat of the sun.

Plants which come up too quickly in the seed-beds are apt to be weedy and spindly specimens, and should be thinned out so that each occupies an area of about a square inch.

If plants are not coming on as fast as it is wished after they are up, a sugar bag may be filled with horse-manure, the neck tied, and the bag soaked in a cask of 40 gallons of water for a day. The liquid can then be freely used twice a week on the beds with a can that has a fine rose.

Pests of Seedlings.

The beds should be covered every evening and not uncovered until sunrise. Possibly the grower has not been troubled with the moths which lay eggs on the seedlings and develop into the caterpillars commonly known as "Stem Grubs" or "Tobacco Leaf Miners," and which work their way through the leaf tissues into the stem and stalk, and it is well to take some precaution. If the grub is present, or feared, spray the plants when they have four leaves with two teaspoonsful of arsenate of lead to one gallon of water, and at an interval of four days later repeat the spraying.

Look out for cutworms, as they work havoc in the beds if neglected. If their presence is suspected, for two evenings before sowing lay baits on the seed-beds and the surrounding cleared land. The bait is made with 1 lb. arsenate of soda, 8 lb. treacle or sugar, and 10 gallons of water. Dissolve the arsenate of soda in one pint of boiling water, add the sugar or treacle, and the water, cut up some greenstuff, and mix all together. Pollard also may be used in place of greenstuff, and, if so, it should be mixed to the consistency of porridge. The quantity mentioned should be enough for the seed-beds for 10 acres of plants.

To Hasten Development.

Possibly it is required to obtain plants quickly, and in the following manner growers may expect to have them ready for transplanting in about six weeks. Before sowing, lightly cover the whole bed (so that it may be plainly seen) with high-grade superphosphate; about 3 or 4 lb. will be required for each 100 square feet of seed-bed. Take a rake and *lightly* draw it over the bed once, and then sow the seed. When the plants are well up (which should be in about three weeks), soak a sugar bag full of horse manure in a 40-gallon cask of water, and give the bed a good watering. This should be repeated weekly. Plants so grown will do well in the field, but it must be understood that the grower *cannot* obtain plants quickly if the ground is not warm and the weather spring-like.

Keep the beds moist, but not wet, until the plants are well established. It is important that the beds should never be allowed to become dry on the surface while the seed is germinating. After the plants have reached some size it is better to thoroughly water occasionally—not too often, but *thoroughly* when it is done. This will reduce the danger from mould.

No fixed rule can be given for watering, but do not water beds which are uncovered while the sun is at all strong.

Transplanting.

When the plants are from 6 to 8 inches in height and well hardened off, they are ready for setting out. Plants which are stunted and yellow, and which have long pointed leaves, should not be used. The best are those which are most vigorous looking, and with short, broad leaves. If the beds are dry and hard they should receive a good soaking some little time before the plants are drawn, as it is necessary that as little damage as possible to the root system takes place, and the earth adhering to the plants should not be interfered with more than can be helped.

The best way to remove the plants is with a three-pronged fork. If the tap-root is long, it should be trimmed off with a pair of seissors to about 2 inches. The less handling the plants have the better, and after they have been drawn they should be placed, root downwards, in a cool place, and kept covered with wet bags. Only the plants that can be set out on the same day should be drawn at the one time.

It may here be stated that where the aim of the grower is to produce a fine-textured leaf, the plants should be set out close together, and although past experience must be taken as a guide, it will generally be found that a space of 2½ feet in rows 3 feet apart on light sandy loam will not induce heavy growth and coarse texture. This distance of 3 feet between the rows will allow of horse cultivation, and thus lessen labour.

A simple and effective way to mark out the land is to attach four light chains spaced 3 feet apart on a light pole with a handle, so that a man can drag it behind him and walk in accordance with sighting poles fixed for that purpose.

The ideal weather for planting out is just before and during rain, so that the roots of the plants may have very little check, and growth may be established as soon as possible. Unfortunately, however, weather conditions do not always suit the planter, and possibly owing to the lateness of the season he is forced to set out during dry weather. In this case holes should be made and filled with water, and the plant carefully put in and the earth well packed round the roots. Care should be taken that the roots are not doubled up, and that the hole is properly filled with earth. A simple test is to pull the tips of the two top leaves gently in an upward direction, and if they break off in the fingers they are right. Another method where irrigation is not carried out, is to make a hole close to the plant and fill with water, and then cover up to prevent evaporation. If the weather continues hot after transplanting, the plants should be shaded with grass. Paper folded in the shape of a tent and held down by two clods of earth is also very effective. It may be necessary to water, and, if so, it is best done early in the morning or about an hour before sundown. Plants which have struck well usually start growing in about ten days, and the covering may be removed.

If irrigation is carried out, a good plan is to turn two shallow furrows together with a light plough, and run the water so that the ridge gets a good soaking some little time before transplanting. The plants should then be set out on the shady side of the ridge, care being taken that the stem and leaves are high enough above the water to avoid being submerged.

As soon as possible after transplanting it is advisable to run water through again to set the earth well round the bottom of the roots. After five or six days the crust around the young plants should be lightly stirred and broken.

Cultivation.

Tobacco quickly responds to cultivation, and the grower should aim at keeping his land in fine tilth, and free from all weeds up to the time the plants are ripening. During dry weather, by creating a dust mulch, excessive evaporation of moisture is avoided. The root system of the tobacco plant is largely near the surface, and for that reason shallow cultivation must be practised. As soon as a crust is formed, or the ground becomes hard, get to work with the horse cultivator and hoe, and when the plants are high enough, arrange the tines of the cultivator so that the earth is gradually drawn from between the rows towards the crown of the plants. Pronounced ridging will induce the drying-out of the soil, and should be avoided. Neglect of cultivation shows itself very clearly in the value of the tobacco, and no plant is so easily affected. It may be stated generally that the crop should receive a thorough cultivation every week or ten days after the plants have started growing until such time as the horse cultivator cannot be used without damaging the leaves of the plants owing to their size.

Where irrigation is carried out, cultivation must take place as soon as the ground begins to harden or crust. It is useless to water alone if good results are expected.

The bottom leaves are almost invariably damaged and dirty. These, generally numbering from four to six, should be removed, and the sap will then be taken up by the remaining leaves, which will be well off the ground.

Topping.

When the flower head or inflorescence has started to develop, the top length of stalk must be broken off. Plants which are strong and vigorous are topped high, and those which do not present these features are topped low. Experience and a fine judgment is necessary to determine the number of leaves that should be left on a plant, but for a normal season twelve to fourteen would seem so be about the number that should be left to mature. Where the entire plant is to be harvested, the planter should aim at obtaining as even ripening as possible to enable him to secure a good uniform cure and quality of product.

Suckering.

Soon after topping has taken place, and sometimes before, suckers will appear at the junction of the leaves and at the bottom of the stalk. As soon as they are about 2 inches long, or large enough to be conveniently grasped, these must be removed. Care must be exercised that in breaking them off the remaining leaves are not torn or damaged. It will be found that early in the morning is the best time to carry out this work, as during the afternoon of a hot day they are tough and leathery. The operation of suckering will most probably have to be repeated each week. Particular attention should be paid to this work, because if suckers are allowed to go far, the quality of the tobacco will be seriously impaired.

Harvesting.

Some three to five weeks after topping, maturity will be reached, and there will be various indications that the time for harvesting has arrived. The varieties which have been distributed by the Department, if planted under suitable conditions, on reaching maturity, should show lighter shades of green, a golden sheen when looked at in certain lights, and in some cases a yellowish blotchy discoloration, or yellow spots. When the leaf is folded between the fingers, too, it will crack across.

Plants should not be cut or handled while the dew is still on the leaves, or after rain, until the gummy feeling has returned to the leaf.

There are several methods of harvesting.

The "Priming" Method.

It will be observed that all the leaves on the plant do not ripen at the same time, but in all cases they start to mature from the bottom upwards. To secure the best results, and obtain an even cure, each leaf should be taken off separately as it reaches maturity.

The leaves are then placed in baskets or other suitable receptacles and taken straight to the barn to be strung in the shade, care being taken that after "priming" they are kept out of the sun as much as possible. The leaves are then made up into "hands" containing four in each. A 4-foot stick will take about twenty "hands," ten on each side. In each "hand" of four leaves two should face one way and two the other, the middle two having their backs together. When the tobacco is to be flue-cured, the "hands" should not be jammed up close together, but there should be a space of a few inches between each on either side of the stick. Where air-curing is practised, the leaves should be placed *close* together until they have assumed a yellow colour, after which they should be opened out as above.

The method of stringing it is somewhat difficult to describe. The stem-butts of each "hand" are strung with a twist of the string to hold them together. The string, which is about twice as long as the stick, is held fast permanently at one end by being pressed into a slit in the wood, and when the required amount of tobacco has been strung, the loose end of string is run through another split at the other end, and made secure. The grower quickly finds out how it is done, after a trial or two.

Hanging may also be carried out by threading each leaf with a needle and twine through the midrib, but the process is a tedious one. Yet another method is to put fixed wires through the curing stick, so that they project 5 inches on each side, and are 7 inches apart. The leaves can be hung on the wires by piercing through the stem-butts. Leaf so strung is very liable to damage by tearing when the stick is being handled, and it is not possible to bulk down without removing the leaves from the wires.

Harvesting the Whole Plant.

When the whole plant is to be harvested, a fine discrimination must be shown in order that the largest proportion of leaves shall be at the right stage to ensure a satisfactory cure afterwards. As stated above, the whole of the plant does not ripen at the same time, and where the whole plant is

to be harvested and cured it must be cut when the middle leaves have matured. The plant should be split down the middle to within a few inches of the bottom, and then chopped off and placed astride the curing stick. The stick must be carried so that the leaves will be clear of the ground, as otherwise dirt may adhere to the leaves and depreciate their appearance and value.

The Method Recommended.

A combination of the two harvesting methods—the “priming” method and the whole plant—is recommended to growers as productive of satisfactory results without the labour involved by “priming” throughout. When the bottom leaves of the plants have come to maturity they should be primed off and strung, and the upper leaves left until they are ready, when they should be taken off with the stalk attached and strung, as in the case of harvesting the whole plant.

Curing Tobacco.

With very few exceptions, the methods of curing adopted in this State are not such as ensure the best results from the leaf as grown. It should be understood that mere cutting, scaffolding, and hanging in an open shed can never be expected to give good uniform results. Leaf so treated is just dried out. This State is subjected to rapid changes of climatic conditions, and tobacco which is left solely to the wiles of the weather invariably suffers.

What is termed “sun and air drying” has in the past been the method usually adopted, but it has rarely produced the bright or yellow tobacco now sought for by the manufacturers. Local buyers state that Australian tobacco so dried has an aroma which is peculiar, and not agreeable. Tobacco which has a pleasant aroma is usually agreeable to the palate; and it is this the grower has to cater for. All our remarks must be taken to refer to the curing of the bright and yellow tobacco, which it should be the aim of every grower to obtain.

Air-curing.

As tobacco is so easily affected by climatic conditions and rapid changes of temperature, it is necessary, if the leaf is to be air-cured, that the grower should have at his command a building which can be closed up or opened, as becomes necessary, and the ventilation of which can be perfectly controlled. In continuous wet weather the grower must be able to allow a current of air through his barn; and if dry, hot weather prevails, it must be possible to close the building up completely to prevent too rapid drying of the leaf, or to open the ventilators during the nights. If the leaf is showing signs of fungus, or “pole burn,” and the weather is wet, charcoal or corn-cob fires should be placed in the barn, and the ventilators opened until the excess of moisture has departed.

Sun and Air Drying.

Where curing is effected by means of an open shed, as is the usual custom in this State at the present time, the tobacco should be cut late in the afternoon, and hung on the sticks close together. When it has wilted it will be possible to pack much closer. A scaffold should be erected close to the shed, the sticks of tobacco placed close together, and allowed to remain so until the leaf has assumed a yellow colour. When this change of colour has taken place, each stalk should be separated by a space of about 6 inches,

and the stick taken to the barn. Growers should note that in the barn the sticks must have sufficient space to allow a free current of air to pass through the tobacco; it is a great mistake to let the leaf be crowded together in the shed. Tobacco which shows every promise on the scaffold of securing a good colour is often spoilt by neglect of this precaution, and the result is a dark and dingy coloured leaf.

There is another point which growers would do well to observe: they should see that when on the scaffold the leaf does not get burned by the sun. If it is not possible to place the scaffold in such a position that it will be shaded during the middle of the day, a covering of cheese-cloth should be passed over all the leaf to break the rays of the sun, so that it may go into the barn of a yellow colour instead of a dark-brown. Tobacco on the scaffold should *never* be allowed to get wet; and a good cure cannot be expected if this happens.

Flue Curing.

To successfully flue-cure leaf, the grower must have considerable experience. Few barns of tobacco can be cured alike, and almost every one requires different treatment. In a very short space of time a barn full of leaf may be totally spoiled through neglect, lack of knowledge, or a little bad judgment.

To cure in this manner special buildings are necessary; they must be draught-proof, and so finished that heat and moisture cannot escape; and they must be erected of materials which will permit the interior to be effected by outside temperature to only a minimum degree. Iron erections are, therefore, totally unsuitable, while brick is expensive. It is suggested that the building should be erected of wood or pisé. The inside dimensions of a building suitable to cure the crop of 6 or 7 acres would be 16 feet by 16 feet, and 17 feet high, with a spacing of 3 feet 6 inches vertically between the tiers on which the sticks of tobacco are hung when harvested on the stalk, and 2 feet when the leaves have been "primed." Two furnaces should be provided at one end of the building, and from it flue-piping of heavy Russian iron should run round inside, with the outlets between the two furnaces. Ventilators are necessary at both the top and bottom of the building, and may be provided by two rabbit-hutch types on each of the four sides at the bottom, and two cupola ventilators at the top. Plans will be forwarded to any grower desiring to erect such a building on application to the Department of Agriculture.

As already stated, considerable experience is necessary to successfully flue-cure tobacco, and no definite rules can be laid down, as each type of leaf is a factor of importance, and each barn-full differs from its predecessors.

There are three stages in curing. They may be stated as follows:—(1) Yellowing, (2) fixing, (3) killing. No fixed formula can be given, but if the following is taken as a basis the grower will, after curing a few barns, be able to modify or vary the process in some respects to give him the desired results.

As soon as the barn is full close the building right up, start the fire going, and bring the temperature up to 90 degrees Fah. Keep it at this point for eighteen to thirty-six hours, according to the condition of the leaf, limiting the time to the shorter period in the case of leaf that is quite ripe, and allowing the full period where the leaf is not so well matured. If the leaf

is not yellowing as it should, place sacks on the floor and soak them with water to produce a moist heat; or, better still, if a boiler is handy introduce steam. When the leaves have assumed a nice yellowish colour raise the temperature to 100 degrees, at the rate of 5 degrees each two hours, and keep at this figure for some six hours. Then raise the temperature to 105 degrees and give a little ventilation top and bottom, opening the ventilators a few inches. In these directions it is presumed that the curing-room is one that has been erected in accordance with proper plans, such as would be supplied by the Department of Agriculture, as stated above. In such a building, both temperature and ventilation could be controlled so as to produce the results desired.

Having obtained the temperature of 105 degrees with the limited ventilation mentioned, the conditions should be maintained for three or four hours. Then increase the temperature to 110 degrees, and also increase the ventilation to about one-half of the capacity of the ventilators, and hold at that for three hours. Do not raise the temperature above 110 degrees until the tips of the leaves have dried, however. Next, again raise the temperature to 115 degrees for six hours, giving *full* ventilation, and then again advance to 120 degrees for two hours with full ventilation. The most critical time is between 110 degrees and 120 degrees. If the heat is too fast the leaf will splotch or blister, and if too slow it will sponge. When the sweat can be observed on the leaf, and it will not go off at once, the temperature must be increased rapidly by 10 degrees, and all available ventilation given; but if ventilation is given as directed there is little fear of sponging.

After remaining at 120 degrees for six hours, leave the ventilation at full, and increase the temperature by 5 degrees every two hours to 135 degrees; beyond this do not further increase the temperature until the blade of the leaf has dried out completely. Then exhaust all moisture by raising the temperature every hour by 5 degrees to 180 degrees, and gradually decrease the ventilation until only a very little is left at the top. Keep at the latter temperature until the stems and stalks have completely dried out. Ventilation plays a *most important part* in successful flue-curing during the stage from 105 to 140 degrees, and growers should pay particular attention to this matter. The whole process will take five or six days.

Extinguish the fire as soon as the tobacco is cured, and open the doors and ventilators to cool it off for twenty-four hours. If the weather be very dry, the moisture content of the barn may be increased with the aid of steam, or by means of water thrown on sacks on the barn floor. When the tobacco is in a condition to handle without the leaves breaking, it should be taken down on the sticks and bulked until the grower is ready to grade and bale for market as opportunity occurs.

Stripping.

So much time and labour have necessarily to be expended by growers before the tobacco leaf is ready for stripping and bulking, that the adoption of correct methods at this stage is a matter of enhanced importance. Yet there are those who quite fail to realise the extent to which the quality may be influenced in the processes of stripping and bulking, and who are consequently disappointed at the eventual refusal of buyers to take the leaf at all, or at the very low price offered. A few suggestions should, therefore, be helpful to growers.

As soon as the stem and stalk of the tobacco have dried, and the atmospheric conditions will permit, the leaves should be stripped from the stalk, and made into "hands." Each hand should consist of twelve leaves, and should be made by binding the stem-butts with a leaf tightly and neatly passed twice around them, and by opening the hand in the centre and pulling the end of the binder through.

When stripping from the stalks, opportunity should be taken to sort the leaves into three classes, No. 1 containing only leaves that are of good bright or yellow colour, and undamaged. No. 2 containing the leaves that are reddish-brown and undamaged, and No. 3 containing dark leaves, such as are damaged and would not fall within either of the other two classes.

While not necessary with flue-cured tobacco, in the case of leaf that has been air-dried the hands should be re-hung on the sticks, and given as much sun as possible for a few weeks on a scaffold close to the shed. Care should be taken not to put out more stocks at one time than can be removed to cover at the approach of rain. After each lot of sticks has been "sunned," they should be hung in the shed for a further period of about two months, after which the hands should be bulked down, each in its own class, for some six weeks at the beginning of the warm weather.

Bulking Down.

For bulking the hands, the leaf should not be moist, but in such condition that the tips can be squeezed together without breaking, and that a slight shaking will release one from the other. Opportunity should also be taken of straightening out the hands to improve their appearance before putting into bulk. Leaves with "fat stems" (stems not dried out) should not on any account be included in the bulk, or mould will very quickly appear.

"Bulks" are made by placing two rows of hands, overlapping by about one-third of their length, with the butts outward. The height should not be less than 4 feet. The length will be determined by the amount of leaf to be treated. The larger the bulk, the less it will be affected by outside climatic influences.

Growers are advised to cover each bulk as it is completed with blankets or tarpaulins, and to place weights on top, the object being to conserve the heat and moisture, and to avoid the drying out of the leaf. The prime cause of mould is the bulk becoming moistened and chilled, and every precaution should be taken against this. The bulk should be placed on boards well off the ground, so that air may circulate freely underneath.

Each bulk should be carefully examined every day, and if one is found to be too warm it should be broken down, and after each hand has been well shaken and lightly aired, should be rebuilt, those hands which were formerly in the centre being placed on the outside, the outside layers in the centre, and the lower layers on the top.

Leaf that has been through the bulking process satisfactorily shows an absence of gumminess, and also the presence of crystals, which, though minute, can be seen when the leaf is held up to the light.

Fungus Diseases of Tobacco.*

Blue Mould.

This disease makes its appearance particularly in seasons when the rainfall is excessive. It is due to a fungus, *Peronospora* sp. As in the case of most fungus diseases, a particular relationship must exist between the weather, the plant attacked, and the fungus before the latter can establish itself



Fig. 1.—A young Tobacco plant infected with Blue Mould.
Note the shrivelling leaves.

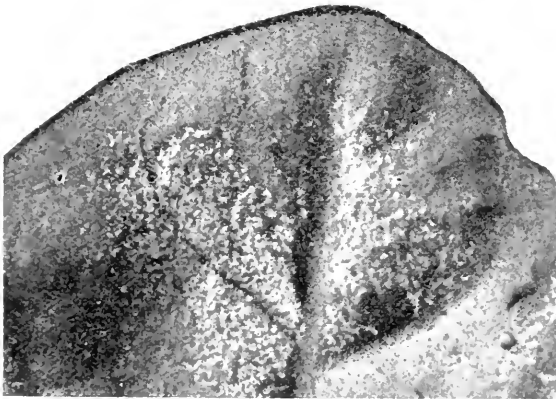


Fig. 2.—The underside of a young leaf infected with Blue Mould.
Showing the production of spores. [Magnified.]

* G. P. Darnell-Smith, D.Sc., F.I.C., F.C.S., Biologist.

and spread with rapidity. Blue Mould especially attacks young plants in the seed-bed; and if its makes its appearance when the particular relationship above referred to exists, it spreads so rapidly that the whole seed-bed may be damaged in the course of a few days.

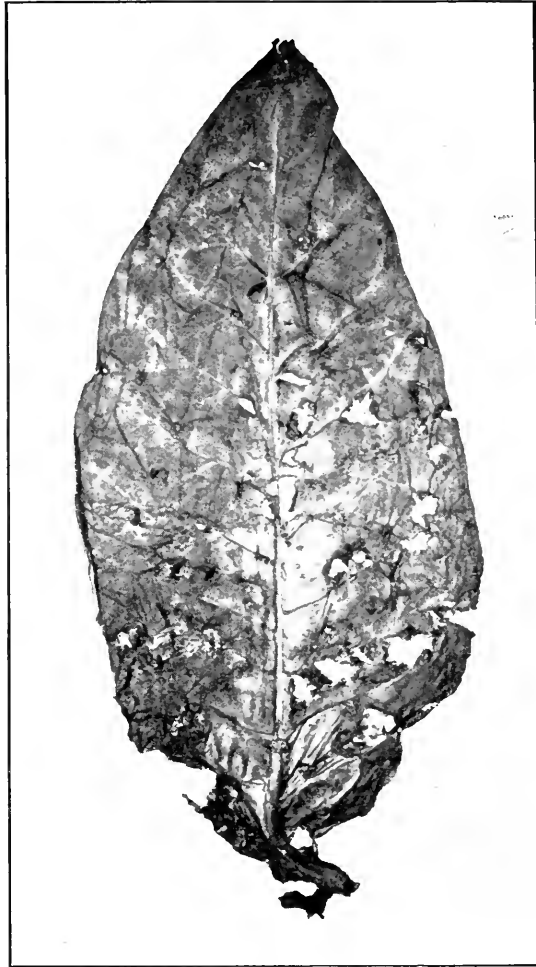


Fig. 3.—Adult leaf showing holes in places previously attacked by Blue Mould.

The fungus makes its appearance on the *under* surface of the leaves, which appear to be covered with fluff of a faint violet tinge. This fluff consists of fungus threads which come out from the leaf and branch freely, each branch bearing at its extremity a small oval spore; these spores are produced in millions. Another kind of spore (known as an oospore) is produced within the tissues of the host plant. It can remain dormant much longer than the other form of spore, hence old diseased plants should be burnt. The fungus

threads travel in the tissues of the young leaf, absorbing nourishment and causing it to wither rapidly and die. Attacked plants early lose their bright green colour, and a practised eye can quickly detect the change.

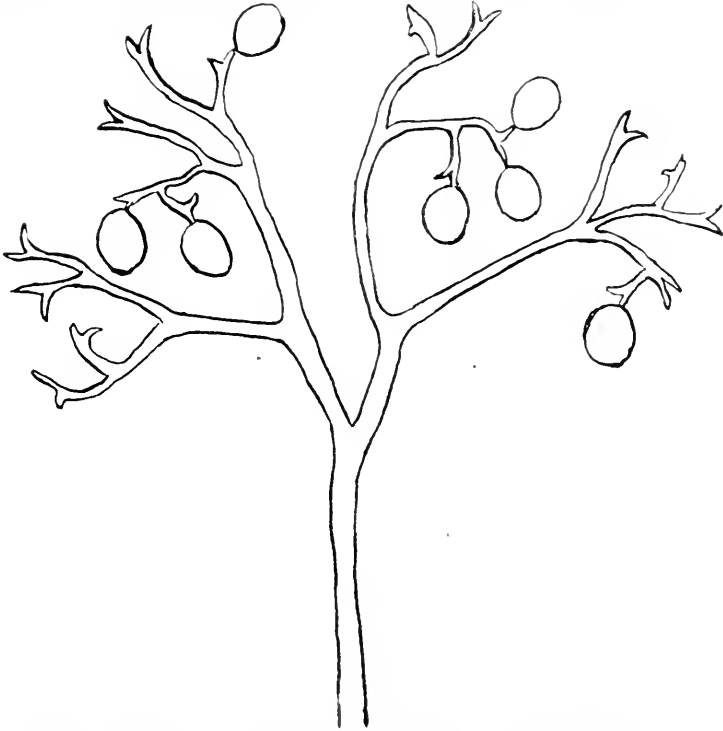


Fig. 4.—A single fungus branch, highly magnified, showing the manner in which the oval spores are attached.

Methods of control must aim at preventing conditions favourable to the development of the disease. They may be summarised as follows:—

1. Prepare a number of seed-beds, suitably manured, so that the young plants may quickly become established.
2. Sow these beds at intervals of two to three weeks.
3. Do not over-water the young plants; excessive moisture favours the disease.
4. Allow the young plants plenty of air and sunlight. Plants grown under hessian are more liable to develop the disease than those grown under straw.
5. Transplant at the earliest opportunity.
6. If the disease makes its appearance in any one of the beds, pull up and burn the infected plants immediately, and spray the remainder with Bordeaux mixture (2-2-50).

A Bacterial Disease of Tobacco.

Seedlings that have been attacked by Blue Mould may die out completely, or they may exhibit a partial recovery, sufficient to induce the grower to transplant them. Such plants may grow in the field and completely recover, or they may attain a certain size and then wilt. They seldom have the

appearance of normal, healthy, vigorous plants, and are very liable to develop brittle stems that break off in a very moderate breeze. The stems of all such plants, when cut sharply across just above the root, show a ring of sap-conducting tissue that is discoloured—it is brown or black. Cutting the stem across at intervals, this discoloured tissue may be traced upwards towards the apex. The colour becomes fainter, but it can be traced even with the naked eye into the veins of the big leaves. In the neighbourhood of this discoloured tissue cells containing bacteria are found. They exist in

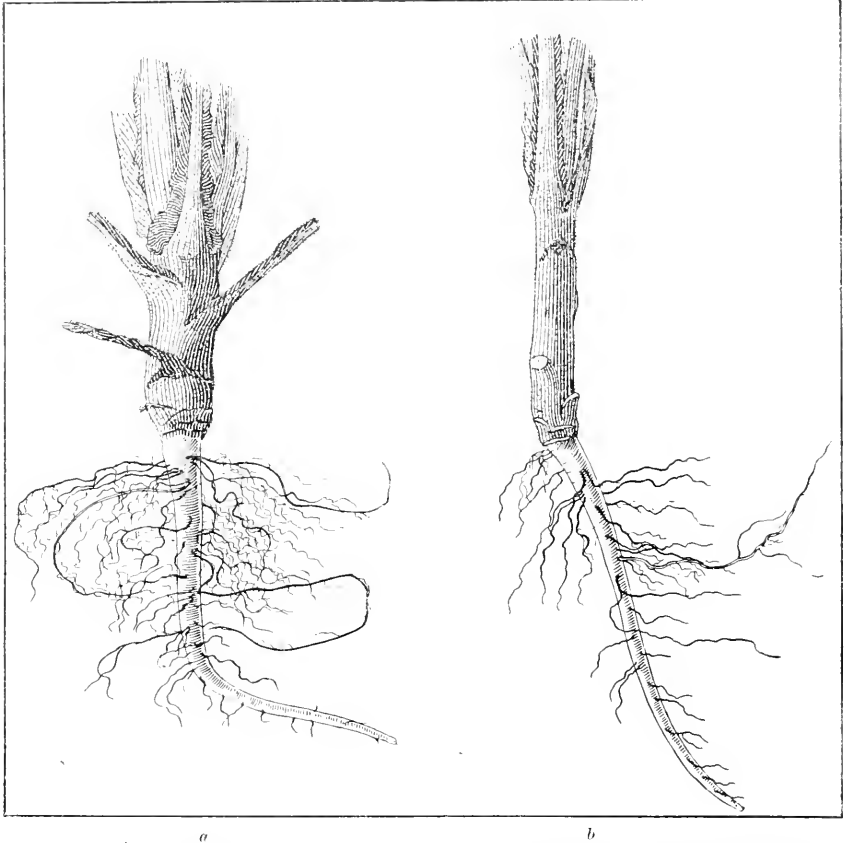


Fig. 5.—*a* A young tobacco plant that is diseased showing the characteristic bulbous appearance at the base of the stem. *b* Young diseased tobacco plant which has started to lengthen and the bulbous swelling at the base base is diminishing.

such numbers that there seems good reason to suppose that they are connected with the discolouration and the diseased condition. The stems of infected plants swell and become tumid (sometimes almost bulbous) immediately above the roots. If the plant remains short and swollen it is regarded as being worthless for planting out, but if, as sometimes happens, it begins to lengthen and lose its swollen appearance, it may be worth transplanting, though it never fully recovers. A plant showing the abnormal swelling is shown at Fig. 5, *a*, and one that is lengthening and recovering is shown at Fig. 5, *b*.

COTTON.*

Cotton has never at any time been extensively grown in New South Wales. The Department of Agriculture has for a number of years planted experimental plots on one and another of the farms, and has also distributed seed to farmers, but the culture of the crop has never been taken seriously—probably because of the good returns that have always been obtainable from dairying and from maize-growing. In the districts most suitable for cotton the climatic and soil conditions are particularly favourable for dairying, and what land farmers can put under cultivation has usually been laid down in maize, a crop that has the dual recommendation that if the season happens to be dry and the maize fails for grain, the pastures are also poor, and then maize stalks give a good return by serving to keep up the milk flow.

Suitable and Unsuitable Soils.

Cotton will thrive on a fairly wide range of soils, but it will not produce profitable yields on poor, hungry land. Its growth should not be attempted on land that is not capable of producing at least 40 bushels of maize per acre under average conditions. Where the soil is poor the yield is light, the staple short, and the cotton of little value. The best soils are the rich, friable, alluvial soils of the North Coast rivers. Fairly good crops may also be produced on some of the higher land.

It must not be imagined that cotton will thrive on poor land. As a matter of fact it requires a good, fertile soil, such as is capable of producing crops of not less than 40 bushels of maize.

Cotton is a plant which thrives under warm conditions. In cold, wet soils the growth is retarded. The drainage should therefore be good. On the other hand, a regular supply of moisture is essential, and soils which dry out rapidly are not suitable.

Climate.

Cotton can only be successfully grown in warm climates, with a summer season of about seven months between frost. The crop requires a fairly good and evenly distributed rainfall. The ideal conditions are warm days and nights, with a good rainfall up till about January, followed by fairly dry, bright weather in the succeeding months, when the cotton is ripening. Heavy rains during the ripening period interfere with the picking, and also cause deterioration in the quality of the cotton. Where the rain is excessively heavy, particularly from January to May, cotton cannot be successfully grown.

In this State the climatic conditions are most favourable on the North Coast. Cotton cannot be successfully grown on the tablelands nor the western slopes in close proximity to the tablelands.

In the north-west the conditions in regard to heat are suitable and in seasons when the summer rainfall is fairly good cotton thrives, but the rainfall is too uncertain for the crop to be successfully cultivated as a general practice. In the western and southern districts the rainfall is altogether too light during the summer. On the Murrumbidgee Irrigation Areas cotton gives good yields where the soil is suitable.

* A. H. E. McDonald, Chief Inspector of Agriculture.

The Preparation of the Land.

It is necessary to give careful attention to the preparation of the land. An early and deep ploughing should be given ; the time depends, partly, of course, upon when the preceding crop is taken off, but arrangements should be so made, if at all possible, that the first ploughing should be given not later than June. The land should be allowed to lie in the rough through the winter, and about the end of August a cross-ploughing may be given. As planting takes place about the end of September, it will probably be necessary to plough again in order to put the land into a good, friable condition for the sowing. This spring ploughing should be only about 4 inches deep. The surface soil has been sweetened and improved in fertility by the weathering during the winter, and if the ploughing is too deep the sweet soil will be buried and inferior soil brought to the surface. As the best conditions must be provided for the germination of the seed and the feeding of the young seedlings, the richer and more friable surface soil should therefore be retained on the top and merely given a shallow turning.

The soil should be in a fine, firm condition, and the harrow and roller should be used to ensure that it is so. Thorough early cultivation leads to the decay of trash, such as maize stalks, &c., improves the fertility of the land, and tends to ensure a vigorous growth of the crop, while at the same time conserving any moisture that may fall before sowing, thus making it available to augment any rain that may fall during the growth of the crop.

A great deal of labour and time is involved in the picking of the cotton crop, and this is very considerably reduced if the plants are large and vigorous and carry a good number of large bolls. On the other hand, much time is lost if the plants are small and poor, with few bolls. Hence the cultivation, which is comparatively inexpensive, should be done carefully with a view, not only to producing a heavy crop, but also of reducing the expense of gathering the cotton.

Sowing the Seed.

Cotton seed is somewhat shy in germinating, and therefore a fairly liberal seeding is required. Many growers sow only 10 to 12 lb. per acre, but more satisfactory results are obtained with 15 to 20 lb. A thin stand is unsatisfactory, as it leads to a woody or vegetative growth rather than to good cotton-bearing plants. A thin stand cannot be subsequently remedied, but it is a simple matter to thin out the plants where the stand is too thick. In cotton-growing countries thinning is recognised as an essential cultural operation.

The seed carries short fluff, and requires treatment to facilitate sowing when machines are used, but if dropped by hand the fluff is not so objectionable. Various methods of removing the fluff are adopted. We have found that rubbing the seed in clean, sharp sand is effective. In Queensland, growers obtain a dry, hollow log which is fired inside and then placed in an upright position over a tub of water. The seed is dropped through the fire into the water. Another method is to dip the seed in a thin paste made of clay or flour, and then dry it ; but care must be taken that the seeds do not stick together while drying.

The seed is dropped in rows, about 4 ft. apart in the richer soil, and about 3 ft. 6 in. apart where the soil is of a lighter character. Where weeds are likely to come thickly the wider space is desirable, as it gives better opportunities for the destruction of weed growth by cultivation. It should be planted on the flat, and must not be covered more than 1 to 2 inches deep. The seed should be sown in moist, firm soil to ensure prompt germination.

The ordinary maize-dropper is most suitable for planting, as it can be adjusted to plant the seed at the right depth, and to firm the soil around the seed to the right extent to promote germination. Where the surface soil is dry or cloddy a furrow-opener should be attached to the front of the drill to open up the moist soil to receive the seed. This furrow should be deep enough to push away the clods and dry surface soil. The plate supplied for the sowing of maize for silage purposes is very suitable for the sowing of cotton seed.

Varieties.

Seed of only one variety is available in quantity at the present time. This is an Upland variety which is grown largely in Queensland.

The New South Wales Department introduced a number of the best varieties from the United States of America some time ago, but none of the seed is yet available for distribution, as it is being grown to obtain larger supplies of seed on the experiment farms of the Department. Among these is Pima, an Egyptian-American variety. It produces a long, fine-stapled lint, and is therefore more valuable than the usual Upland type.

Perennial Cotton.

From time to time reports are circulated of perennial types of cotton, and of cotton plants being carried over into the next season, thus avoiding re-sowing. Perennial types exist, but the quality of the cotton is inferior and not popular with spinners.

It is claimed by some growers in Queensland that the cotton plants may be pruned at the end of the first year, and that they will then give a good crop in the next year. Such a system is not suitable for New South Wales conditions, owing to the plants being cut down by frost, to the growth of weeds, and to the setting together of the land. The crop must therefore continue to be grown annually.

Fertilisers.

Cotton gives its best yields on soil that is well supplied with the substances which usually form plant-food. No exact information is available in regard to just what fertiliser will give the best results, but experiments with a number of other crops indicate that a mixture of equal parts of superphosphate and bonedust is most suitable. While the nitrogen content of many of our soils is not high, the climatic conditions in those districts where cotton can be grown are particularly favourable to nitrification, and therefore sufficient nitrogen in an available form can be relied upon without recourse to artificial fertilisers. It has not yet been found that potash needs to be supplied to crops on the North Coast, but phosphoric acid is deficient, and is supplied by the above mixture, partly in an immediately available form in

the superphosphate, and partly in a form which becomes available to the plant at the later stages in the bonedust. The combined fertiliser therefore feeds the cotton regularly throughout its life.

On the medium soils 2 cwt. per acre should be applied, but on the better-class land 1 cwt. will be sufficient. The fertilisers should be sown at the same time as the seed. Most maize-droppers are provided with a fertiliser distributor, but if no machine is available the fertilisers may be broadcasted.

Cultivation.

When the soil conditions are favourable in regard to warmth and moisture, germination occurs immediately, and the plants appear in a few days. As soon as the young plants are well above the ground, cultivation should be commenced. It loosens up the soil and destroys the sprouting weeds. The first cultivation should be light, and generally a light tine cultivator or harrows will do all the stirring that is needed. It is most important that this cultivation should be given as early as possible, and that it be repeated as frequently as necessary. At this stage the cotton plants are not vigorous enough to outgrow the weeds, and furthermore it is necessary to destroy the weeds before they are well rooted. Cotton is somewhat shallow-rooted, and if the weeds are allowed to make much headway deep cultivation will be necessary to dislodge them, and by cutting and tearing the cotton roots, this deep working will be somewhat harmful. In the later cultivation disc or tine cultivators may be used, according to circumstances. The aim all the time should be to keep the soil in a fine, loose condition on the surface to retain the moisture and destroy weeds, and to avoid going so deep that the roots be broken.

Thinning.

This process in cotton-growing countries is known as "chopping," and is essential to the ultimate success of the crop. As already indicated, the seeding must be heavy to insure a good stand, but this results in many plants coming close together, and, to give each plant sufficient room to develop satisfactorily, thinning is necessary. Failure to thin results in many of the plants being spindly and unthrifty. The operation should be delayed until the plants are about 9 inches high, and they should be thinned to about 9 inches apart. Leaving the thinning until this stage makes it possible to select the strongest plants, and also tends to check what are called the vegetative branches (those that bear few bolls), and to cause the plants to produce chiefly fruiting branches. Some growers thin to 12 to 15 inches apart, but it is considered that by leaving the plants closer together a good yield, if not better, is obtained and picking is carried out more easily.

Thinning can be done with the hoe, but hand-pulling is more satisfactory, as the weakest plants can then be pulled, and the strong, vigorous plants preserved, a more regular stand being obtained than is possible when the plants are "chopped."

Cotton Under Irrigation.

Cotton can be grown successfully on the Murrumbidgee Irrigation Areas on the light loamy soils, but not successfully on the heavy soils, chiefly owing to the difficulty of securing a satisfactory germination. The details given above in regard to culture apply largely to cotton grown under irrigation also. The land should be well graded, and should be flooded, and then

cultivated to a fine condition for sowing. While the cultivation of cotton grown without irrigation may be largely on the flat, in the case of irrigated cotton, after the first cultivation the earth should be gradually worked towards the plants, to form a central furrow for the water and to support the plants.

Picking.

The first flower-buds appear about forty to fifty days after planting, and it is another thirty days before the flowers are fully opened. After fertilisation the flower drops off, and the small boll commences to develop. Meantime other flowers are being produced, and will still be appearing when the first bolls are ripening. The bolls increase in size until they are about $1\frac{1}{2}$ in. in length and slightly less in diameter. On maturity (towards the end of February in the case of the first bolls), the bolls burst, exposing the cotton, which is held very lightly in the open boll. It is not necessary to pick at once, and as a rule picking is not commenced until sufficient bolls are open to allow of a fair day's picking being done. The cotton bolls continue to form until the plants are cut back by frosts. Hence the plants must be picked over several times; as a rule about three pickings are made.

Many attempts have been made to devise a machine that will pick cotton, but so far nothing of a practical kind has been evolved, and picking must still be done by hand.

The cotton is, of course, very light. Where the fibre is of good length the produce of about 80 to 100 bolls will weigh 1 lb., but when the bolls are smaller from 100 to 150 bolls will be required to give 1 lb. of cotton.

The cotton should not be picked when it is wet with dew or rain, and when the mornings are dewy picking should be delayed until the sun has dried the cotton. It is also essential that the cotton be kept clean. All trash, such as dead leaves, &c., that may become attached to the cotton must be picked off before it is put into the bag. When the cotton is picked in a damp condition it must be dried by spreading it out in thin layers on a clean cloth before baling.

The different pickings should be baled separately, as there is generally a difference in the quality of each picking.

From the foregoing it will be seen that there is likely to be no difficulty about growing cotton, provided that the right district is selected, and that good farming methods are adopted, the various operations being carefully carried out as outlined above.

The limiting factor in regard to its profitable production is the labour involved in picking. Under average conditions the yield can be set down as about 600 lb. per acre, although where the soil is very fertile and the weather conditions favourable, up to 1,000 lb. or more can easily be obtained.

The amount of seed cotton which can be gathered per day depends, of course, upon the pickers. The work does not entail heavy labour, but it requires speed in the movement of the hands and steady application throughout the day. A fair day's picking is from 80 to 100 lb. Assuming a yield of 600 lb. per acre, the total time occupied in picking one acre would therefore be six days. If a wage of 12s. per day is allowed the picker, the cost of picking works out at approximately $1\frac{1}{2}$ d. per lb. As the cotton is picked from the plant it is called "seed cotton,"⁵ as it still contains

seed. When the seed has been removed (by the process known as ginning) it is called "lint" or cotton. About 3 lb. of seed cotton are required to produce 1 lb. of lint.

When the seed cotton has been gathered it is packed into bags or bales and sent to the ginning mill for the removal of the seeds. In cotton-growing countries ginning mills are located close to the cotton fields. The seed having been removed, the cotton is then baled and despatched to market. Most of the cotton grown in Queensland is sent to England, which offers the most favourable market.

Growers must realise that cotton requires a fair amount of labour in the picking, and it is unwise to plant extensive areas until they satisfy themselves that they can provide this labour. It would be wise for those who have had no previous experience with the crop to confine their plantings to comparatively small areas. The uncertainty in regard to price should also be taken into consideration by intending growers.

Pests.

A number of insects do some damage to the cotton in this State.

Occasionally *cutworms* attack the young seedlings, cutting them off below the surface. By thick seeding any danger of loss in this way can be avoided.

In the northern districts, a green striped *Boll moth* (*Earias smaragdina*) has attacked the bolls to some extent, while on the Irrigation Area the early bolls were attacked by the *Yellow Peach Moth*. The grubs of these moths burrow into the boll and destroy the cotton.

The *Boll Weevil*, an extremely serious pest in the United States of America, has not yet been reported in this country, and very great care is being exercised in order to keep it out. It is necessary to import some varieties of cotton seed, but only small quantities are brought in, and the seed is sown in strict quarantine. If this pest is once imported it will do enormous damage; and the most stringent action must be taken to prevent it gaining a footing.

Spraying with arsenate of lead would check these pests, but it does not pay to spray cotton in large areas.

LINSEED.

War conditions lately called attention to this plant, which is grown for two main purposes:

- (1) The production of flax (the fibre used in the manufacture of linen), and
- (2) The production of the seed for oil.

The Department of Agriculture is anxious to promote and encourage its cultivation in New South Wales, but the experiments carried out so far are not promising.

Most authorities on linseed culture agree that it is necessary to have light but frequent falls of rain during the growing season, and a humid atmosphere to give the best results. †

As at present cultivated in Europe and other parts of the world, the limitations as to climate are rather sharply defined. Generally speaking, linseed grows best in the colder parts of the temperate regions.

In North America the bulk of the linseed is produced in Canada and the northernmost limits of the United States (where the climate is distinctly cold).

In New South Wales the experiments with linseed have been largely conducted in the wheat districts, because the machinery used on the wheat farm is necessary for dealing with the seed crop. In most of these districts the rapid increase of temperature and diminution of the rainfall which characterise the spring and which are so favourable to the production of an excellent sample of wheat, do not seem to be so well suited for the production of linseed.

In 1918 experiments with linseed were carried out in twenty-three centres in the State, and in 1919 in forty-one centres.

The results of these trials are by no means encouraging, although it must be added that both seasons were unfavourable. In most of the trials only a few pounds of linseed per acre were obtained, and even in some favoured localities where 25 bushels of wheat per acre were harvested, only 3 or 4 bushels of linseed per acre were obtained.

At Yanco, under irrigation, it has been tried for several years, and the best crop—14 bushels per acre—was obtained in 1916. This yield, however, is not considered profitable in comparison with other crops which can be grown on this area under irrigation.

Although most of these experiments have been made to determine whether profitable crops of linseed can be raised in this State, the crop for fibre or flax has also been kept in view, but no hopeful results have been obtained in this direction, few of the crops making more than 12 or 18 inches of fibre at best.

Experiments with linseed are still being continued by the Department with a view to determining those districts in which profitable or hopeful results can be obtained. Seed will be supplied gratis to anyone who would like to make a trial with this crop. Application should be made to the Under-Secretary, Department of Agriculture, Sydney.

SECTION IX.

Vegetable Crops.*

IN this section only crops are dealt with that are grown by farmers under what may be called field or extensive conditions. To attempt to include all the numerous lines that go to make up an ordinary vegetable growers' produce for the city market, or even all that are grown by farmers for their own use, would be to make undue demands upon space. Hence it is that only a limited number of crops are dealt with, and in a manner that presumes production on a fair scale, though the alterations in method where only a small area is contemplated will really be few.

For convenience, certain crops are included in Section VI. "Root Crops"—the potato because it is grown on such a large scale as to make it the most important of all roots, and others, like the turnip, the sweet potato, and the artichoke, because they are grown even more extensively as food for stock than as vegetables for human consumption. Sweet corn is treated in conjunction with maize, to which it is closely related.

CAULIFLOWERS AND CABBAGES.

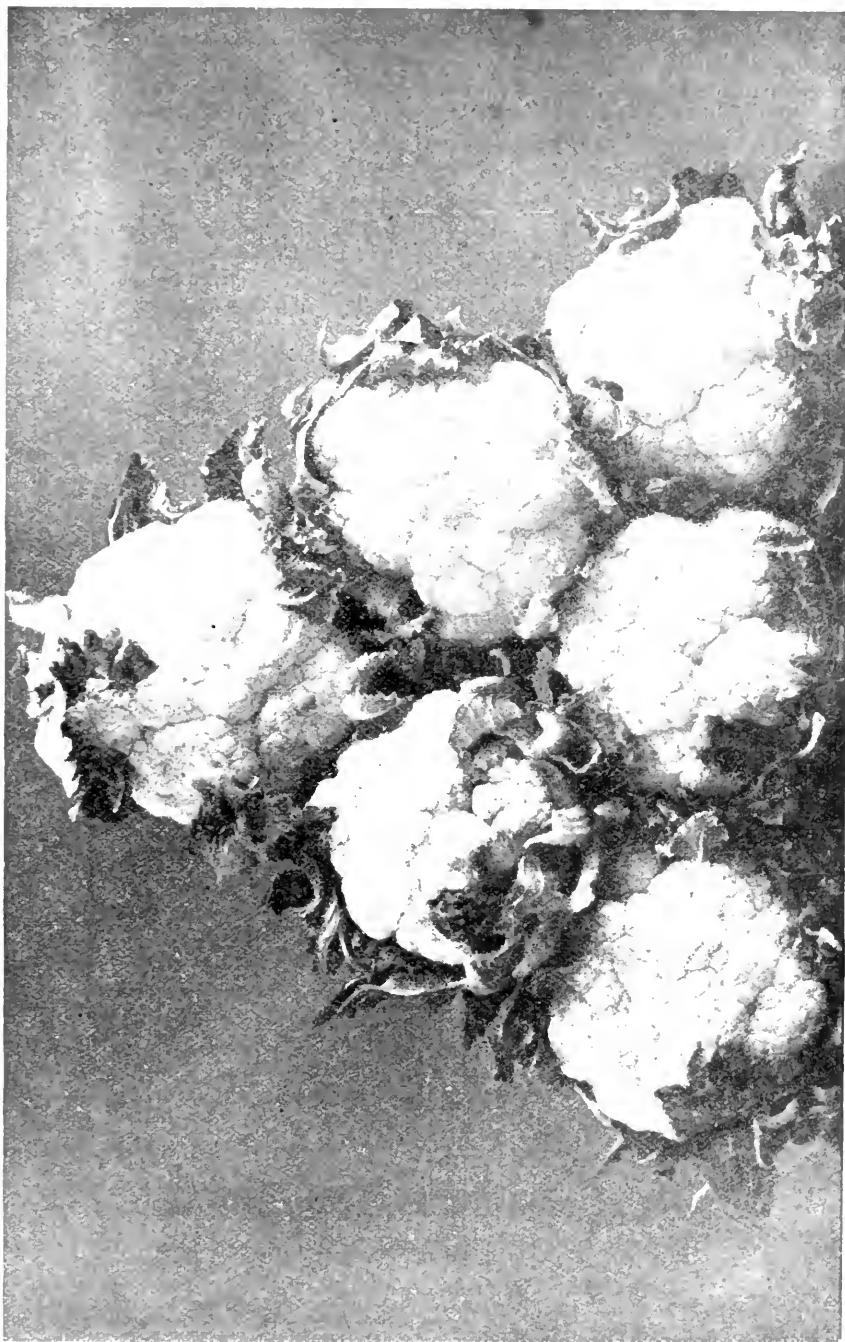
This article deals with the growing of these crops in large areas, but certain recommendations can be modified to suit small growers, *e.g.*, plants can be set closer in small garden plots, as all cultivation is carried out by hand, and there is not the same necessity for leaving so much space.

With the ever-increasing population of Sydney and inland towns, it would appear that the cultivation of these crops can yet be extended with every likelihood of profitable returns to the growers. Apart from the metropolitan markets, there are many instances in which cultivation for local requirements could be extended. Even in the most fertile division of the State—*i.e.*, the North Coast—it is common to see large quantities of these vegetables on the boats from Sydney. Also in many of the inland towns, where the conditions are suitable, the quantity grown is not sufficient for requirements. At Goulburn, for instance (which by virtue of its situation should be on a level with the Bathurst district in production), consignments are sometimes brought from as far back as Wagga.

Many people are under the impression that the growing of these vegetables for Sydney market is confined to the Chinese; but such is not the case. In the vicinity of Sydney the market gardens are practically all controlled by Chinese; but in inland districts, where the gardens are not of such a mixed character—where practically only one or two varieties of vegetables are grown—the areas cultivated are chiefly worked by Europeans.

About 1,000 tons are imported annually from Victoria. The charges for handling and boat freight have increased considerably of late, and the produce is generally not as fresh as it should be when marketed—due to unavoidable delays in delivery—so that there is an excellent opportunity offered for local growers to supply the whole demand. A local commission agent, who handles a considerable quantity of Victorian cabbages and cauliflowers, has stated that the expenses attached to shipment from Victoria are equal to the cost of the vegetables in that State.

* Compiled by A. J. Pinn, Inspector of Agriculture



Cauliflowers grown by Mr. T. Kook, "Rock Mount," Inverell.
Watered by natural rainfall only. Weight, 29 lb., each.

Cauliflowers.

Although belonging to the same family as the cabbage, the cauliflower is not grown to nearly the same extent. This is due chiefly to the necessity for more favourable conditions during the growth of the plant than are required by other members of the same order.

Extent of the Industry.

The district in which the greatest area in this State is devoted to cauliflowers is in the vicinity of Bathurst, including Esrom, Orton Park, Perthville, Campbell's River, and White Rock. The crop is also grown fairly extensively in the Hunter River Valley, chiefly in the vicinity of Bolwarra, Louth Park, Oakhampton, Miller's Forest, Raymond Terrace, Nelson's Plains, and Raworth, mainly to supply the Maitland and Newcastle markets.

Good cauliflowers are produced in many other districts, but their cultivation is not so extensive as in the districts named. One of the chief limiting factors in the success of the crop is the need of a quick train service to market. It is essential, if best prices are to be obtained, that the produce should be placed on the market within twenty-four hours of harvesting.

Climate.

It is preferable to grow this crop so that the flowers form in the cool months. The ideal climate is one in which the days are fairly warm and the nights cool, such as is experienced in the tableland districts.

The Soil and its Preparation.

The soils most suitable for their cultivation are alluvial flats that are fairly rich in organic matter, due to periodical flood deposits. These soils are usually fairly loose in texture, and, being situated on the banks of rivers and creeks, are generally well drained. As a rule the rental value of land of this character ranges from £2 to £4 per acre.

The land should be well prepared, and this is best effected by working a rotation on the farm. A crop such as early potatoes could be harvested in time to allow of cauliflowers being planted out. Again, the cultivation during the growth of potatoes reduces the soil to a suitable tilth, and renders it free from weeds. By employing such a rotation, the land is in use during the spring and early summer months. On account of the risk of reducing the amount of available moisture in the soil by the growing of a crop during the spring months, the practice is not recommended in districts where irrigation cannot be carried out and the rainfall is scanty. If it is desired to bare fallow the land before planting, the soil should be ploughed in spring and cultivated during the summer months to kill weeds and conserve moisture. If it is intended to supply farmyard manure, this should be ploughed under when the spring ploughing is carried out.

Seed.

Good seed is of the utmost importance, and most growers are fully aware of this fact. Bad seed is dear at any price, because, no matter what attention is paid to the crop during growth, there will always be a large proportion of useless plants.

The members of the Cauliflower Association of Long Island (United States of America) placed so much importance on the selection of seed that they sent a representative to Denmark to select a crop from which seed was saved and purchased for the Association. The price charged for seed by the Association before the war was £3 6s. 8d. per lb.

Good seed should give a 90 per cent. germination, and should not be kept for more than three years after harvesting. As there is little difference between one and two-year-old seed, it is advisable for the grower to buy his supply of seed one year in advance. This allows of a small portion being planted, so that its relative value may be gauged one year in advance.



Cauliflowers at Campbell's River Lagoon.

Raising the Plants.

In small gardens, cauliflowers can be grown over a longer season than is possible on large areas. The small gardeners are prepared to take risks that it is not advisable for larger growers to take.

For main crop sowings, the plants are put out from the end of December to the end of February, the seed being sown about six weeks prior to the time of transplanting.

Make the seed-beds where they will be constantly under observation, and where every care can be bestowed upon them. The beds should be wire-netted, as it does not take long for a rabbit or fowls to cause almost irreparable damage.

The beds should not be too wide; they should allow of half being weeded from each side. A suitable width would be about 4 feet. A bed large enough to produce plants for one acre when seed is broadcasted would be 20 feet long and 4 feet wide. It is always advisable to put in sufficient seed to raise more plants than are actually needed. This allows for loss by pests, faulty germination, and the transplanting of healthy plants only.

Two or three ounces of seed is more than sufficient to supply plants for one acre.

The best method of raising plants is to sow the seed in drills in the seed-bed, allowing about 4 inches between the rows. Plants raised in this manner are usually sturdy, and differ from the lanky plants obtained from beds where the seed has been broadcasted. The seed should be sown thinly, and each ounce of seed should sow a length of about 200 feet.

Another method sometimes adopted is to sow the seed broadcast in boxes, and when the young plants have two good leaves on they are pricked out and planted into other seed-boxes in rows about 1 inch apart, where they are left until they obtain their fourth leaf. After this the plants are transplanted into rows 4 inches apart in the beds, remaining there until ready for transplanting, being then about 4 or 6 inches high. This method is more often employed for cabbage when seed is raised during the winter months.

It is advisable to protect the seed-boxes during frosty nights by screening with hessian. The seed-beds should have a north-easterly aspect, and should be protected from the westerly winds.

The young plants should be watered occasionally in the seed-bed, but should not be forced so as to make them spindly.

The soil in the seed-bed should be of good texture, and, if possible, a quantity of well-rotted farmyard manure should be incorporated. The organic matter supplied by the manure regulates the water-holding capacity, and also offers less resistance to the tender roots in their development. After the seed has been sown, it is advisable to scatter dry, finely pulverised manure lightly over the surface of the bed. This acts as a mulch, and prevents caking of the surface soil, thus offering no resistance to the young plants when germinating.

Transplanting.

If possible, a dull day should be chosen, but with a large area it is impossible to choose so carefully. If the weather is very hot and the planting cannot be postponed, it should be done during the latter part of the afternoon. When this is the case part of the morning can be employed in lifting the plants in readiness for afternoon planting. The plants when lifted should be laid straight and covered with wet bags.

Unless the soil is very dusty and hot, the dibber holes are better left dry until after planting, but the roots should be covered with puddle (liquid mud) to prevent injury. After the soil has been pressed firmly round the roots, a quantity of water should be applied in order to give the plants a fair start.

The quickest method of planting by hand is to have a boy dropping the plants a few holes ahead of the man planting. The boy can then carry the plants in a bucket, so that the roots are constantly in puddle.

If the plants are somewhat large, it is wise to screw the tops off the leaves. This considerably reduces transpiration, and the roots are able to keep up the supply of moisture needed.

In America, planting machines have been tried extensively of late, but the bulk of the growers have again fallen back to hand-planting, as they consider this method, although slower, gives more reliable and better results. One of these machines has been used in the Moss Vale district. The machine requires a driver and two lads to drop plants. A barrel of water is carried, and at each click which marks the time for dropping a plant, about half a pint of water is delivered into the furrow. As the lads cannot always drop the plants just at the right moment, the water is usually allowed to run all the time.

For early varieties the planting is usually closer than for the later varieties. For the former the distance is usually 3 feet x 2 feet 6 inches, requiring about 5,800 plants per acre, and for the latter 3 feet x 3 feet, requiring 4,840 plants per acre.

Manuring.

It is essential that soils for this crop should be well supplied with organic matter. Unless frequent applications of organic manures are made, the supply of this constituent is soon depleted, and the grower wonders why his soil does not produce profitable crops. The tendency of European growers is to grow these crops until the natural fertility of the soil has been considerably reduced, and then abandon cauliflower cultivation.

Most of the river flats are rich enough to grow several crops without the application of farmyard manure, and where the land is subject to periodical floods and benefits by flood deposit, there is scarcely any need for heavy manuring.

Where the soil is not naturally rich and the crop requires stimulating, the following application of artificial fertiliser will usually be found to be productive of good returns. Apply a mixture of dried blood, bonedust, and superphosphate in equal quantities at the rate of not less than 6 cwt. per acre, and later (usually just before the heads begin to form) a top-dressing of sulphate of ammonia or nitrate of soda at the rate of 1 cwt. per acre. Care should be exercised in making this top-dressing, and it is advisable to mix these nitrogenous manures with a bulk of earth or sand in order to facilitate distribution. The application should be made to the soil between the rows and contact of the manure with the plants avoided.

Cultivation.

Cultivation between the rows with horse cultivator should be continued at short intervals, until the plants are too big to allow of it being carried on. If plants are not planted on the check system, and do not allow of cross cultivation, chipping-hoes will have to be used to keep down weeds, and establish the earth mulch between the plants.

Tying.

This is the practice of tying the outside leaves over the plant to protect the flower from weather influences. The system has its drawbacks, and is seldom adopted in this State. The chief difficulty in adopting this method is the trouble of determining whether the plants are ready to harvest. Some growers use a different coloured band each day, so that when examining for fitness for market they can pick out the mature heads by the various coloured bands. This method is a satisfactory one, if the development of the heads is even.

It is very important that the flower should be kept clean and white. While the head is small, it is well protected by the young leaves surrounding it, but when the coral head begins to grow rapidly, it must be covered in some manner to protect it from sun and frost. This is usually accomplished by breaking off some of the largest outside leaves, and placing them amongst the other leaves so as to properly cover the head, or it may be done by bending over some of the larger inner leaves.

Harvesting.

As soon as any of the plants become fit for harvesting, examination of the field must be made daily, and heads must be cut before they show signs of the flower stalks breaking away, thus giving the head an uneven, loose appearance.

The cutting is usually done with a large knife, the plants being cut about 3 inches below the head, keeping all but the outside, dirty leaves to avoid damage in transit. The plants, when cut, may be carried to convenient heaps round the field; or, if the waggon or cart can be taken through the crop without damaging the growing plants, they may be loaded direct.

The weight of cauliflowers, as marketed, varies with the size, ranging from fifteen to twenty dozen per ton.

Yield and Returns.

The yield varies considerably, according to the season and the variety grown. When good seed has been used, and irrigation has been practised, the yield from main crops can be reckoned at about 400 dozen per acre. This allows of very few misses, but this yield is frequently obtained under the above conditions, even when planted 3 feet x 3 feet apart.

With cauliflowers selling at from 3s. to 3s. 6d. per dozen, a yield of 400 dozen per acre would give a gross return of from £60 to £70 per acre. This return should allow of a substantial profit being made after paying all expenses.

The prices taken for the purpose of showing the probable return are the average prices obtained for medium grade. Prime cauliflowers would average at least 5s. to 12s. per dozen, while the small ones would not bring more than 1s. 6d. per dozen. This latter grade is often sold to the local pickle factories.

Care should be taken not to plant a greater area than can be properly attended to. By attempting too much, many a grower has failed. The area to be worked per man should not exceed 3 or 4 acres.

The cost of transport by road can usually be estimated at 1s. per ton per mile.

Varieties.

Veitch's Autumn Giant is, undoubtedly, the chief variety grown. It is a late variety, with long stem and large undulating dark leaves. The head is large, very white, and well covered by inner leaves.

Dwarf Erfurt (also known as Early Erfurt or White Queen) is an early variety, and is practically the only variety grown by the Long Island (U.S.A.) growers. It is a plant of medium size, producing a fairly large, solid, heavy head of good shape.

Snowball.—This variety is a good early sort, and is much favoured in the Goulburn district. It is a little earlier than Dwarf Erfurt, but not equal to it in quality.

Early London.—A fairly early variety, grown largely in the metropolitan gardens.

Broccoli greatly resembles cauliflower, and should receive the same treatment. It takes longer to mature.

Cabbages.

The cultivation of this crop is practically identical with that of cauliflowers, and it will only be necessary here to deal with any points of difference.

The largest cabbage-producing district in this State is undoubtedly Burrawang, situated about 9 miles east from Moss Vale, and in the surrounding localities, including Wilde's Meadow, Myra Vale, &c., and extending to Robertson and Kangaloon. About 300 tons are consigned from Moss Vale Station every month during the season, and large quantities are also sent out of this district from Bowral. Large areas are also grown in the suburban gardens, as well as at Gosford and in the Maitland district.

The crop can be grown in practically every district in the State. Nearly any soil will grow cabbages successfully if sufficient manure and decaying vegetable matter are added to keep it in good physical and chemical condition.

As a rule, in the Burrawang district, the rich volcanic soils are chiefly used for the winter crop, and the lower land for the summer crop.

This vegetable has, perhaps, a wider range than any other, being more or less successfully grown in the hot interior and on the cool tablelands. It is essentially a cool climate plant, and when grown in the hot districts must be planted so as to mature before the heat of summer.

In some portions of the State, and chiefly during the winter months, cabbage plants are raised from seed in hot-beds, and gradually hardened off before planting. As with cauliflowers, the seed should be sown six weeks before the plants are required in warm weather; but during the cooler part of the year two months should be allowed.

The distance varies according to the variety used. For the smaller varieties, such as St. John's Day, 2 feet 6 inches x 2 feet is sufficient, and for larger sorts, as Savoy and Succession, 3 feet x 2 feet. If the soil is of poor quality the plants should be given more room, and should be planted 3 feet x 3 feet. When planted at this latter distance on rich soils, the tendency is for the plants to become too large.

The time to harvest is when the heart is fully developed, and does not yield to pressure from the hand.

Cabbages being planted closer than cauliflowers, the yield is, consequently, larger in number of heads, and a yield of from 500 to 600 dozen per acre can be expected in average years. The average price is about 2s. per dozen.

Succession (Henderson's).—This is a very popular variety, and the one most largely grown. It is fairly early, has large flat heads, closely packed, carries well, and is a favourite on the market. It stands the heat of summer fairly well, and does not run to seed quickly. The best all-round variety grown.

St. John's Day.—This is one of the best for hot climates. It is very early and produces a firm heart. A small cabbage.

Improved St. John's Day.—This is the best of summer cabbages, and altogether distinct from the small St. John's Day, being somewhat later and larger.

Savoy.—This is a very crinkled type of cabbage, having a very dark green colour and a distinct flavour. It is especially suitable for the cooler portions of the State, being planted in February so as to mature during autumn and winter, the flavour being considered best after exposure to frost.

London Market.—This is a good main crop variety for autumn planting.

Early Jersey Wakefield.—An early sort, and largely grown in small gardens. It has a very pointed heart, and should be cut as soon as ready for use, otherwise it will run to seed.

Pickling Cabbage.—The cultivation of this class of cabbage is identical with that for the other varieties. Most are red in colour.

Fungus Diseases of Cabbage and Cauliflower.*

Black Rot.

This disease, popularly known as Black Rot, but sometimes as Dry Rot, Brown Rot, Black Stem, Black Vein, &c., is a bacterial one, caused by *Pseudomonas campestris* (Pammel), Erwin Smith. Most cruciferous plants are liable to attack, e.g., cabbage, cauliflower, kale, kohlrabi, rape, turnip, swede, radish, &c. The following account refers more particularly to cabbages and cauliflowers.

The plants are attacked in all stages of growth. When young plants are attacked early and severely they may be destroyed in a few weeks. The severity varies with the season. In moist weather the disease may become epidemic and destroy an entire crop. In ordinary weather it may take several months to cripple the plants or destroy a crop. Infection takes place through wounds, but chiefly through the water pores on the margins of the leaves. The bacteria brought to the leaf often commence development in the drops of water exuded by the leaves, and then enter through the pores. They rapidly multiply and spread through the veins (vascular system) of the leaves, and finally travel down the leaf stems (petioles) and stem of the plant. The affected area of the leaf becomes dry and leathery, and the veins have the appearance of black streaks. In the thick leaf stalks the black streaks may not show from the surface, but on cutting across or along them the streaks will usually be seen. Often a part of a leaf or one side of a plant only will be attacked, and the black streaks can then be traced down the corresponding side of the leaf stalk and stem of the plant. Dwarfing, one-sided growth, yellowing of foliage, gradual loss of leaves, and brown streaks in the vascular bundles are the chief symptoms of the disease. The cortex and pith of the stem are usually free from bacteria. The gradual and successive shedding of the leaves often result in the production of a long, dry stem with the conspicuous scars of the many cast-off leaves upon it.

In ordinary weather, the picking off and burning of all affected leaves helps to check the disease; but when the plants are about ready for market no time should be lost in harvesting them, as they will not keep. It has been proved that the bacteria are capable of living for months (even a year) on the surface of the seed, and that infection is spread in this way.

The chief methods of prevention are: Disinfection of the seed for fifteen minutes in a solution of formalin 1 part, water 250 parts; or corrosive sublimate 1 part, water 1,000 parts. The latter is a very strong internal poison, and must be handled with care. All insects should be kept down, to prevent them spreading the disease, and if a field is infected, all refuse of old, diseased plants should be collected and burnt, not buried, and rotation practised, excluding the above-mentioned crops.

In making the seed-bed, manure known to be free from cabbage refuse should be used.

Club Root.

The cause of this disease is a small parasite known as *Plasmodiophora brassicae* (Woronin), one of a lowly group of organisms known as myxomycetes.

Plants affected with Club Root are characterised by swellings of the roots, sometimes as large as two fists. Few or no lateral roots are formed. Affected plants have a wilted appearance during the day, but recover at

* Compiled by Officers of the Biological Branch.

night. Plants are generally attacked when young or in the seed-bed, and when so affected have a stunted and sickly appearance and seldom grow to maturity. The malformations may be confused with root-knots caused by eelworms (or gallworms), but these as a rule are not so large as the malformations associated with Club Root.

The parasite lives within the cells of the roots of certain plants, especially these belonging to the natural order Cruciferae. It is

mostly confined to the cortex, and within the cells the parasite passes through some of the stages of its development. At one time the cell is filled with what appears to be a number of shapeless specks of jelly (protoplasm). These later unite to form one mass, the plasmodium, which practically fills the cell, the original contents of which have been absorbed. Still later, the plasmodium divides up to form numerous spores covered with a thin membrane. The parasitised cells and also the neighbouring ones are stimulated to very active growth. They increase in size and also in number by rapid cell division, thus producing the remarkable enlargements of the underground parts of the plant. The parasite becomes distributed within the tissues by this cell division, but it is also able to penetrate the cell walls. By the decay of the attacked parts, the spores are set free into the soil. Under favourable conditions, the spore germinates and gives rise to what is known as a zoospore (or swarm spore), a speck of protoplasm provided with a long appendage or cilium. These swarm spores move about in the soil and are capable of entering a root apparently through a root hair. Once within the plant the swarm spore goes through the stages outlined above.



Club-root of Cabbage.
(*Plasmiodiophora brassicae*.)

We thus see that the parasite is confined either to the soil or to the underground parts of the plant, and therefore no sprayings of any kind are of any use against this disease. The majority of Cruciferae are susceptible, but it appears that varieties of cabbage vary in their susceptibility. Soils of an acid nature are favourable to the development of the parasite. Air-slaked lime is the most valuable substance to use to check it. Applications of 2 to 4 tons per acre are recommended, thoroughly incorporated in the soil, after all refuse of diseased crops has been removed and burnt, not

buried. Seedlings should be carefully examined, and if they show any signs of Club Root should be burnt. As the soil may remain contaminated for some time after a crop is attacked, a rotation of crops should be made. What the rotation should be the farmer will determine for himself, provided that cabbages or other Cruciferae be not grown more often than once in three years.

Downy Mildew.

This disease probably occurs wherever cabbages are grown, but as a rule does not cause any serious loss except in seed-beds.

The cause of the disease is a fungus, *Peronospora parasitica* (Pers.) De Bary, which may attack any cruciferous plants. It first appears as a whitish downy mould in spots mostly on the under side of the leaves, but may overrun the plant-stem and leaves. The parts of the leaf immediately surrounding the diseased area appears yellow and later turns brown and dries up. Frequently a mottled appearance results. The hyphae of the fungus live entirely within the tissues, and send out branches into the open air, and on these are borne numerous spores or conidia, which are readily carried from one plant to another by a gentle breeze or by insects. The spores germinate and send their hyphae into the leaves through the breathing pores (stomata). The disease is carried over the winter by means of another kind of spore (oospore), which is much more resistant to unfavourable weather and soil conditions than the conidia, and these will re-establish the disease in the spring.

The chief control measures are concerned with the seedlings. Any plants found diseased and all remains of dead plants should be destroyed. The seedlings should not be grown too thickly nor kept too wet in the seed-bed. When attacked they should be thinned out and sprayed about every ten days with a weak Bordeaux mixture (6—4—50).

This disease is sometimes associated with another disease that is common on Cruciferae, known as "White Rust," as it appears like a white crust on the plants, and is due to the fungus *Albugo (Cystopus) candida* (see "White Rust of Turnip," page 514). The same conditions and precautions apply to both diseases.

Black Leg.

This disease occurs on cabbages and cauliflowers, especially when young. A fungus *Phoma oleracea* (Sacc.) is responsible for the condition. Infection frequently takes place on the stem at the surface of the ground, just below the junction of the leaves, and also at the margins of the leaves. The disease spreads downwards to the roots and around the stem, often completely girdling it, giving it a black appearance—hence the name. Often the fibrous roots and the lateral roots are killed. Before the plant dies, a purplish tint is developed in the foliage, and persists until the plant dies. Wilting of the plant is very characteristic, the leaves adhering to the stem and drooping. On the leaves sunken spots occur, and later these dead areas become covered with numerous minute black specks, which are the pycnidia of the fungus enclosing numerous spores. It is harboured for the most part in the soil on decayed stems and leaves of plants. Hence, in preventing the disease, the need is shown, as is usually the case, of collecting all refuse of present and past crops, and burning it. No leaves or parts of diseased plants should be thrown on manure heaps, to harbour the disease for the next crop. Seed-beds can be sprayed with weak Bordeaux mixture (6—4—50), at the rate of 1 gallon to each 10 square feet of bed space, and only clean seedlings should be planted out.

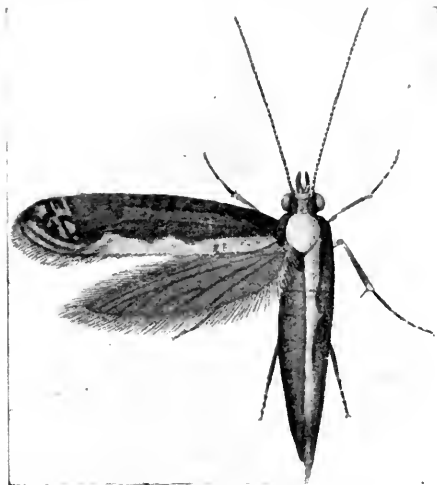
Insect Pests of Cabbages and Cauliflowers.*

The Diamond-backed Cabbage Moth (*Plutella maculipennis*).

Under the name of "cabbage grub" or "cabbage worm," the caterpillar of this little moth, once a European turnip pest, but now world-wide in its range, is well known to Australian cabbage growers, as well as to the cabbage consumer when he finds the little green worms among the leaves of his purchase.

The life-history of the Diamond-backed Cabbage Moth is so well known that it need only be briefly outlined in these pages. The moth, on the wing among

the herbage, appears to be of a uniform brown tint, and does not show the distinct angular row of pale markings along the upper margin of the folded wings from which it takes its popular name, "diamond-backed," and by which it can be so easily identified among pinned specimens from all other allied species. It measures slightly over half an inch across the outspread wings. Emerging from the stout chrysalid skins, which, attached to bits of cabbage leaves, stalks or weeds, have protected them, under shelter of their flimsy cocoons, through the winter months, these active little moths lay their eggs upon the foliage of the young cabbage plants, and remain in hiding among the weeds and on the under side of the cabbage leaves. As soon as the fine

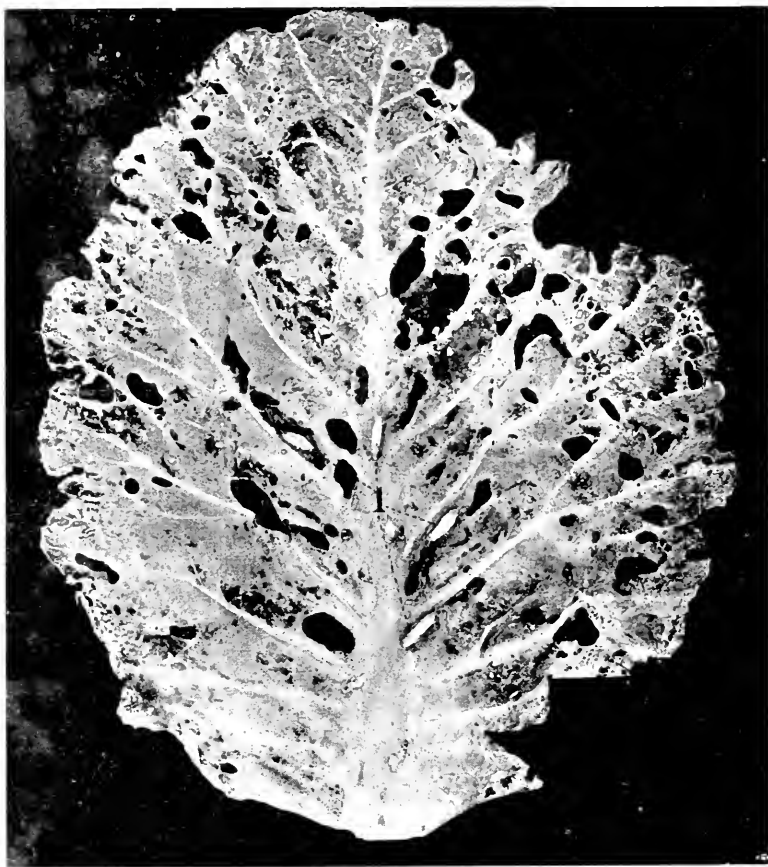


Diamond-backed Cabbage Moth, viewed
from above. [Enlarged.]

weather sets in, if one walks through a cabbage patch, and sees numbers of small brown moths rising up before him, he will, even if the plants have not begun to show its effects, know that the cabbage moth is about. If he investigates the plants, he will find the leaves marked with glassy spots where the tiny, black-headed, pale green caterpillars have been at work. So like the surface of the leaf are these caterpillars in coloration that they would be easily passed over, if it were not for their gnawing off the epidermis of the leaf.

As they increase in size, they become slender, bright green caterpillars (popularly known as "cabbage worms"), and rest upon the surface of the leaves, gnawing holes right through them. At first they confine their attention to the larger outer leaves, but as they increase in numbers they gnaw all through the plant, and if they are allowed to reach this stage the cabbage or cauliflower is soon of no marketable value. The caterpillars are active little creatures, and if touched they roll away or drop from the leaf to the ground, often hanging suspended on a silken thread, and thus they escape their many enemies. When full grown, they betake themselves to the shelter of the under side of the leaf upon which they have been feeding, and spin

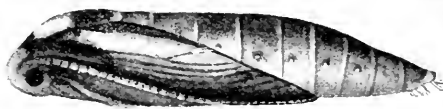
* Compiled by Officers of the Entomological Branch.



Leaf of Cabbage showing damage caused by Caterpillars of Cabbage Moth, with larvæ and cocoons on the leaf. [Reduced.]



Caterpillar. [Enlarged.]



Pupa (chrysalid) removed from cocoon. [Enlarged.]



Cocoon enclosing the pupa. [Enlarged.]



Cabbage Moth, side view. [Enlarged.]

The Diamond-backed Cabbage Moth (*Plutella maculipennis*).

a lattice-like, elongate, oval cocoon, or rather hammock, of silken strands, securely attached to the leaf, but open at both ends. It is such a flimsy, delicate structure that one can observe the transformation of the insect. At first a green pupa, it changes to dull brown, and finally reveals all the delicate outlines of the coming moth, enclosed in the pupal skin.

Our cabbage and cauliflower growers in many districts grow these vegetables practically all through the year, the young plants often being set out alongside those ready for cutting, or upon the patches from which the marketable vegetables have been cut. Thus, with a continuous crop, the cabbage moth can breed all the year round. This is one of the reasons why the cabbage moth is such a serious pest in New South Wales.

Many of our growers are not careful enough in seeing that the young cabbage plants which they buy are perfectly free of moth grubs. Anyone going around the Sydney shops when the suburban resident is busy planting his kitchen-garden, and there is a brisk demand for cabbage plants, will see plants for sale with leaves riddled with holes caused by the cabbage moth, and covered with grubs and eggs.

Unless the young plants in the seed-bed are treated until the time of planting out, they soon attract the moths from old cabbage patches. If all cabbage plants were carefully clipped and washed before they were planted out, they would have a fair start in life, without any aphid, cabbage moth, or other pests infesting them.

Then again, cabbages and cauliflowers are grown in open fields, and as soon as they are ready, all the marketable ones are cut and bagged; the unsaleable ones are left on the ground to rot or run to seed, and remain until the owner wants the ground for something else, which may not be for months. This neglected plot is the breeding-ground for the cabbage moth and all other cabbage diseases, insect and fungus.

There is no question that the application of boiling water will kill all the grubs with which it comes in contact, without doing any serious damage to healthy plants. It is applied with a watering-can with a fine rose, the operator walking down between the rows and giving each infested cabbage or cauliflower a good sprinkle. This is very handy for a small garden patch, but in a large field the difficulty is to keep a large quantity of water at the proper temperature, and to distribute it over a large area.

Some growers depend chiefly on kerosene emulsion, and keep the young plants clean until they begin to heart, when the danger is considered to be over. Lime and tobacco dust (lime-dust 4 parts, tobacco-dust 1 part) is a very effective remedy. Start with clean cabbage plants in clean ground, and keep the ground clean; and after the crop is marketed clean up the cabbage patch.

Before transplanting dip all young plants in any of the spray solutions for sucking insects. Such solutions are miscible oil spray and tobacco wash, ingredients for the preparation of which are obtainable from stores and seedsmen; soap wash (one cake sunlight soap dissolved in 2 gallons water, and used warm); and kerosene emulsion, directions for the making of which are given in one of the free leaflets of the Department.

Spraying with arsenate of lead 1 lb., soap 3 lb., water 25 gallons has been found effective, but growers are prejudiced against using it on maturing plants. Being a poison it should, of course, be used with care, but if the spraying is done during the early stages of growth there will be no necessity to spray later.

Cabbage Aphis.

This insect (*Aphis brassicae*, Linn.) is one of the worst with which the growers have to contend. It breeds very quickly, and lives on the juices of the plant, giving most trouble in a dry season when the plants are stunted and not growing.

The young, when first hatched, are yellow; in the second, wingless, stage, a dull olive-green, covered with a mealy bloom; when full-grown, of a greyish-green tint, with the eyes, legs, spots on either side of the body and tips of the antennae black; the winged forms are of a much lighter green colour.

Controls.—Spraying with tobacco and soap wash early in the season, when the plants show the first signs of its attack, is recommended; also dusting with soot or lime early in the season.

Spray with kerosene emulsion, made on the following formula:—Hard soap, $\frac{1}{2}$ lb., kerosene 2 gallons, boiling water 1 gallon. Dilute or dissolve in 22 gallons of water. To make, dissolve $\frac{1}{2}$ lb. of hard soap in 1 gallon of boiling water; then remove the vessel from the neighbourhood of the fire, add the kerosene and churn for ten minutes. One essential condition of success in making this emulsion is that the liquids should be as warm as possible. It is also necessary that the water be as soft as possible.

In preparing this compound, the main trouble is in getting a true emulsion, which can only be done by thorough agitation. This is best done by pumping the mixture into itself for some minutes. When this creamy mixture becomes cold, it gets thick and almost solid, and there should be no trace of free oil on the surface. If there is still unemulsified oil, the best plan is to add some more boiling soap solution and pump again. Free oil destroys the foliage. Care should be taken to use the best kerosene and good soap.

Kerosene being highly inflammable, particular attention should be paid to the directions for mixing well away from the fire. Boil the soap and water in one vessel and carry it away from the fire before mixing with the kerosene. Any kind of vessel may be used.

Kerosene attacks india-rubber; consequently the tubing, and indeed the whole spraying outfit, must be well washed with hot water directly after use.

Sometimes it is of advantage to prepare a quantity of emulsion as a stock, for use as required. When this is done and it is required to dilute it to make up a spray, this should be done by adding boiling water to it, and not by melting it over the fire, which is dangerous, especially indoors.

Cutworms, Eel-worms, and Rutherglen Bug.

Cabbages and cauliflowers are also attacked by the above-named insect pests.

Suggestions for the control of cutworms will be found in connection with maize (see page 437), while eelworms and Rutherglen bug are dealt with in connection with potatoes (pages 492 and 491). The change of crops advised in connection with these pests will, of course, be adapted by the grower to his own conditions. Those mentioned in reference to eelworms, for instance, are not likely to suit the grower of cabbages, but the principle still applies, viz, change to some crop that the eelworm will not attack, or, in other words, deprive them of their natural food and starve them out.

THE ONION.

In view of the large quantities of onions that are annually imported into New South Wales from other States (notably Victoria), and of the natural facilities for the production of the crop which portions of our own State possess, the development of onion-growing into a substantial local industry would seem to be long overdue. New South Wales has ample land of a suitable type, a climate that is particularly well adapted to the crop, and a season several weeks ahead of the southern states, which gives the New South Wales grower a great advantage in marketing. Our farmers are, unfortunately, loth to undertake onion culture, mainly because of the tedious work involved in keeping the crop free from weeds, though weeding is not arduous if care has been taken in the preparation of the land and a deep preliminary ploughing is followed by a succession of harrowings extending over some months. By this means the work after planting is reduced to a minimum. Successive sowings on the same land for a number of years still further reduce the weeds, and are recommended, for, unlike most other crops, onions may be grown for ten or twelve years without a rotation crop, provided no disease makes its appearance. The seed-bed must be fine and moist at sowing time, and must have a firm subsurface.

The ideal climatic requirements for onions are warmth, ample moisture, and absence of strong winds. Owing to a comparatively deep-rooting habit, however, the crop will withstand excessive heat, and will weather dry conditions longer than most others. The soil chosen should be well drained and of a loose, friable nature, and the best crops are obtained on black or red volcanic or dark sandy loams. The keeping quality and size of the bulbs is largely determined by the nature of the soil. Onions grown in sandy soil mature quickly and are of large size, but they are of poor keeping and carrying quality, while those grown on chocolate or black soils of a stiffer nature have thick skins, keep and handle well, and are of greater substance and solidity of flesh.

Preparation of Land.

It is a great advantage to get the land ready as early as possible, so that any weeds which appear can be got rid of and much subsequent labour thus saved. The land should be ploughed as deeply as the subsoil will permit. The character of the soil should determine the proper depth of ploughing. If the land is loose, rich, and friable, ploughing to a depth of 10 to 12 inches is recommended; there is little danger of ploughing too deep. It is not desirable to turn up a stiff heavy subsoil in preparing ground, for this invariably diminishes the yield, renders cultivation more difficult, and requires more frequent tilling. Frequent cross cultivation and harrowings are essential to reduce the soil to a firm tilth; the finer the tilth the better for weeding and hoeing. The soil cannot be too fine for the reception of the seed, and must be firmed with the roller, for that condition is requisite to ensure the proper development of the bulbs. A disc harrow is almost indispensable if clods and lumps are numerous. The roller and this implement may be used alternately with advantage. Soils which are stiff and heavy, and are deficient in fertility, may be greatly improved by growing and ploughing under cowpeas. The effect of such treatment is to enrich the soil, making it loose and friable, and free from many weed seeds.

Selection of Seed.

It is a most essential point to obtain fresh, reliable seed true to name. Onion seed loses its vitality very quickly, and none older than last season's crop should therefore be procured. Growers sometimes make the mistake of purchasing seed of uncertain vitality because it is cheap, but it is impossible to secure satisfactory results without seed of superior quality. A good plan to determine the vitality is to place some of the seed in a moistened cloth, put it in a shallow dish, and note the number that germinate.

Many experienced growers invariably save their own seed, for by selection and judicious cultivation through a series of years it is possible to raise the standard of excellence. To do this, large, well-matured, evenly-formed bulbs of the respective varieties should be selected and carefully stored each season and planted out in the following season in rows about 3 feet apart, stakes being placed to each bulb to secure the heads from being blown and knocked about and probably broken by the wind. If the season is favourable—that is, dry and hot—a fair amount of well-ripened seed should be obtained.

Promptness in harvesting is essential, for if delayed too long the seed receptacles open, and part of the seed will be lost in handling. When the tops turn yellow, remove them with about 6 inches of the stem, and place them in strong paper bags, and hang up in a well-ventilated place to dry. Frequent turning will hasten the drying, and most of the seed will drop out in the operation. Any seed remaining can be beaten out with a flail and cleaned by winnowing. The seed should be stored in a well-ventilated place free from excessive moisture.

In other cases it might be possible to secure the seed from a neighbouring grower, whose stock is known to be good, and suited to the district. Where this is not convenient or possible, the seed should be obtained from a reliable seedsman. Mixed sorts should be avoided, in order that one part of the crop shall not ripen before the remainder.

Varieties Recommended.

The number of varieties of onions is very considerable, and among the recognised types are Silver Skin, Extra Early Globe, Yellow Globe, Brown Spanish (Portugal), James' Keeping, Giant Rocca, Flat Italian Tripoli, and others.

Being one of the earliest, Extra Early Globe is recommended for early crops. It is a fine, well-shaped globe onion, small in the neck, and a heavy cropper. Silver Skin is also a good early variety. Brown Globe is a good strain, and coming in between early and late kinds is suitable for a mid-season crop. It is a good cropper, and has a solid flesh, good colour and skin. Brown Spanish (or Portugal) is an excellent main crop variety, of handsome shape and appearance, has a skin of deep brown colour, and white and solid flesh. It stands handling in transit well, and is unequalled for storing. Mammoth Silver King is a fine white large onion, a medium keeper, with firm flesh, and a mild flavour. Ailsa Craig is of exceptionally large size, has light-brown skin, mild flavour, and keeps fairly well. Many other varieties will be found suitable for the various soils and differences of climate. Varieties should be selected which contain desirable characteristics or command the highest price in the market. The best type for general purposes should be nearly globular in form, hard and compact in structure, and mild and sweet in flavour, fine skin and small neck, and medium size.

Time to Sow.

The time for sowing varies considerably, and may extend from February to August, according to the variety used and earliness of the district, and it is wise to make inquiries and follow the practice of successful growers in the locality. To ensure the crop ripening before the heat of summer in short-seasoned districts, early sowing of early-maturing varieties is advisable. April, May, and June are on the average the most suitable months for seed-sowing.

Sowing.

The ground, having had a thorough course of preparation, should be rolled and firmed for the reception of the seed, otherwise the plants will run to neck and leaf. While maintaining a firm soil, the grower may with advantage maintain a mulch on the surface by the movement of the hoe in keeping down weeds. Though broadcasting is still practised, sowing in drills is increasing in favour, and this is the system recommended. The seed should be drilled to a depth of about 1 inch, and the rows 15 to 18 inches apart; these distances will admit of efficient weeding operations. It is an important matter to have straight rows, with a uniform distance between them; it adds to the attraction of the field and facilitates the use of the wheel hoe. A line may be stretched as a guide by which to drill the first row; if the spaces become irregular as the operation proceeds, the rows should be straightened by means of the line. The quantity of seed required per acre, if drilled, is from 2 to 3 lb., and if broadcasted, from 4 to 6 lb.

The plants should subsequently be thinned out to about 4 to 6 inches apart, but transplanting is greatly favoured by some growers. Onion seedlings may be considered ready for transplanting when they have attained the thickness of a slate-pencil. If the soil of the seed-bed has contained a fair proportion of sand, the root development of the seedlings will often be excessive, and may need a little trimming before they are planted again, but providing the soil in the plot has been well prepared and is of fine texture and reasonably moist, little harm is done. A few inches of the top growth is also usually screwed off. When transplanting care should be taken not to bury too deeply—merely cover the roots and base of the young bulbs with soil. About 4 lb. of seed per acre is required, if it is to be drilled in, and 1½ to 2 lb. if it is to be sown in the seed-bed. The after-cultivation of the crop consists of hoeing and intertillage with the hand cultivator, and this should be commenced as soon as there is no danger of covering the plants with soil. It is essential that all weed growth be kept absolutely in check, and the surface well stirred, so as to form a mulch that will prevent evaporation, especially the formation of a crust after rain.

Harvesting.

Onions take from six to seven months to reach complete development. Bending the stems over is a great aid to ripening. When the tops have withered and are dry and crisp, the bulbs should be lifted; the plants are simply pulled by the hand, three or four rows forming one windrow. They should be allowed to remain in the sun for about five to seven days, the length of time depending on the weather, but they should not be allowed to scald. If the weather is wet it may be desirable to take the bulbs under cover, spreading them out in an open dry shed and turning them occasionally. Some growers adopt the method of bunching and suspending

them. Before bagging, the tops and roots should be trimmed off, leaving about an inch of the top on the bulb; sheep shears are very suitable for the purpose. Great care should be taken not to bruise any of the bulbs, for decay sets in quickly. Storage is best effected in cases in a well-ventilated shed.

Under fair conditions a yield of 4 to 6 tons per acre can be expected.

Insect Pests and Diseases.

The worst insect pest is the onion maggot (*Phorbia ceparum*). The maggots come from the egg deposited on the plant, and require about a week to hatch; the larvæ burrow into the bulbs and remain there about two weeks, then emerge and pupate in the ground. The first indication of their presence is the tops turning yellow in colour, then withering, and finally drying before the bulbs have matured. It is difficult to suggest a remedy, but liming the soil is found to be beneficial. If the infestation is very severe, rotation of crops should be tried.



Onion Plant affected by
Downy Mildew.

Downy Mild or Blight.—This is one of the most important diseases of the onion. The cause is a fungus (*Peronospora schleideniana*, Whetzel). The disease is best diagnosed by the presence of more or less oval yellow spots with a purplish border. On these spots the fungus is produced, giving the surface a downy, violet appearance. Owing to the breaking down of the tissues, due to invasion by the fungus, the leaves fall over or collapse.

The spores of the fungus germinate and put forth a tube which penetrates a stoma (breathing pore) of the leaves and thereby causes infection. Distribution of the spores can be brought about by wind and cultivation. Another type of spore, a thick-walled resting spore (oospore) is produced in the tissue of the onion leaf. This spore is much more resistant than the summer spore and enables the fungus to live over from season to season upon dead leaves. Wet weather and humid atmosphere favour the disease, whereas a dry spell will check its progress.

Good results have been obtained by spraying with Bordeaux mixture (6-4-50). The number of applications necessary to control the disease will vary with the climatic conditions. If the weather is moist and the atmosphere humid, repeated sprayings may be necessary.

Should a dry spell be experienced, a halt in the operations can safely be made. As far as possible all diseased material should be collected and burnt.

BEANS AND PEAS.

Beans.

There are a number of species of beans, all of which can be grown in this State. The best known are the Broad bean, Kidney or French bean, and Runner bean. The first named, which is grown for the seeds, does best in the cooler portions of the State, or in warm districts as a winter crop. The Kidney or French and Runner beans are esteemed for the edibility of their pods, and can only be grown in the warm seasons of the year, being very susceptible to frost.

The crop is influenced to a considerable extent by the quality of the soil, a light, shallow soil giving much inferior returns to a rich alluvial one. Bean plants of all kinds respond readily to dressings of manure, those that are most beneficial being those containing phosphoric acid and potash. As with all other legumes, there is little necessity for nitrogenous manures, but some advantage in the use of lime. The crop has long been known to farmers as an excellent soil-renovator, and it is particularly valuable in a rotation.

Farmyard manure cannot always be used with advantage in connection with beans, its application, particularly on heavy soils, being apt to produce too much leaf growth at the expense of the crop of pods.

Kidney or French Beans.

The first thing to take into consideration in bean culture is the preparation of the soil. It should be thoroughly ploughed twice, and harrowed; if the season is inclined to be dry, and the land cloddy, the roller may be used to advantage before planting.

The soils best suited for growing beans differ considerably with the conditions and the time of sowing. For instance, if an early spring crop is required, a rich loam is found very suitable, as this class of soil is generally sweeter in the spring than the low-lying lands. But if a summer crop is required, then the lower lands are found to produce very prolific crops.

Beans should be planted in rows, 2 ft. 6 in. apart, and from 3 to 6 inches apart in the rows, according to the quality of the land, the thicker sowing being made in the richer soils. They should be covered to a depth of 2 inches. The usual practice is to strike out shallow drills with a plough, and then to drop the seed by hand at the intervals named. The covering can then be done with an ordinary light harrow. Some growers have had a special plate made to fit the maize planter, and sow their seed in that way. The plate requires to be a very thick one, in order to save the grains from being cracked. Under ordinary conditions, from $\frac{3}{4}$ bushel to 1 bushel of seed is required per acre.

When the plants are a few inches high they should be worked through with the hoe. On low-lying land the beans may show a pale green colour, and a furrow should then be taken away with the plough, and left open for a couple of days if the weather will permit. This allows the ground to sweeten. The cultivator should be put through as often as possible, until the plants are tall enough to be hilled with the plough, and the middle should then be cleaned out. If the weather is dry, or a heavy downpour of rain comes, the cultivator can again be used to advantage, breaking the crust, and also checking any weeds that might spring up after rain.

On land that does not answer to the description "low-lying," the cultivation can be confined to intertillage between the rows with a cultivator of an ordinary type.

French beans may be planted at any time after the frosts, say in August on the North Coast, and later in districts further south, until in such localities as the Hawkesbury River, September is the most reliable month for early sowings. On the tablelands it would be risky to plant before, say, the end of October or beginning of November.

Successive sowings can be made in all the localities mentioned until just sufficient time is allowed to enable the crop to mature early enough to miss the first frosts of autumn.

Harvesting must commence as soon as the pods are of sufficient size, and should continue at frequent intervals. If the pods are allowed to become too ripe, not only is that particular picking spoiled, but the cropping power of the plant is considerably reduced. They are usually forwarded to market in full chaff bags, and delivery must be effected as quickly as possible, in order that the produce may reach the market quite fresh.

Of varieties, that most esteemed for commercial purposes is Canadian Wonder.

Peas.

The popular garden pea, valuable as any summer vegetable next to the potato, can be grown in almost any part of New South Wales, though allowances must necessarily be made for climatic and other conditions in considering the proper time to plant.

The pea plant itself is not subject to frost, though an inopportune "freeze" at flowering time will destroy the pollen, and therefore the capacity of the plant to set its pods, and will even damage the pods while in their tenderest stages. Young pods that have been frosted, and that are unlikely to develop, may be distinguished by a characteristic white mottled appearance on the outside skin. The pea is naturally a cool-climate plant, and little success can be expected from it in the height of summer except in cool, elevated districts.

Soils and Districts.

A sandy loam is most suitable for the crop, but almost any soil of fair average quality will yield good results. As with all legumes, the supply of nitrogen in the soil is matter of less moment than that of phosphoric acid, potash, and lime, and hence it is that in some localities dressings of fertilisers that contain the last three have a material effect upon the yield. The crop has the strong recommendation that in addition to yielding profitably, it contributes to the fertility of the soil for the purpose of subsequent crops by increasing the store of nitrogen, and by enabling the gardener or farmer to add to it a considerable quantity of top-growth of a kind that humifies readily when turned under. It does well on newly-broken land, and can be used as a preparation crop; indeed, there are some farmers who own a decided preference for it as a first crop in their own districts.

The crop is largely grown in central coastal districts, considerable areas being devoted to it on the Kurrajong, round Gosford, Penrith, and Camden, and on the Hunter River. These localities supply the early market requirements, and there are favoured parts, such as on the Kurrajong, that maintain the supply well into the winter months.

In early districts the first plantings are made from June onward. These make their growth during the winter, and come into flower late enough in the spring to miss the late frosts. In these districts there are practically

two defined planting seasons, the second being from January and February until just sufficient time is given to allow the crop to be gathered before the early frosts of winter. In frost-free situations along the coast, plantings are made in late autumn, and as the crop is harvested at a time when the market is scarcely supplied, prices are usually high.

On the tablelands plantings are made continuously from September until the end of January. In certain localities such as Bowral, Mittagong, Moss Vale, Orange, Oberon, &c., the city market is specially catered for, the last planting just catching the Easter season.

Sowing, Cultivating, and Harvesting.

The water requirements of a crop of peas are considerable, and the preparation of the soil should be commenced early enough to enable a supply of moisture to be stored. The ploughed land should be cultivated as required to conserve all rain that falls, to destroy weeds, and to produce a good tilth in which the roots will find favourable conditions.

Both the maize drill and the wheat drill can be used for planting the seed, but in the latter case sufficient of the feeders must be closed up to obtain the proper distances between the rows. It is much the more common practice, however, to open up shallow drills, drop the seed by hand, and cover to a depth of about 2 inches by means of a harrow, light cultivator, or hand hoe.

In small gardens, where the work is all done by hand, the rows are set much closer than in the case of field crops, where often horse-power is used in the operations of intercultivation. In gardens the rows are placed from 15 inches to 24 inches apart, but in the field they vary from 24 inches to 36 inches apart, according to the implements to be used in cultivation. The 24 inches is rather close for horse-power, but lends itself to the hand cultivator, while 30 inches is sufficient for the free movement of horses. In the rows, the seeds are generally dropped 2 inches to 3 inches apart, and about 1 bushel is required for an acre. Where the seed is drilled in, the fertilisers are usually applied through the manure box, but in the case of hand planting, the manure must be dusted along the furrows before covering in.

So soon as the crop appears above the ground, defining the rows, the soil between should be broken up with a cultivator, and should be kept constantly stirred throughout the period of growth. It may become necessary, as the plants attain a height of a few inches, to hand-hoe the weeds that are growing where the ordinary cultivator will not reach them.

Though in the garden it is the practice to stake the rows, a few dry sticks being pushed into the soil on either side, in the field this is unnecessary, the vines being allowed to trail on the ground.

Picking should commence as soon as the peas in the pods are large enough, and while still fresh and young, and should be continued at frequent intervals. Under no circumstances should any of the pods be allowed to approach ripeness, as the effect upon the plant is to exhaust it before it has yielded all that, with care and prompt picking, it is capable of producing. The business of picking is somewhat laborious, and no farmer should venture upon a large area without having assured himself that his resources in this respect are sufficient for the quick removal of the crop. Picking is usually done by contract, the standard price being about 1s. 6d. to 2s. per bushel, or 9d. to 1s. per kerosene tin, at which rate children often make good wages.

Chaff bags are used to contain the pods when they are forwarded to market, the practice being to cut the bags in two, and to put 2 bushels into each half, or growers may secure proper 2-bushel pea bags from their agent. The peas are not so liable to sweat, and are more conveniently handled in the small bags than in the large ones.

Varieties.

There are a number of good varieties of peas, each of which has its admirers, but the most popular is Yorkshire Hero. It is a main crop variety, hardly maturing quickly enough to justify its use for very early purposes. It produces a rather small pod compared with some other varieties, but the pods are usually well filled. Of late years other varieties with larger pods have been more extensively grown, and of these the most popular appear to be American Wonder, Greenfeast, and Richard Seddon; all main crop sorts. For early varieties William Hurst and Hundredfold can be recommended.

Fungus Diseases of Beans and Peas.*

Anthracnose or Pod Spot.

The disease known as Anthracnose or Pod Spot is caused by a fungus *Colletotrichum lindemuthianum*. Recent investigations show that there may be several biologic forms of this species of *Colletotrichum* that attack beans, and that *C. lindemuthianum* is only one stage of growth in an ascomycete fungus known as a *Glomerella*. The disease occurs all over the world wherever beans are grown, often doing very serious damage. It attacks pods, stems, and leaves, but the most conspicuous injuries are the spots on the pods. The fungus penetrates the affected parts to a considerable extent, and the seeds in the pods beneath the spots are often spotted or discoloured. The fungus is present in the seed, and by the use of infected seed the fungus is readily distributed. It appears upon the cotyledons (seedling leaves) of the young plant when badly infected seed is sown. The fungus spreads from the seed leaves to the first-formed true leaves of the plant. The stems of plants are often so badly diseased near the base that they may fall over and die. The pods, when quite young and succulent, offer the best conditions for the growth and development of the fungus, which develops best with continued wet weather or with heavy dews. Spores from diseased spots on stems and leaves may fall on the pods, where, in the presence of moisture and a sufficiently high temperature, they germinate rapidly and produce the spots, which enlarge and darken until nearly black. The dead tissue dries and shrinks. Spores are produced by the fungus in these spots in great abundance, and ooze out, forming pink masses held together by a mucilage, which, when dry, sticks them to the spot. When dew or rain falls on these spots the mucilage is dissolved and the spores set free in the water. At this time any disturbance of the bean plant will scatter these spores to other plants. For this reason beans should not be cultivated nor handled in the early morning while the dew is still on them, or after a shower. The spores are scattered when wet, and hence a rainy season is most favourable to the spread of the disease.

Prevention and Treatment.—Since diseased pods and stems left in the fields will provide infection for the new crop, all diseased plants, leaves, and pods should be collected and burnt.

* Compiled by Officers of the Biological Branch.

Only clean seed should be used in any future planting. This should be obtained from some source known to be free from disease. All seed should be hand-picked, and any showing spots or discolorations should be discarded. These two operations (burning refuse and selecting seeds) should be rigidly carried out.



Bean Pods attacked by Bean Anthracnose.

The seed should not only be selected, but the pods should also be selected in the field, and as a further precaution all seed should be disinfected. The most satisfactory dip is a solution of about 1 oz. corrosive sublimate or mercuric chloride in 6½ gallons of water in which the seed should be soaked for ten minutes, while a formalin solution (strength, 1 oz. commercial

formaldehyde to 2 gallons), in which the seed is soaked for twenty minutes, is also useful. This method of disinfection is also of great service in checking other diseases.

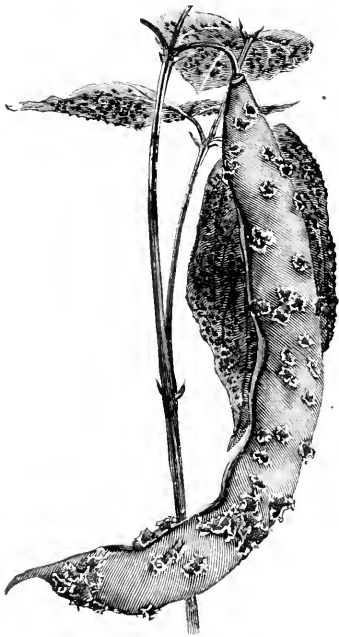
A rotation of crops is useful and also good farm practice. It affords time for the spores in the soil to die out.

Spraying helps to keep the growing crop clean. Bordeaux mixture, made according to the 6—4—100 formula (described in this Handbook in connection with Late Blight of potatoes on page 498) should be sprayed on when the first true leaves are unfolding; a second spraying should be given about two weeks later, and a third when the young pods are being formed. The pods, stems, and leaves should be well drenched with the fungicide.

Soil well fertilised with stable manure some time previous to planting has been beneficial in promoting active plant growth and also reducing disease. The grower should also be on the lookout for resistant varieties—selecting seed from any plants that show resistance to the disease at any time. The wax variety has proved susceptible, while Lima beans have been quite resistant.

Rusts.

Several species of rust fungi, belonging to the genus *Uromyces*, affect varieties of beans and peas. In New South Wales our commonest species is probably *Uromyces phaseolorum*, De Bary (= *U. appendiculatus* (Pers.) Link), which occurs upon the ordinary varieties of our garden beans (*Phaseolus vulgaris*) and also on the cowpea. The fungus usually appears late in the season and is destructive to foliage and may thus result in an earlier ripening of the crop as well as a reduced crop. Spots appear on the leaves (especially on the under surface though occasionally on the upper), at first blister-like and small. These rupture and the spores produced give an iron rust colour to the mass. The fungus is harboured by the old leaves and vines.



Bean Rust (*Uromyces phaseolorum*).

Control.—Burn all refuse. Neither throw any on the manure heap to be returned later to the field, nor turn any under with the soil. Early spraying with Bordeaux mixture should be given. Later, when the pods are well developed the English practice is to use permanganate of potash, about 1 oz. in 8 to 10 gallons of water. The grower should always be on the lookout for selecting seed from any resistant varieties. Climbing varieties are most generally attacked.

Another species that has been recorded in New South Wales is *Uromyces fabae* (De Bary) on broad beans (*Vicia faba*). This attacks pods, leaves, and stems, and in other parts of the world occurs on garden peas (*Pisum sativum*) and several species of vetch, e.g., common vetch or tare (*Vicia sativa*). If it be remembered that these rust fungi commence their attacks

from germinating spores that have hibernated on parts of old plants, it will be evident what benefit will be derived from collecting and burning all old refuse.

Mildews.

Beans and peas and allied crops suffer attack by a number of fungi which produce appearances known as Mildew. The most important of these are—

- (1) Damping-off Mildew, due to *Pythium de Baryanum* (Hesse).
- (2) Downy Mildew, due to *Peronospora vicivæ* (De Bary).
- (3) Downy Mildew, due to *Phytophthora phaseoli* (Thaxter).
- (4) Powdery Mildew, due to *Erysiphe polygoni* (D.C.).

Damping-off Mildew.—Seedlings are often affected with a disease known as Damping-off. The conditions which favour its development are a considerable degree of warmth, abundant moisture, and a weakened condition of the seedlings. It is common when plants are grown in a crowded condition. The fungus attacks the seedlings at or near the surface of the ground, the stem shrinking and the plants falling over. Thinning out seedlings, reducing the water supply, and allowing the free access of air and sunshine will check the further development of the fungus.

Downy Mildew due to *Peronospora*.—The fungus *Peronospora vicivæ* (De Bary) attacks the leaves of various leguminous plants, such as broad bean, pea, vetch, melilotus, &c., producing felt-like patches of hyphæ, which become dense and whitish to greyish in colour. The hyphæ produce many branched conidiophores, and the spores, borne on the ends of the pointed branches, rapidly spread the mildew in moist weather. When favourable conditions change, the fungus produces a globular thick-walled resting spore which can live from one season to another in any decaying parts of the plant. The destruction of all plant refuse, the reduction of the moisture on the plants by the access of sunshine, and the free circulation of air will check the disease. Spray with Bordeaux mixture (6—4—100).

Downy Mildew due to *Phytophthora*.—A downy mildew, similar to Late (or Irish) Blight of potatoes, but caused by another species, *Phytophthora phaseoli* (Thaxter), causes destruction of Lima beans in some countries, attacking young shoots, flower clusters, and leaves, causing them to become dwarfed and distorted, and also forming a dense, woolly-white growth on the pods. This does not occur in New South Wales, but might be introduced at any time. The preventive measures used are:—The use of clean seed, rotation of crops to get rid of the resting spore stage, destruction of old plant parts, and spraying with dilute Bordeaux mixture (6—4—100).

Powdery Mildew.—A powdery mildew, caused by the fungus *Erysiphe polygoni* (D.C.), is a common disease that attacks over 300 species of plants, including many of the Leguminosæ, e.g., garden peas, beans, and vetches. On peas in moist seasons it may form a dense, persistent mycelium, covering stems, leaves, and pods. When mildew attacks young plants the crop is generally a total failure. The fungus produces spores in great profusion, and in later periods develops its perithecia (cases enclosing asci which hold about two or three ascospores). This stage will carry the fungus on till the next crop. The fungus may hibernate in the seed derived from affected pods. Dusting with flowers of sulphur and the destruction of any dead vines or plants are recommended as methods of control.

Leaf Spot of French Bean.

Leaf Spot is caused by the fungus *Isariopsis ariseola* (Sacc.). This attacks the leaves, stems, and pods, producing brownish patches, and causes the leaves to fall away. The spots become large and angular; they are often limited by the veins. Bordeaux mixture (6—4—100) should be used and affected plant refuse destroyed by fire.

Pea Spot.

This disease, due to the fungus *Ascochyta pisi* (Lib.), attacks French and haricot beans, garden and sweet peas, hairy vetch, lucerne, and some other leguminous plants. The first indications of disease on the pods is the appearance of pale green spots of variable size and irregular shape. These spots continue to increase in size, and eventually become whitish, bounded by a dark line, and dotted with minute black points, which are the pycnidia of the fungus and contain numerous spores. The fungus may grow through the pod into the seed, and thus the disease becomes further distributed. The mycelium hibernates in affected seed, reduces the germinating power, and carries the fungus over to the succeeding crop. Similar spots may occur on leaves and stem. The spots often penetrate through the woody part and cause wilting of the plant.

On young plants the disease often assumes the character of a "damping-off" disease. Spraying with dilute Bordeaux mixture (6—4—100) on the first appearance of the disease checks its spread. As the disease is also distributed in affected seed careful attention should be given to the selection of good seed. As in the case of Anthracnose, any spotted seed should be discarded, and all seed should be dipped. It is safer not to obtain any seed from a source known to have the disease.

Sclerotium Diseases.

A disease that is common to very many different plants, including beans and peas, is associated with the fungus *Sclerotinia sclerotiorum* (Masse). It attacks the stems, commencing as a white mould at the ground line and working upwards. After the fungus has developed for some time the leaves become yellow, and wilt, and finally the stem collapses owing to the mycelium of the fungus blocking up all the water-conducting channels. When the stem of the host is hollow the mycelium is produced in considerable quantity in the cavity, and forms numbers of lumps or sclerotia that are white at first, then black externally. When the stem is solid the sclerotia are formed in its substance and become visible on the outside. These sclerotia, which vary in size, some being as large as a pea, form a resting stage of the fungus. They remain either free in the soil or in decaying plants, and in the spring develop small, brown mushroom-like structures on long stems, which produce spores that are able to infect a new crop.

Another form of wilt due to *Sclerotium rolfsii* is often met with. This attacks beans, rhubarb, potatoes, and occurs on snapdragons, carnations, and other garden plants. The fungus affects the root system, covering it with a felt-like whitish mould which may ascend the stem somewhat. The plants die, and then tiny brown sclerotia, slightly larger than a pin's head, are found in the webbed growth of the mould.

Control.—Plants affected with either of these diseases should be burned and not allowed to lie on the ground. The sclerotia lying dormant in the soil are difficult to deal with. In small gardens the top few inches of soil can be removed and replaced by fresh soil mixed with quicklime. If all infected plants be pulled up and burnt as soon as the first indication of disease is observed, the formation of sclerotia may be forestalled. As an additional precaution it is useful to spray the infected area with Bordeaux mixture (6—4—50) or with a 2 per cent. bluestone solution, though the latter is not practicable on a large area.

Fusarium Diseases.

Several *Fusarium* diseases causing wilting are known. One form causes a staining of the tissues of the stem to a pink or red colour. A form occurring in French beans—apparently the American Dry Root Rot—is also known.

Control.—These diseases are most common where continuous cropping is practised. Rotation is just as important with legumes as with other crops, as soil-borne diseases tend to accumulate when land is continuously cropped to the same family of plants. Obtain clean, well-filled seed. Select the best plants in the plot when saving seed. Destroy all diseased plants and rubbish from the crop by fire.

Insect Pests of Beans and Peas.*

French Bean Fly.

This little black fly (*Agromyza phaseoli*), about one-twelfth of an inch in length, does a good deal of damage to French bean crops in some districts. The fly lays its eggs upon the stem near the ground, and the resultant maggots tunnel along under the skin, leaving the stem rusty-red and cracked, so that the plant eventually dies.

Growers report that spring crops are seldom, if ever, damaged by this moth to any appreciable extent, but as the weather becomes warmer the flies gradually breed up and develop in such numbers as to be very destructive in the fall of the year.

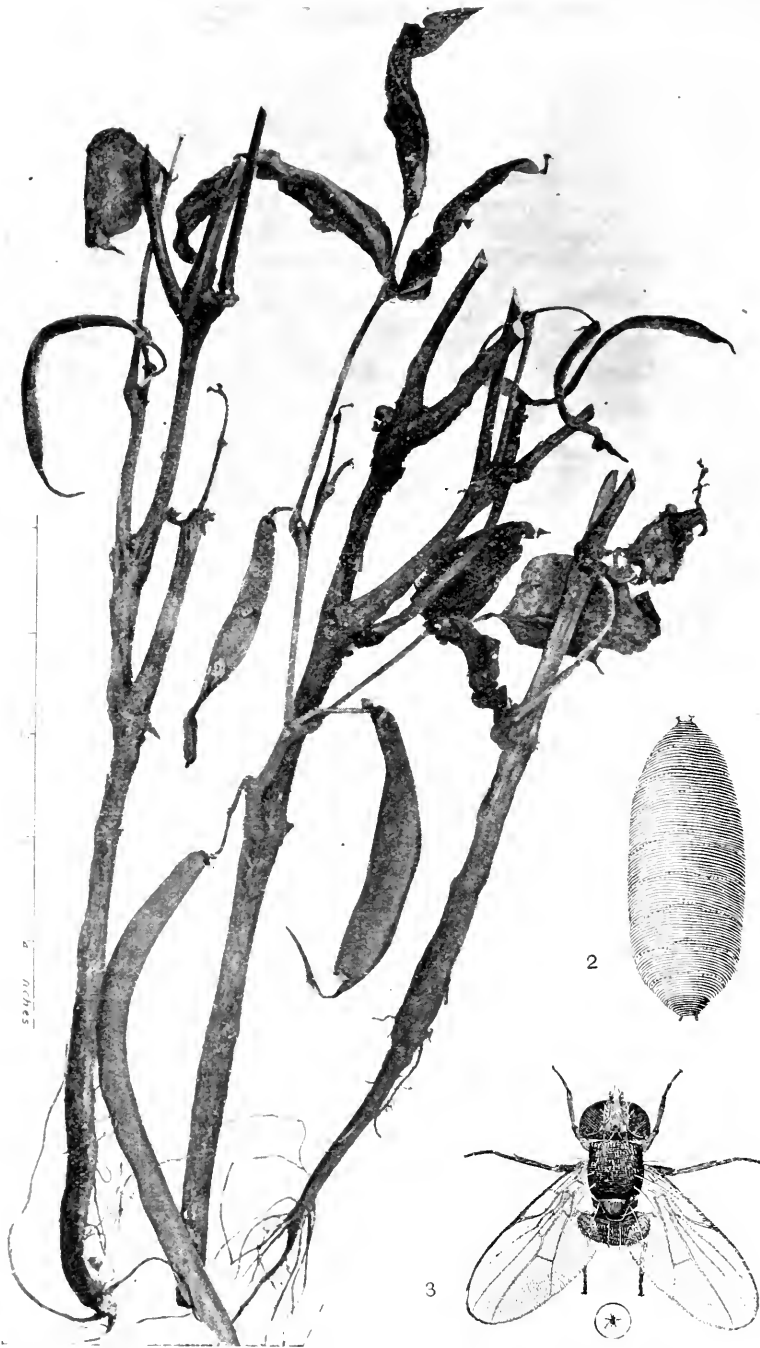
In good growing weather some advantage can be gained over the pest by hilling up the soil round the plants, so that the stems are covered; the bean plant then puts out a fresh supply of fibrous roots above the damaged tissue. The hilling up of the bean rows also protects the stems if it is done before the flies first appear. No spray or wash that has been used seems to have any effect upon the flies; and as the maggots do not feed upon the surface of the plant but under shelter of the tissue, no poisonous spray upon the foliage would injure them.

As with many other pests, this is a case for clean cultivation. The maggots pupate in the bean stems, from which, if the plants are allowed to remain in the field, the flies emerge in due course. It would be advisable to pull and burn all infested bean plants as soon as the last picking has been gathered; otherwise, if the plants remain dead and dry, many pupæ may drop out of the cavities in the stems, and, falling on the earth, remain in the ground long after the dry stalks have been removed. Several growers have reported that, although they had cleaned up and burnt all the old beans the previous season, they found the following year, when they planted beans in the same land, that they had not got rid of the flies. Probably some pupæ had dropped from the damaged bean plants before they were removed.

Bean Aphis.

The small bean aphides develop through the summer months on various plants, including the many varieties of beans. At this time they are all females, some winged, but many wingless, and they give rise to their young without the aid of males, the young aphis being born viviparously, that is, extruded alive. The aphis are born in rapid succession, and the numbers increase with amazing rapidity. The effect of these thousands of tiny insects, each sucking up sap by means of its little beak, is to cause

* Compiled by Officers of the Entomological Branch.



- 1. Bean plant, showing ravages of the fly.
- 2. Pupa. [Much enlarged.]
- 3. French Bean Fly. [Much enlarged.]
- 4. Larva. [Much enlarged.]

French Bean Fly (*Agromyza phaseoli*).

the plants to weaken and wilt. Towards the end of summer, winged forms are developed more numerous, and the aphides spread. Winged males are also now developed and fertilise the females, which then lay eggs known as the winter eggs. These eggs tide the winter over and hatch in the following spring to start the broods of that season.

Controls.—Spray with tobacco and soap wash, or sunlight soap wash, or even a dilute kerosene and soap wash, say, 1 part of kerosene to 30 parts of water; the mixture must be very thoroughly emulsified with soap to prevent burning of the tender parts of the flowers and foliage. Further, it is recommended that stubble and weeds in the bean fields be thoroughly destroyed or well turned in to destroy any aphids or eggs.

Peas are attacked by an aphid which may be controlled in the same way as bean aphid.

Green Bug.

These plant juice-sucking bugs (*Cuspicona*) are sometimes numerous and destructive. They are wide-bodied, green bugs, about one-third of an inch long, with a triangular plate or shield in the middle of the back.

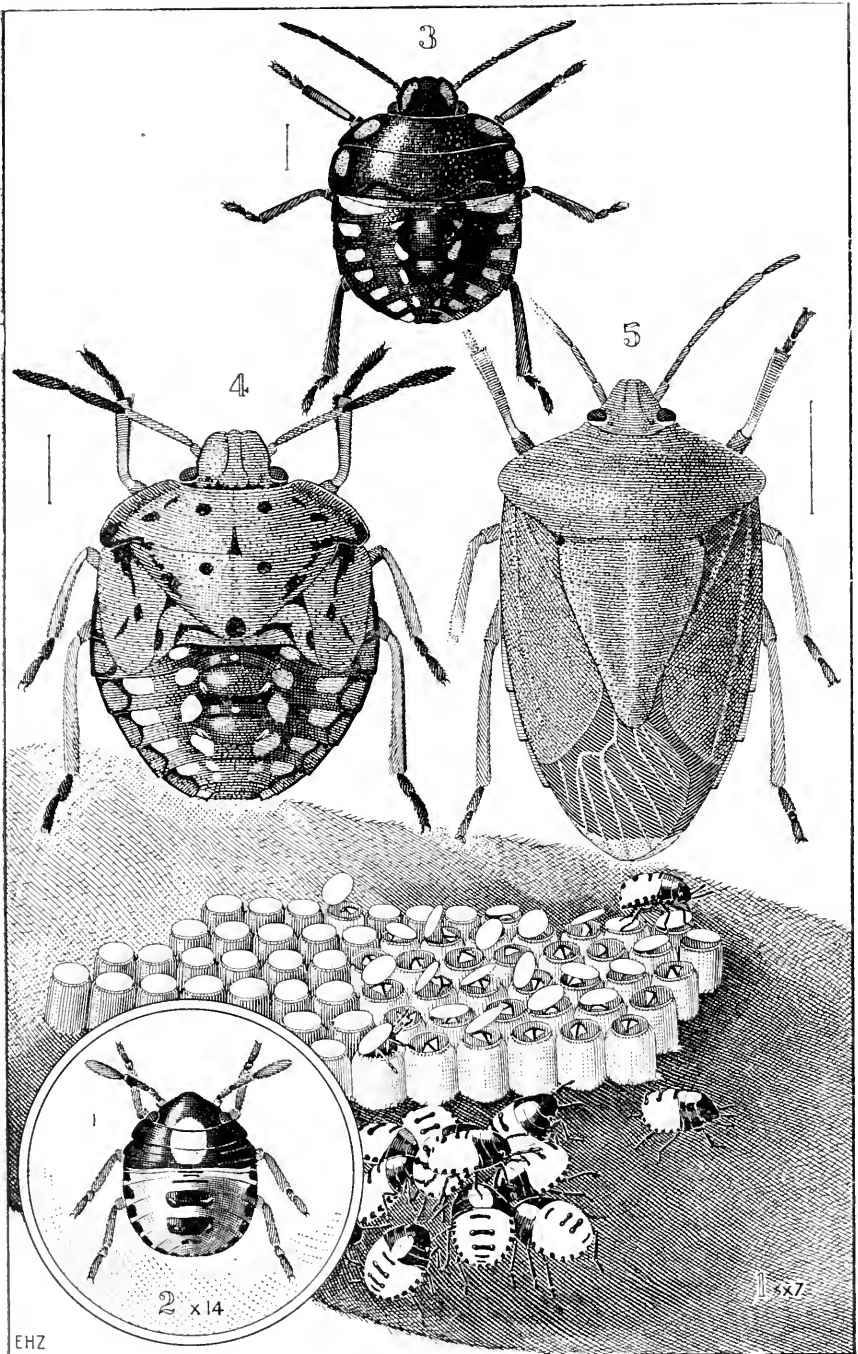
Controls.—Oil spraying is not so effective as hand-picking, *i.e.*, collecting them by hand (preferably in early morning), and destroying the limited number which may be present. The use, as follows, of a tray of oil and water can also be recommended. A shallow iron trough, 1 foot or 18 inches wide, 2 or 3 inches deep, and about 3 or 4 feet long is made; a sheet of galvanized iron may be used, the ends and sides being turned up and soldered. About a cupful of kerosene or other oil and half a gallon of water are poured into the tray, which is then drawn slowly along between the rows, while someone follows behind and beats or brushes the bean plants with a bundle of brush, dislodging numbers of the bugs, which usually fall into the trough of oily water. Repeated two or three times, say, once every four to seven days, the limited number of bugs present may be much reduced.

Tomato and Bean Bug.

The distinctive bright green and unmistakable shield form of this plant bug (*Nezara viridula*) have become quite familiar to vegetable growers in coastal districts, where it is now known as a pest on the fruits and foliage of the tomato, on the foliage and young pods of French beans, and on the foliage of potato plants. In Florida, U.S.A., the species is known as a pest of orange trees, and in some districts of New South Wales it has acted similarly. They damage plants by sucking the plant juices from the tenderest parts.

The accompanying plate illustrates the typical shield shape. The insect can run and fly very well, but it generally drops to the ground when the plant is disturbed. The female lays her eggs in little patches on the surface of the foliage of the young beans, and the baby bugs, when ready to emerge, push off the flattened lid, leaving the empty eggs like tiny glass cups. The bugs are dark-coloured when they first emerge, but during successive moults they gradually change to a lighter colour until they appear as the perfect green shield bugs. They may be present among the foliage of a plant in numbers, and yet escape detection, so closely does their colour harmonise with the background.

Controls.—The clusters of round, flat-topped, glassy eggs are very noticeable on the foliage, and if the infested leaves are snipped off and destroyed large numbers can be destroyed before they even hatch. If the bugs are noticed on plants, a sheet could be spread on the ground and the plants



Tomato and Bean Bug (*Nezara viridula*).

DESCRIPTION OF PLATE.—1. Cluster of eggs and young bugs immediately after leaving the egg shells. 2. Enlarged figure of young bug just emerged from egg. 3. Second stage after leaving egg. 4. Last stage of immature bug, showing definite wing pads. 5. Adult bug with fully developed wings; leaf green in colour.

shaken suddenly over it; most of the bugs will drop on to the sheet and can be collected and destroyed. In the early stages of development, the little bugs have not yet fully developed wings, and an oil spray, or tobacco and soap wash, can be used effectively.

Pseudo-Looper or Silvery Plusia Moth.

The green caterpillar of this species (*Plusia argentifera*) commonly feeds on the foliage of beans, creepers, and potatoes. They pupate in loose, silken cocoons, which they spin on the foliage or stalks and sometimes on the ground.

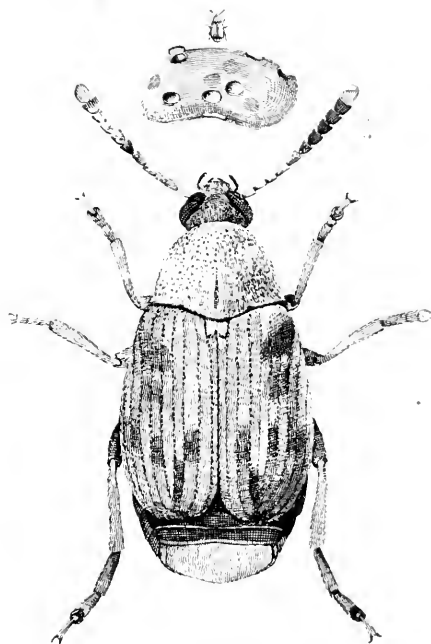
Controls.—Brushing into a tray of oil and water as is described above in connection with Green bug is recommended. Spraying with arsenate of lead in the proportion of 1½ lb. arsenate of lead to 50 gallons of water, is also advantageous where the foliage is not too dense.

Cutworms.

These insects attack peas as well as other vegetable and field crops. They are described in connection with maize on page 437.

Bean and Pea Weevils.

The grubs and adult beetles of several species of the genus *Bruchus* commonly attack various peas and bean seeds. The cowpea weevil (*Bruchus chinensis*), the common bean weevil (*B. obtectus*), and another species (probably *B. quadrimaculatus*), are recorded doing damage in New South Wales. Though these beetles will lay their eggs in the field, their ravages are not generally sufficient to be noted until after the crop has been gathered and stored. Then the grubs become full grown, pupate, and change to the adult form within the beans or peas, as the case may be. This brood will again lay eggs on the seeds around them in the store, and the infestation is thus increased and with it the damage.



Bean Weevil (*Bruchus obtectus*).

Fumigation with carbon bisulphide is generally the most satisfactory method of treatment. The seed should be placed in an airtight space such as a box, tank, barrel, or room and treated with the liquid at the rate of 4 lb. to 1,000 cubic feet for a period of twenty-four hours. For smaller containers 1 fluid ounce (two tablespoons) could be used to 200 lb. of seed. The liquid may be poured directly over the seed or placed in a saucer or pot on the top. To get the best results the temperature during treatment should be about 70 deg. Fah. As the fumes are highly inflammable no light of any kind should be allowed near where the fumigation is being carried out.

Cowpea seed was kept in cold store (35 deg. Fah.) from August to December one year, and, though infected, the weevil was found not to have developed. The seed planted in December yielded a good crop, and did not seem affected by the cold. This method destroys the grubs and beetles, and, even if it does not destroy the eggs, prevents their development. Cold storage, though presenting practical difficulties, will certainly save a large percentage of grain that would otherwise be lost.

THE TOMATO.

The extensive cultivation of the tomato is of comparatively recent years, but it has advanced so rapidly in public estimation as a most useful, wholesome, and delicious fruit or vegetable, that very large areas are annually planted with it. In this State the production of early tomatoes for domestic use and mid-season crops for sauce manufacturers is a distinct and profitable business, occupying considerable areas.

The best land for tomatoes is a rich mellow loam, with a little sand in the upper layer, and a good clay subsoil. For early crops a northern aspect is desirable. Poor and medium quality lands will frequently give early crops, but not heavy ones. Where this plant is to be grown in quantity for manufacture or the open market, when quantity is of more consequence than earliness, the soil must be either naturally rich or artificially made so.

Preparation of the Land.

Having selected the land for this crop it must be prepared during the autumn previous to planting in the spring. If new land be taken it must be broken up and prepared with all the care advocated for onions and potatoes.

Planting in the open cannot take place until the district is clear of frosts unless means be taken to shelter the young plants every evening as the Chinese do. Meanwhile the young plants have to be got ready in a cold frame, or some warm sheltered spot.

The Seed Bed.

The seed or plant bed may be made of any desired size, according to the extent of cropping. A frame of boards of the required size may be built on this plot, and covered with calico or new hessian; the latter should be made to shift or roll up, as will be frequently needed. The seed may be sown in shallow boxes under cover, or in the frame, and covered with a sprinkling of fine loamy soil. One to two ounces of seed will produce more than sufficient plants for one acre. As soon as the plants are large enough to handle (2 or 3 inches high) they should be transplanted into the frame, which by this time should have been worked up to the finest condition and tith.

The plants may be set out, say, 5 or 6 inches apart, both in rows and spaces, setting each plant opposite the space in the former row. Here they may remain and grow until time for transplanting into the field; and by

removing the calico, giving them air, light, and sunshine on fine days, and covering up in the evenings or during cold spells or frosts, they should presently become stout and stocky plants. After they are once set out, do not give them much watering, or they may be inclined to draw up and become lanky and tender.

The main point in a frame or bed of this character is to keep it dry and warm, and in transplanting into it, care must be taken that the plants are not much lower than they sat in the seed-bed, as the deeper they are set the more liable they are to damp off. If any plants have got rather down in the seed-bed, and become long-shanked, they should be laid slanting, just below the surface, and they will take root along the stem, and become stout and stocky plants after all. The drier the bed is kept (with discretion) the better. When they become 5 or 6 inches high, some will want to outrun their neighbours; these should be pinched in a little, so as to allow the weaker plants to come up uniform in strength before putting out. Any suckers that may appear should also be removed if it is intended to grow for early fruit.

For successive crops seed may be sown at intervals in the open, after the frosts are gone. Prepare a bit of rich soil, and strike out drills not more than half an inch deep. Sow thinly, cover lightly, and water sparingly. The young plants should show up within a week, and if it is desired to push them along, transplant into a nursery bed when they get their third leaf, putting them 5 or 6 inches apart as previously advised, and then follow on as before. Seed may be sown from June (under cover) to end of January, and crops may be grown for eight months in the year—in some favoured spots even longer.

Transplanting.

When all is ready for removing the young plants into the field, they should have a good watering some hours before, so that the roots will retain hold of as much soil as possible. The earth may be cut both ways between the plants with a sharp spade or knife, and lifted underneath also. When the plants are lifted out, as much soil should go with each as may remain with the roots, taking care not to break the fine rootlets, so that the plants may suffer as little shock as possible. A large number may be lifted, and carried out to the field at one time by using large board trays or other rough appliances made for the purpose. In fact the plants may be treated in every way the same as when transplanting cabbages, cauliflowers, celery, &c., either with the plough, spade, or trowel. Plant at least one inch deeper than in the frame, and if the quantity is not very large, evening is the best time for moving them, or after showers.

Unless the soil is dry, do not use water in the transplanting as the plants are liable to damp off in cold wet soil. They may need shading a little in the heat of the day for the first two or three days after moving, otherwise the more light and air they get the better.

It is better to plant $4\frac{1}{2}$ feet or 5 feet apart, and to stake them up like vines in a vineyard, instead of letting them trail on the ground, as some do. These latter hardly bear as well, and are far more subject to disease than those supported from the earth. The land should be kept clean between the rows and plants, as in any other well-tended crop.

Pruning.

If it is intended to keep the plants well pruned throughout their growth (and for early fruit this will be necessary) $4\frac{1}{2}$ feet will be found ample space in the rows, and 5 feet between the rows, but if quantity of crop is of more consequence than earliness, little or no pruning will be needed.

Pruning should commence as soon as suckers get to be an inch long. Frequently these will appear immediately the plants are set out in the field, and if the tendency is not checked by their removal, the plants generally lose their first bloom and earliest fruits. Some experienced growers prefer to leave one sucker and the main stem, some two suckers, and others the main stem only, until the first or second cluster where it will fork, then leaving the fork or two stems. Pruning for an early crop is specially referred to a few pages later.

When working amongst the crop, diseased plants or fruit should be immediately removed from the field and *burnt*, and after the crop is gathered the haulms or stems should be collected and burnt also. It is not advisable for tomatoes to follow a crop of tomatoes on the same land, at any rate without a crop or two of a totally different nature intervening. This precaution is necessary to prevent the spread of disease.

Picking, Packing, and Grading.

Care should be taken when gathering the fruit that it be not bruised, or it will decay rapidly. Tomatoes that are to travel long distances, or occupy days in transit, should be picked when they begin to colour at the blossom-end.

When packing, the fruit should be graded according to size and ripeness, all in each package being as near alike as possible. The grading should be something like this:—

- | | |
|-----------------------|-----------------------|
| 1. Large ripe fruit. | 4. Small medium ripe. |
| 2. Small ripe fruit. | 5. Large green fruit. |
| 3. Large medium ripe. | 6. Small green fruit. |

The fruit will thus look better, sell better, keep better, and pack or travel better; the arrangement will be found advantageous to the buyer and more profitable to the seller, besides establishing a reputation for the brand amongst buyers. Each package must have the contents and quality faithfully marked on the outside, so that buyers may learn to rely on the brands without wanting to overhaul the fruit.

Culls should not be marketed, but fed to pigs or destroyed, as is done with other refuse fruit.

Varieties.

There are several good varieties from which the grower can make his selection. Spark's Earliana is an excellent early tomato that does well where the vines are trellised. Chalk's Early Jewel is also favoured by some growers for the early crop. Burwood Prize, which shelters its fruit beneath abundant foliage, is largely grown in the Hawkesbury district under field conditions for the purposes of the sauce-making trade. Dwarf Champion is also used for field crops, its strong, upright stems saving the labour and expense of staking. For private gardeners, Ponderosa can be recommended; but it has the disadvantage that it does not carry well.

Growing for the Sauce Trade.

When it is realised that the Sydney market consumes some thousands of tons of tomatoes annually, some idea may be formed of the extent of the industry at the present time.

At the beginning of each season the different jam and sauce manufacturers let out contracts for the tomatoes they will require during that season. Some firms deal with as much as 400 tons annually, letting out contracts for about 50 tons to each man willing to supply. The contract is only binding to a certain point. If the season turns out unfavourable, and the grower cannot supply the full amount, no attempt is made to compel him. On the other hand, if a man grows the tomatoes and tries to dispose of them in a more profitable direction he will certainly be brought to book.



A 9-acre Tomato Plantation at Richmond, N.S.W.

As nothing is gained by getting early tomatoes for this trade, the seed need not be sown till all danger of frosts is over. Seed sown in September is likely to escape frosts, and at the same time will come on better than the earlier-sown beds. Burwood Prize stands easily first as the best all-round variety. It is a sure and even cropper, a good carrier, and, what is very important also, a most vigorous grower. During the very hot scorching days of December and January the fruit will scald very badly unless well protected by the foliage, and this is one reason why the Burwood Prize is so popular.

With a good germination one ounce of seed is sufficient to plant 2 acres where field spacing is 6 feet x 6 feet.

The usual method of planting is to first open out drills with the plough and then to dig small holes at the required distance along the furrows for the plants. About 1½ pints of water are then put in each hole before the

plant, which is just pushed into the mud, and some soil pulled round it. A man with a team of horses and two boys can water and transplant about 1 acre of tomatoes per day. This includes digging the holes for the plants, but not the drilling. If the weather is at all favourable, the plants will want cultivating in at least a month's time, and a week or two later will require hilling. It is found better to turn two furrows to the plants, and then clean out the intervening spaces with a cultivator. The plants very soon spread all over the spaces between the drills.

The cases used for marketing are the standard $\frac{3}{4}$ -bushel case, holding about 22 $\frac{1}{2}$ lb. of tomatoes, and are supplied by the factory. A good puller can pull and pack fifty to sixty cases a day in a good crop, and about 100 cases go to the ton.

There are few other crops which, grown under similar conditions, can show returns equal to tomatoes, but the intending grower should take care that he has a market ensured before planting largely, as the factories naturally favour their own clients, and the returns in the ordinary market are often very disappointing.

Early Tomatoes at Hawkesbury Agricultural College.

The prices received for tomatoes raised and placed upon the market before the bulk crops come in more than justify the small expenditure and the considerable amount of light labour required for their special treatment.

At Hawkesbury Agricultural College, a method is adopted that has for years proved this to be true, and as the College is situated in a belt of country particularly liable to frost, a study of the returns obtained and a brief description of the methods employed will no doubt be interesting. For the season 1920-21, a gross return of £165 14s. was received from a $\frac{1}{4}$ -acre plot, 315 half bushel cases being harvested, which had an average value of 10s. 6 $\frac{1}{2}$ d. The actual values ranged from 16s. in early December, to 10s. on 31st December. That this is not an occasional return is shown by the following table, giving the average returns from a $\frac{1}{4}$ -acre plot for an eight-year period.

Year.	Date of Harvest.	Total Cases.	Average Price Realised.	Approximate Total Return.
			s. d.	£ s. d.
1911-12 ..	Nov. 28, 1911, to Jan. 27, 1912 ..	347	5 8	98 6 4
1912-13 ..	Nov. 21, 1912, to Jan. 21, 1913 ...	460	5 8	130 7 6
1913-14 ..	Nov. 26, 1913, to Feb. 17, 1914 ..	373	6 1	113 6 6
1914-15 ...	Nov. 30, 1914, to Feb. 27, 1915 ...	557	4 8 $\frac{1}{2}$	131 3 6
1915-16 ...	Nov. 25, 1915, to Feb. 28, 1916 ..	397	7 1	140 10 6
1918-19 ...	Dec. 5, 1918, to Feb. 28, 1919 ..	808	5 11 $\frac{1}{2}$	240 14 6
1919-20 ...	Nov. 24, 1919, to Mar. 3, 1920 ..	736	5 5 $\frac{1}{2}$	200 11 3
1920-21 ..	Nov. 27, 1920, to Mar. 4, 1921 ..	315	10 6 $\frac{1}{2}$	165 13 6

Average returns over the eight years from 1911-12 to 1920-21 (excluding 1916-17 and 1917-18), £152 11s. 8d.

Avoidance of Frost.

The tomatoes should not be planted out in the field until all reasonable danger of severe frosts is passed. Consequently, an "early" district has an advantage over a "late" one. Richmond is not an early district by any means, as the belt of country in which the College is situated is far more subject to frost than, for example, the lower part of the Hawkesbury Valley. Seed is sown about the middle of July, in seed-boxes covered with glass and placed in a hot-bed, where the growth of the young plants is forced, and where they can be covered from frosts at night.



Early Tomatoes at Hawkesbury Agricultural College, showing the Trellising Method.

Varieties.

The variety always used for early fruit at the College is Spark's Earliana. This is a very good tomato, fairly smooth and round, and admirably adapted for trellising and pruning. In a number of comparative trials at the College it has always come out best for early fruit.

Burwood Prize, a tomato largely grown, is not suitable for this purpose. Its growth is very sturdy, and it is not adapted for trellising; and, moreover, it is not nearly as prolific as Earliana.

Dwarf Champion is a good bearing variety, and does not require staking. It is used at the College for mid-season sowing for main crops. As tomatoes are cheap in season no attempt is made to trellis or prune this variety.

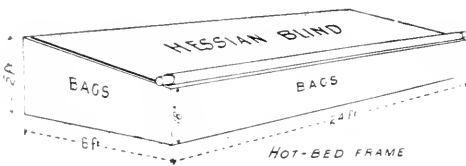
For late fruit, in a district suitable for such crops, Spark's Earliana could be used again. Two ounces of seed will be found sufficient to plant half an acre of Spark's Earliana on the College system.

The Hot-bed.

For half an acre of tomatoes the hot-bed will need to be about 24 feet long by 6 feet wide, if it is proposed to set out the plants about 2 inches apart each way without pots. If 3-inch pots are to be used, the hot-bed will need to be proportionately larger for the same area of tomatoes.

A few loads of fresh stable manure are put in a heap, and allowed to heat for about a fortnight. When quite fresh it heats too rapidly, and will burn the plants, so it should be allowed to ferment a little before use, and turned over at least once to regulate the heat. This should be spread out evenly to a depth of 2 feet on the surface of the ground facing, for preference, the north-east. The quantity of manure required can be gauged from the size of the hot-bed proposed to be made.

Around the hot-bed, build a frame of battens, 2 feet high at the back, and 18 inches high at the front above the level of the manure. Cover the sides



and ends with bagging or other such material. Over the top place a hessian blind fastened at the back, and at the front put a long piece of round wood, upon which the blind can be rolled back to admit sunlight and air. Glass

is largely used for covering the frames, but the hessian blind is quite as satisfactory and much less expensive. The blind is let down at night to protect the plants from frost, and rolled up in the morning.

The Seed-boxes.

These may be made from kerosene cases. One side of a case is removed, and the top closed so as to give a flat box about 10 inches deep. Put 3 inches of rotten manure or similar material in the bottom for drainage purposes, and then 3 inches of nice, free, sandy soil. This will leave about 4 inches of space for the seedlings to grow. Sow the seeds in the box, and place a sheet of glass over it in order to exclude the cold air. Plunge the box into the hot-bed, so that the heat may germinate the seeds. Draw down the hessian blind each night. As the plants come up, the glass cover is gradually tilted back to give ventilation, until eventually it is removed altogether.

Four such boxes will be enough for half an acre of tomatoes.

The seedlings must be taken out of the boxes as soon as they are strong enough—generally when about 2 inches high. If left too long they will grow spindly and possibly “damp off.”

Planting in Hot-bed.

The practice of pricking the young seedlings into 3-inch pots, and plunging the pots into the hot-bed, is preferable to planting direct into the hot-bed. The advantage is that the plants can afterwards be turned out of the pots into the field without suffering any check. In case the pots are not available, however, 4 inches of soil may be put on top of the hot-bed, and

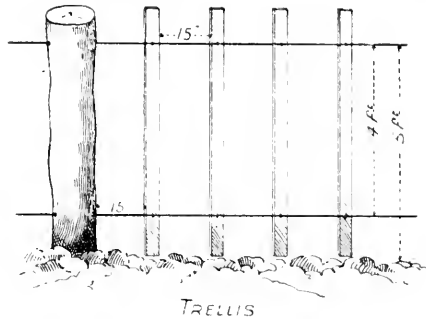
the seedlings planted out 2 inches apart. This will necessitate much care when planting in the field afterwards; otherwise the plants may receive a severe set-back.

In the hot-bed, whether in pots or not, the plants should be shaded from the bright sun for three or four days after setting out. Then all shading is removed by day, but at night the hessian blind is let down to protect them from frost. The tomatoes are kept under shelter in this way until all reasonable danger of severe frosts is gone.

Trellising.

The plants are put in trellised rows 4 feet or 4 feet 6 inches apart, and 15 inches apart in the rows. The trellises are made of 3 inch x 2 inch or 3 inch x 3 inch posts, 9 feet apart, with light 2 inch x 1 inch battens nailed to them, and laths fastened perpendicularly every 15 inches. But where a man has land in such a position that long rows can be laid out, it will be cheaper to use wire to support the laths. Posts can be placed 18 feet apart.

and two wires run—one a foot from the ground and the other 4 feet above—so that the top wire is 5 feet from the ground. The posts, of course, need not be of sawn timber. Then the laths may be fastened to the wires every 15 inches with string or tie wire (see illustration). Builder's laths, bamboo sticks, or light saplings will do. They should be long enough to extend from the ground to well above the top wire. Stout wire is sometimes used instead of laths, but this often burns the plants in hot weather. A tomato plant is set out at the base of each lath.

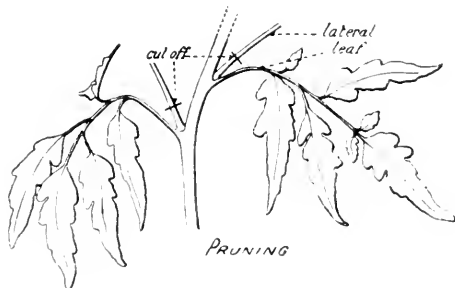


After planting out, a tea-tree bush is placed on the south-west side of each plant if a late frost is anticipated. This shelters the plant from the cold winds, but leaves it open to the sun on the north.

Pruning.

This is the most important operation in the whole process. It is no exaggeration to say that by careful pruning, tomatoes can be made to ripen a month earlier than they otherwise would.

All lateral growth of shoots is pinched off, leaving only the main stem, which is trained up the lath. A lateral shoot starts from just above each leaf on the main stem. The leaf must not be interfered with, but the shoot must be pinched off as close to the stem as possible without damaging the leaf.



The trusses of bloom which give the fruit are thrown out along the main stem. Care must be taken not to injure these when pruning. When the main stem reaches the top of the lath it may be pinched off, but not before. This pruning should be practised regularly, about once a week. Wherever laterals appear they should be pinched off.

The tomatoes will start to ripen from the base of the plant, and the ripening will proceed gradually towards the top.

Watering and Spraying.

The tomatoes, whether in the seed-box, hot-bed, or in the field, must be regularly but not excessively watered. The soil should be kept always in a moist, growing condition. Harm can be done by too much watering, but soil should never be allowed to get dust-dry. At the College we irrigate tomatoes and vegetables with the effluent from the septic tank.

If there is danger of frosty nights, the best practice is to water the young seedlings in the mornings. If the plants are watered in the evening and a cold night follows, the plants will receive a check. In warm weather, however, watering at night is the rule.

The plants are sprayed occasionally with Bordeaux mixture, 6—4—50 formula, to check fungus diseases. The method of manufacture is described in connection with potatoes.

If the weather is wet, spraying is carried out once a fortnight; but in fine weather it is not necessary to spray so often.

Diseases of Tomatoes.*

Black Spot.

Black Spot usually makes its appearance first at the flower end of the South Wales, and probably no tomato disease causes greater loss.

Black Spot usually makes its appearance first at the flower end of the fruit as a small brown discoloration. The discoloration spreads, and the spot becomes more distinct and definite in outline. At the same time it becomes depressed and darkens in colour. The larger spots, which may be an inch or more across, have a dark-brown or black appearance, and are often somewhat velvety in texture. Later the whole blossom-half of the fruit may be involved. The affected tissue collapses and becomes firm and leathery. This collapsing of the diseased tissue, together with the continued development of other parts of the fruit, may produce a definite depression on the blossom end of the fruit, or often it results in only a flattening of the surface.

The first effects of the disease are not always superficial. Fruit that appears entirely normal from an external view often has the tissue of several, or sometimes all, its placenta collapsed and blackened in the parts nearest the blossom. The velvety appearance that develops later on the surface is due to a growth of a fungus, a species of *Macrosporium*. This fungus is not, by itself, capable of producing the rot, and is apparently a secondary infection. The disease is not due primarily to bacteria or fungi, but to various physiological conditions, and is not infectious.

* Compiled by Officers of the Biological Branch.

Experiments indicate that water supply is of the greatest importance in the production and the control of Black Spot. The disease has been produced on vigorous plants by a sudden decrease in the available water supply. Excessive water supply has also produced the disease more readily and uniformly than a scant or intermittent one. Plants receiving a moderate and regular supply of water develop less rotten fruit than either lightly or heavily watered ones. Too much exposure to the sun also tends to an increase of the disease, so that methods of growth that allow for the foliage shading the fruit, assist in checking the appearance of rot.

The effects of fertilisers on the production of the disease vary with the nature of the soil and the amount of water supplied. Experiments by Brooks in New Hampshire, U.S.A., gave the following general conclusions:—Lime is of value in reducing the disease, especially if the plants are well watered, but under drought conditions it has little tendency to decrease the disease; potash has no tendency to increase the disease, but nitrogenous fertilisers favour its development. Soil factors that decrease the disease are all such as favour oxidation, while those that have increased it—aside from water supply—are either of such a nature as to check oxidation, or else to increase the organic compounds that would require oxidising, *e.g.*, nitrate of soda, being an oxidising agent, has less tendency to increase the disease than ammonium sulphate and organic fertilisers having an equivalent amount of available nitrogen. Heavy applications of stable manure increase the disease out of proportion to the increased vigour of the plants.

As the disease is not primarily due to fungi or bacteria, spraying will not control it.

Blights.

The tomato is included in the family of plants known as the Solanaceæ, which also includes the potato and the tobacco. Many parasitic fungi attack one or more species of plants in a definite family, hence it is natural to find the same fungus diseases occur on the tomato, potato, and tobacco. This is well shown, by several of the fungi causing the diseases known as "Blights."

The tomato suffers from the following blights:—

- (1) Early Blight, due to *Alternaria solani*.
- (2) Late (or Irish) Blight, due to *Phytophthora infestans*.
- (3) Bacterial Blight, due to *Bacterium solanaccarum*.
- (4) Leaf Blight, due to *Septoria lycopersici*.

The first three are common to the tomato and potato, and will be only briefly dealt with here, further details being given in connection with potatoes on page 493 of this Handbook.

Early Blight.—The fungus that causes this disease attacks plants at any stage of their development. The first sign of attack is the presence of small brown or black spots on the leaves, especially the lower ones. At first these spots are scattered and inconspicuous, but later they increase in size and number, and finally cause the death of the leaves. Spots may develop on the stem, and are brown or black, more or less circular, and slightly depressed. Fruit may become spotted either on the plant or after picking. The disease may grow into the interior of the fruit and rot it.

The fungus causing the disease is *Alternaria* (or *Macrosporium*) *solani*. Abundance of spores are produced on the dead spots, and they frequently spread the disease from the centre where infection started. The fungus passes from one season to another on old diseased parts of the host plant.

In the control of this disease the destruction by burning of all parts of old plants is the first consideration. Very often after a crop the refuse of old plants is turned under, and in this way a resting place is afforded for the fungus. Spraying with Bordeaux of a strength of 6—4—100 should be regularly carried out to prevent infection.* If the disease is serious in any year a rotation should be practised, but potatoes should not follow nor precede the tomatoes.

Late (or Irish) Blight.—This disease is caused by *Phytophthora infestans* (Mont.), De Bary, the same as that on potato.

It affects all parts of the plant above ground, making them look as if killed by frost. Small blackened areas appear on the leaves, branches, and stalks, and under favourable conditions rapidly grow in size and number until the whole plant blackens and dies. Dark spots appear on the fruit, which rapidly decays. Fruit in all stages of ripening may be attacked, and diseased spots continue to develop after picking. Young plants even about 3 inches high may be attacked. Tomatoes and potatoes are often grown in the same area, and thus the fungus finds a living host throughout the whole year. Bordeaux mixture (6—4—100) is the best spray to use to prevent infection.

Bacterial Blight.—This is a disease of the vegetative parts rather than of the fruit, and is due to *Bacterium solanacearum*, the same as the Bacterial Brown Rot of potatoes (page 504). On tomato plants it causes an early development of a great number of incipient roots in the form of small nodules, which appear on the shoots. Infection may take place through the leaf, by biting and sucking insects or through the soil in contaminated areas. To avoid its spread the sprays used must be those to keep the various biting and sucking insects in check, and thus prevent infection. Once the plants are infected, spraying with ordinary fungicides will have no effect. Avoid a succession of tomatoes on the same land. Avoid soil known to be infected from the last crop.

Leaf Blight is caused by a fungus, *Septoria lycopersici* (Speg.), which attacks the stem, fruit, and calyx, but more especially the leaves. It produces small circular brown spots on the lower leaves first, and if these are seriously affected they turn yellow and die. If weather conditions favour the fungus, the attack progresses upwards, and in severe affections little of the plant may remain but bare stems and small stunted fruit. The withering of the leaves makes the attack look like "blight," but the spots on the leaves distinguish it from other diseases. Affected leaves have a tendency to curl dorsally throughout their length, and may hang loosely on the stem. With severe attacks, old leaves may be killed faster than new ones are produced, and the plant is finally checked to such an extent that little fruit is produced, or what has been produced may be ripened prematurely.

The fungus produces its spores in pyrenidia, developed on the spots on the upper surface of the leaves, and lives through the winter in old fallen leaves and other parts of the plant. Thus in controlling the disease all such refuse should be collected and burnt.

* The method of making Bordeaux mixture is described in some detail in connection with potatoes on page 498.



Tomatoes affected with Late (or Irish) Blight.

The disease often attacks young plants just after setting out in the field. Bordeaux mixture promptly sprayed on the plants after the disease appears will check it. Spraying, however, should be considered as a necessary operation in tomato-growing, and not be delayed until some disease makes its appearance. For plants less than 8 or 9 inches high, Bordeaux of the strength of 6—4—100 should be used. As the plants increase in size and hardness, the strength of the solution can be increased until 6—4—50 is used.

Fusarium Wilt or Sleeping Sickness.

This is primarily a disease of the plant, caused by a parasitic fungus that invades the vascular tissue, and by its action produces a wilting of the plant. A plant that is attacked gradually sickens, loses its green colour, wilts, and finally collapses to the ground. Plants are attacked here and there in the field, and if a badly-affected one or a dead one be pulled up, the roots are found to be decayed or destroyed by a dry rot. Several species of *Fusarium* have been found to produce a wilt, one being *Fusarium lycopersici*. Other species of *Fusarium* also cause progressive rots of the fruit. As *F. lycopersici* is a soil dweller and a root parasite, spraying is of no value in treating this disease. Good cultivation and long rotation are the chief preventive measures. Pull up and destroy diseased plants at once by fire.

Ripe Rot.

Unlike Wilt, this is a disease of the fruit, appearing usually when the fruit is ripe or nearly ripe. It is due to a fungus, *Glæosporium fructigenum*, which may cause much loss after pulling, as the rot may spread rapidly through the fruit, and also affect other fruit in contact with the diseased fruit in the cases. Large, sunken, decayed spots appear which become covered with small dark pustules formed in concentric rings, and later the spots become white to pinkish, as the spores are produced and forced out over the surface of the diseased area.

The fruit should be handled carefully to prevent any injury, as spores readily infect sound fruit if the skin be damaged. On no account should a tomato showing signs of Ripe Rot be included in a case of sound fruit.

Sunburn.

Fruit sometimes becomes scorched by the sun, spots being formed that at first are pale yellow, and later black. The spots sometimes resemble the diseased areas produced by Ripe Rot, and soon become infected by various fungi. Varieties with extensive foliage can be grown, or methods of cultivation adopted that will provide for the foliage shading the fruit. Plant as early as possible, so that plants will attain good growth before the approach of hot weather. Spraying will do no good.

Spotted Wilt.

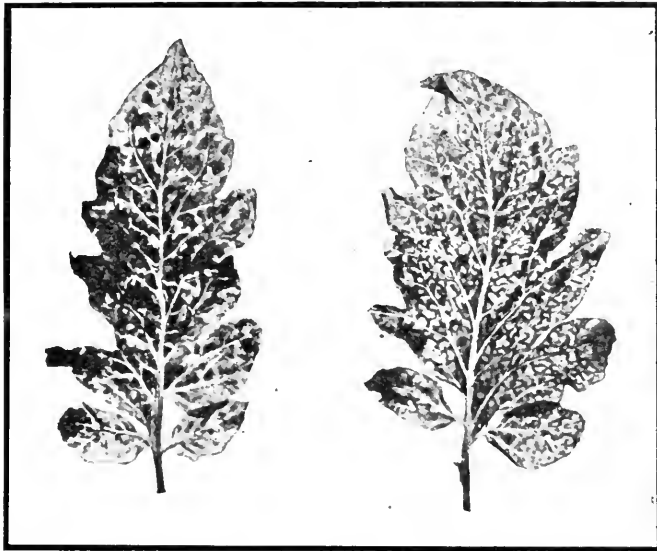
This disease made its appearance in the State in 1918. It is now widespread.

The symptoms first noticed are curious bronzed markings on the young leaves near the apex of the plant. These symptoms may be noticed in the early stages, even in the seedling, but are commoner on plants about 1 foot

high or more. After the appearance of these symptoms the plants seem to make no progress, and any fruit produced is of poor type. The plant finally may wilt and die off rapidly or persist in a diseased state for quite a long period.

This disease is distinct from the *Fusarium* disease (Sleeping Sickness) and from the bacterial wilt or blight. Its cause is unknown. Early crops seem to be more badly affected than late crops.

Treatment.—Pull up and burn affected plants as soon as symptoms are noticed. Do not allow old plants to remain alive in the field over the winter; destroy them by fire as early as possible after removing the crop. No commercial variety entirely resistant is known.



Tomato Leaves (transmitted light), showing the markings of Spotted Wilt.

Stem Rot in Tomato Seedlings.

A disease associated with two fungi, *Fusarium* and *Phytophthora*, has been noted in tomato seed beds. It may prevent the raising of seedlings, doing great damage. The symptoms first noticed are a browning and discoloration of the stem at or a little above the ground level. The plant wilts, and then the top of the plant falls over, the stem being weakened at the affected point. Progress of the disease is rapid, especially under moist, warm conditions.

Control.—Obtain seed from clean sources; use soil known to be uncontaminated; remove and burn boxes of seedlings affected with the disease; spray the remainder with Bordeaux mixture (6—4—100) as a preventive; soil can be sterilised by flooding with formalin (2 per cent.) and covering it with a clean sack for several hours to allow the vapours to penetrate. Sow the seed only after the soil has been turned over and aerated again to remove the formalin vapours. Allow half a gallon to each square foot of the seed bed surface.

Rosette.

The condition known as Rosette usually occurs in a large proportion of plants in abnormally wet seasons. The stems become bunched together and the leaves much reduced in size—the normal spreading habit of the plant being entirely lost. This aborted condition seems to prevent the plant giving rise to flowers and fruit. The calyx may present abnormalities. In cases where fruit is produced it is hard and mottled with red and yellow. A large number of adventitious roots are sometimes produced from the stem. No curative or preventive treatment is known. It is advisable to secure seed from known reliable sources and to avoid seed from affected plants.



Tomato Top showing Rosette.

Insect Pests.*

The tomato is such a vigorous plant under conditions even fairly favourable that it is not much affected by insect pests. The tomato and bean bug, described on page 689, may be mentioned. Its control in this case can be achieved in the same way as the other.

Eelworms.—The injury caused by these tiny round worms is easily detected on examining the roots; irregular enlargements, either scattered or so close together that the whole root system is abnormally thickened, will be noticed. The first indication of the presence of eelworms is the wilting and failure of the plant.

The young worms are not very resistant to unfavourable weather conditions; drying-out or flooding of the soil is usually fatal to them in a comparatively short time, and soil kept free from vegetation for about two years as a rule results in the worms being killed out.

Buff-coloured Tomato Weevil (*Desiantha nociva*).—This beetle belongs to a small group of weevils which damage plants in both the larval and adult stages of their existence. The grubs are slender, active, pale green larvæ, quite unlike the typical form of the family *Curculionidæ*, and not unlike, in some cases, the caterpillars of sawflies.

These grubs hatch out in the soil, and sheltering underground come out at night and feed upon the bark and foliage of plants, they pupate in the earth, from whence, later on, the perfect beetles emerge, and do even more damage than the larvæ, also feeding at night and seeking shelter during the day time.

The buff-coloured tomato weevil is under half an inch in length, thick set in proportion to its length, with the short, broadly rounded thorax, and back flattened. The snout is slender, with the usual elbowed antennæ, clubbed at the tips, standing out in front of the snout; at the extremity of the snout are situated the sharp jaws, with which it does all the damage. The ground colour, as is the case in many weevils, is dark blackish-brown, but so thickly clothed with fine buff and grey scales, and fine scattered hairs of the same tint, that it has a uniform earth-coloured tint that enables it to elude detection when resting motionless upon the dry soil with its legs tucked under its body; a fine example of protective mimicry. When disturbed, however, it is a very active little creature, and runs off to cover at once.

Feeding at night, and hidden away in the cracks in the ground, or just under the surface soil, these beetles may be quite numerous, and yet escape detection unless looked for at night when they are feeding.

Scoping out little depressions in the soil beside the plants, and filling them with a handful or two of weeds, grass, or loose rubbish, has been found an excellent method of trapping the beetles. Collected together in this way, it is a very easy matter to go round every morning, examine these simple traps, and destroy the beetles. Where the seedlings are well grown, after being planted out, it might be possible to place a ring of stiff oiled paper round each stem, and keep the beetles from getting on to the plants. Though provided with a pair of well developed flying wings, hidden under the elytra or wing covers, they do not fly.

* Compiled by officers of the Entomological Branch.

All the foliage-eating beetles are difficult pests to cope with, both on field crops and orchard trees, as they are much more difficult to kill with arsenical sprays than caterpillars, and would, even if the poison acted in a reasonable time, do most of the damage before they died. A contact poison has no effect upon them, as they are well protected with their hard chitinous covering. Trapping them seems to be the only practical way of destroying them.

For other insect pests, such as Rutherglen Bug (page 491), see Leaf-eating Ladybird (page 718), Cutworms (page 437).

PUMPKINS, SQUASHES, MARROWS, GRAMMAS.

For market and for domestic purposes, and as cheap, nutritious, and long-keeping fodder for stock of all kinds, many of the varieties coming within this group have proved to be worthy of attention. There is some confusion as to the correct designation respectively of each distinct section of this family, but for all practical purposes the following classification will suffice:—

Pumpkins.—There are two distinct types of pumpkins—*Table*, medium size, generally flat, with thick flesh, fine-grained. The seed cavity is small in proportion to the size of the pumpkin. *Cattle*, large size, somewhat spherical in shape, flesh coarse and sometimes with woody lumps. The seed cavity is large in proportion to the size of the pumpkin.



A Crop of Cattle Pumpkins at Grafton Experiment Farm.

Of the table pumpkins there are five well-known types—Ironbark, Crown, Triangle, Button, and Turk's Cap. Most of the cattle varieties are red in colour, and of very large size. Some of the varieties are better adapted to hot districts than others, but generally speaking the Ironbark and Crown varieties can scarcely be excelled in any district for productiveness, for value for both table and stock purposes, and for keeping qualities. Owing to the ease with which cross-fertilisation takes place, it is not wise to grow the

table varieties in proximity to the coarser cattle pumpkins, or it will be found that the seed (if sown next season) will produce a crop exhibiting some of the characters of the less desirable type.

Squashes.—Of this group there are many varieties of fanciful shape and colour. Those best known for table purposes are Hubbard, Delicata, and Custard. The last two may be described as soft squashes, and the Hubbard as a hard squash, presenting more of the pumpkin characteristics.

Marrows.—There are numerous varieties of marrows, all of which are adapted for table use. The best-known types are the elongated ribbed, such as the Bush Marrows.

Grammas.—These are sometimes called Rios, and are the largest members of the family of cucurbits. In many districts they provide a large bulk of nutritious fodder for live stock. One type of granma (of a shorter kind than the Crookneck) is largely used for culinary purposes, chiefly for pies. All types are also very good for jam-making.

Suitable Districts and Soil.

All plants of the pumpkin family are very susceptible to frost, and therefore must not be planted until the danger of frosts is past for the season. All of them have been tried throughout the State, and provided the soil selected is well-drained, friable, and abundantly supplied with organic matter in its natural state, or has been enriched by heavy dressings of well-rotted stable manure, they can be depended upon to yield satisfactorily in almost any district.

Preparation of Soil.

The land should be thoroughly worked before planting. If possible this work should be undertaken in June or early in July, especially if stable manure is to be added, so as to give the soil every chance to become mellow before the seed is sown.

In some districts pumpkins are grown between the rows in maize crops, and on rich alluvial soil this plan answers well. When pumpkins are grown by themselves they are usually planted in groups of two or three plants at a distance of 8 to 10 feet apart each way. For bush varieties of marrow and squash about 6 feet apart each way will suffice.

The soil should be deeply ploughed, and care should be taken when adding liberal dressings of organic manure not to excavate in retentive subsoil pits deeper than the surrounding ploughed soil. If this be done water will lodge, and the plants will either "damp off," or refuse to run and produce a satisfactory crop. The manure should be thoroughly incorporated with the surface soil throughout a space of 3 feet or so in diameter. In many districts sandy or stony ridges prove to be highly suitable situations for this crop. Naturally in such places it is necessary to add a large amount of well-rotted stable manure, or preferably old cow manure, with perhaps a small quantity of bone-dust or complete fertiliser, and also to provide a few loads of fairly fine bush rakings for a mulch. The great secret in obtaining heavy crops of pumpkins is to keep the plants moving from the time they show above ground, and everything that can be done to the soil to enrich and increase its powers to retain moisture will help to achieve that end.

Sowing and Cultivating.

As a rule, about 2 lb. of seed will suffice for an acre (less will be required in the case of squash and marrow, which have smaller seeds). Five or six seeds are sown a few inches apart, in groups, and when the plants are a few inches high they are thinned out to two in each "hill."

Care must be taken to keep the soil well scarified to check the growth of weeds and to conserve moisture, and these precautions cannot be discontinued until the plants are running and able to cover the ground.

It is a good plan to pinch back the runners in order to force the plants to produce a dense mass of foliage over the roots, which will resist hot, dry weather, and will also increase the production of fruit.

In the case of pumpkins, both for table and fodder purposes, it is customary to leave the fruit until the vines have died away. Table squashes and marrows may be picked as required as soon as they become firm to the touch and emit a wooden hollow sound when tapped with the knuckles.

Storage.

The keeping quality depends largely on the degree of ripeness. It will be found that if left until it is difficult to pierce the rind with the thumb-nail they will keep throughout the winter, providing they have been harvested with the short stalk attached. Pumpkins from early-sown crops keep better than those from late crops, as they have longer to ripen off. Care should be exercised that the fruit is not bruised in handling. They should be stored on slatted shelves in a dry, airy shed, and looked over from time to time, any showing signs of decay being removed.

MELONS.

Water-melons, preserving melons, and rock melons are grown in practically the same way as pumpkins. Like all plants of the cucurbitaceous family, they are susceptible to frost, and require rich, warm, and thoroughly well-drained soil.

Soil and situations favourable to the production of maize will suit melons admirably. They also do pretty well on sandstone ridges, but their culture in such places should be limited to domestic purposes. Where melons are grown for market, they should be planted in the open, where they can at all times during the earlier stages of growth receive cultural treatment in the way of checking of weeds and conservation of moisture.

Owing to the ease with which all plants of this family are cross-fertilised at the flowering stage by the agency of bees and other insects, it is difficult to maintain purity if more than one variety is grown, and to avoid deterioration it is necessary to obtain from time to time fresh seed from reliable sources.

Water-melons.—For market purposes melons of fair size, firm flesh, and good keeping qualities are preferred.

The best-known varieties possessing these qualifications are Tom Watson, Cuban Queen, Ice Cream, Kolb's Gem, and Kleckley Sweets.

Rock Melons.—Many of the most delicate fleshed rock melons are bad carriers. Emerald Gem may be mentioned as an excellent variety, but for the reason stated elongated delicate varieties are not as profitable for market

purposes as the globular-shaped, firm-fleshed types, of which the most popular are Rocky Ford (or Netted Gem), Haekensack Early, Fordhook, and Spicy Cantaloupe.

Preserving Melons.—There are a number of varieties of preserving or pie melons which are in considerable demand for jam-making, and also for juicy stand-by fodder. The Citron is a well-known and generally approved variety.

Cultivation of the Water-melon.

It is important in connection with melon culture that the plants should be obtained early, so that the fruit shall be available at the season when it is most desirable—the height of summer. This is especially important where melons are being grown for commercial purposes, and various devices



Kolb's Gem Water-melon.

are adopted for germinating the seeds early and ensuring that the young plants shall suffer no check when being set out. Indeed, the young melon plant is particularly tender, and will not survive transplanting if the root system is disturbed.

Some successful growers collect old jam and other tins, and, after melting off the tops and bottoms, arrange them, filled with fine mould, in shallow boxes or trays. A couple of melon seeds are sown in each tin very early in the season, and the boxes are placed in some warm and sheltered place. By the time the season is sufficiently advanced to permit of safe planting in the open the plants are a fair size, and can be readily set out. With a little care the tins can be slipped off without interfering with the roots. Unfortunately for this method, only tins that are soldered at the joints are suitable, and the bulk of the tins now manufactured are not fit for the purpose.

A variation of this system is in use in parts of the United States, where the seed is sown in what are descriptively called "dirt bands." Thin strips of wood veneer, 3 inches wide and 18 inches long, are scored at intervals of 4 inches, so that they can be bent without breaking, and are folded into squares so as to resemble small strawberry boxes without the bottom. These squares are placed close together in a hot-bed, and filled level full with fine, rich soil. With a block of wood shaped for the purpose, the soil within the squares or bands is pressed until it is $\frac{1}{2}$ to $\frac{3}{4}$ inch below the top. If only part of the soil is put in first and pressed down firmly, and the balance is then added and similarly treated, a more compact square of soil is obtained, which will hold together better during transplanting. The bed is then thoroughly wetted, unless the soil was very moist in the first instance. Next, three seeds are placed in each square, and covered with enough fine, loose soil to bring all level again with the tops of the bands. This last layer is not firmed.

The hot-bed for melon plants should have full exposure to light, and be maintained at a high temperature—about 85 deg. Fah. during the day, and 65 to 70 deg. at night. As much ventilation should be given as the weather will permit, and care exercised to avoid over-watering.

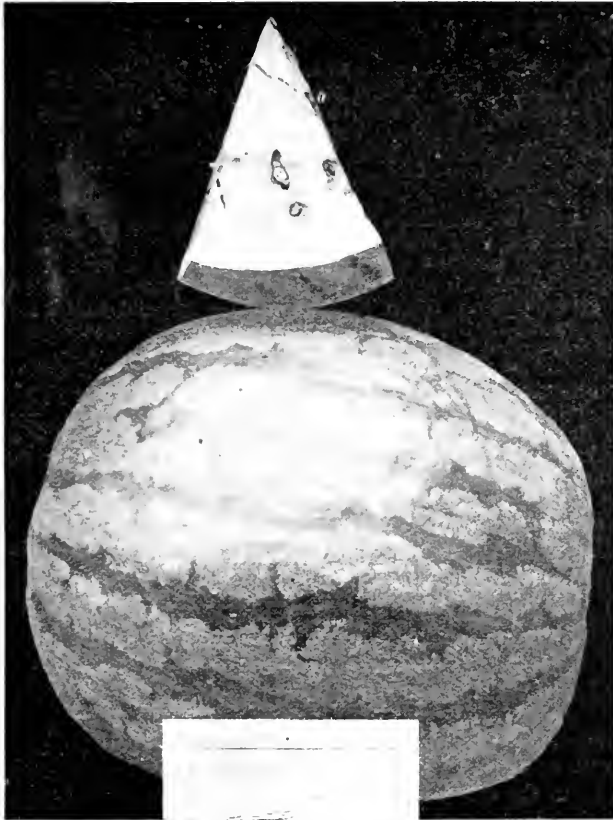
As soon as the plants are started, they are thinned to two in each square by cutting off the weakest with a sharp knife. When they are about four weeks old from planting, they are deemed large enough to transplant to the field. The bed is thoroughly watered, and the bands, enclosing their masses of earth and plant roots, are lifted by means of a spade, placed on a flat surface, and carried to the field, where they are set out with the aid of a flat trowel, care being taken that the bottom of each square is in close contact with the soil. The band is then removed and fine, moist soil is drawn in and firmed against the little square.

For the production of water-melons on a commercial scale, a warm climate and an assured supply of moisture are essential; for market purposes, therefore, the crop is practically limited to the coast, or to areas in the west that can be irrigated.

In field cultivation, the usual practice is to strike out furrows with the plough, say 10 feet to 15 feet apart, according to the soil conditions. Hills are worked up in the furrows, with ordinary or pronged hoes, and the seed pushed under the surface, or the plants set after having been raised as described above. If seed is planted out at once, plenty is used to allow for losses. Some farmers throw a few handfuls of dry farmyard manure on the top of the hill, so that the soil will not cake.

The land is cultivated between the rows as long as the vines will permit, after which they are left to themselves.

The melons are usually marketed in open trucks, without either bags or crates. Large numbers of melons are grown on the banks of North Coast rivers, and these also are marketed without any packing, the growers simply having taken the precaution of scratching a brand on the rind.



Cuban Queen Water-melon.

As remarked above, water-melons should be grown with the object of having them ready as early as possible, and one of the systems of raising plants which are described above will be found of value to that end.

Rock Melon Culture.

In the hope that they may be of assistance to other growers, some suggestions for the cultivation of rock melons, which were made by a member of the Lower Portland branch of the Agricultural Bureau, are reproduced:—

Unlike water melons, rock melons like a good stiff loam—not the stiffest of soil, but land that responds well to cultivation. The land should be ploughed early, say about June, and left open till nearly spring, when it should be harrowed and ploughed, &c.; it will then be in good order. On no account should the soil be worked while it is wet, for it will then go hard, and out of condition, and in that state will not produce good crops.

An experience of forty years had shown him that fowl manure was by far the best. Pig manure and sheep manure were also very good, and stock-yard manure was not to be despised, but he preferred the first-named. To prepare this he dug a hole or ditch of suitable size, and throughout the year put in all the manure from the fowl pens. By spring it was quite decomposed, and second to none for growing rock melons. He had also tried artificial manures, but had had no success with them.

He always "shot" the seed, soaking it for about twenty-four hours and then putting it into a rag-bag, and placing this in the centre of a bag of about a bushel of greenstuff cut up into chaff. This soon heated, and a close watch had to be kept, as the seed would shoot very quickly and spoil. He had planted seeds with shoots an inch long, but great care was necessary as the shoots were very easily broken off.

He generally made the drills about 9 feet apart, and the holes 6 feet apart in the drills, leaving only three or four plants in each. By planting this way he got the vines to properly cover the ground, and one year he took 190 gin-cases of fruit off half an acre, to say nothing of dozens of melons that were wasted or given away. When planting, if the ground happened to be dry, he put some water in the hole, and when it had soaked away he placed the seeds in the wet ground and covered them lightly.

Like all other crops thorough cultivation was necessary. As soon as the plants were large enough the plough should be put through, turning the soil away from the rows to let the warmth into the roots, the rows in the meantime being worked by hand with the hoe or pronged hoe. Before the plants were too large the plough should be put through again, this time turning the soil up to the rows; judgment was necessary to determine whether to harrow down or not. Rock melons were very delicate plants, and care had to be exercised in working through them not to injure the vines.

CUCUMBERS.

To produce early cucumbers for the Sydney market the seed should be sown in June or July, in a warm corner with some bottom heat, or in tins or squares as in the case of melons, and when danger of severe frost is over the plants should be transferred to the warmest situation available and protected by covering at night.

The soil should be deeply worked, and a liberal supply of well-rotted stable manure thoroughly worked into the hills, which should be placed about 6 feet apart.

The plants should be mulched and well watered, if the weather prove dry, and as high winds are prevalent in the spring the vines should be secured in position by means of pegs, otherwise they will become matted and twisted together.

For the Sydney market the fruit should be carefully packed, in layers separated by fine dry straw, in cases having a capacity of about a bushel, and constructed so as to admit air.

In addition to the demand for cucumbers for salad, there is a fair market for cucumbers for pickling; in this case there is not so much importance attachable to earliness, but the crop is harvested at a much younger

stage. It is advisable, before planting, to arrange a contract with some pickle manufacturer, as otherwise it might prove difficult to place the produce when it is ready.

The varieties that do best in this State are Apple-shaped (most suitable for private gardens), Long Green Prickly, White Spine, and Commercial (all popular in the Sydney vegetable market), Gherkins (a small variety grown chiefly for pickle), Fordhook Pickling, and Small Green Prickly (both good pickling sorts).

Diseases of Cucurbitaceæ.*

Pumpkin-leaf Oidium (*Oidium* sp.).

Well known to all growers of pumpkins, squashes, and melon, is the white and powdery or mealy fungus which blights the leaves, causing them to turn first yellow, then brown, and finally to die. The fungus, which probably belongs to the group of fungi known as *Erysipheæ*, or in other words the Oidium group, is mostly external, like its relative the vine oidium. The life-history of the fungus is imperfectly known as yet.

Controls.—(1.) Where practicable, burn or otherwise destroy affected material. Do not plough it in.

(2.) Practise a rotation of crops. Do not grow pumpkins two years in succession on the same land. When possible, put them on new land.

(3.) This disease has been combated with entire success by using flowers of sulphur, as for oidium of the vine. It is necessary to be particularly careful to hit the lower surface of the leaves.

(4.) Bordeaux mixture is often beneficial when applied as a spray.

Anthracnose of Pumpkin.

Anthracnose attacks pumpkins, marrow, squash, water-melon, and rock melon. The seriousness of the attack depends on the weather, hot, moist conditions favouring the disease.

The cause of the disease is a fungus, *Gloeosporium* sp. It attacks all parts of the plant except the root. On the stems it causes water-soaked spots, which turn brown and become depressed and cracked; on the leaves, circular dark spots are developed which become so numerous as to involve the entire leaf, which crinkles and has the appearance of having been burned by fire; on the fruit, anthracnose is manifested on the rind as circular depressions which become covered with a salmon or pink coloured coat made up of the spores of the fungus.

The disease may become serious on land where pumpkins or other susceptible crops are grown successively for a period of years, and spreads rapidly during transit.

For the control of this disease a rotation of crops should be practiced. A three-year rotation, excepting the susceptible crops, should prevent the disease from gaining a foothold. Diseased vines should not be ploughed under or allowed to lie about the field, but collected and burnt.

* Compiled by Officers of the Biological Branch.

Spraying with Bordeaux mixture will help to keep the disease in check. Some members of the pumpkin family, for instance the water-melon, have rather delicate foliage, and under these circumstances a weak Bordeaux mixture, with a large amount of lime, should be used to prevent burning of the foliage. A Bordeaux mixture made by using 3 lb. of copper sulphate and 8 lb. of lime and 50 gallons of water (3—8—50) should be satisfactory.



Anthracoese of Rock Melon, due to *Gloeosporium* sp.

Wilt.

Some members of the pumpkin family are subject to a wilt disease due to different species of fungus—*Fusarium*. As the name implies, plants suddenly droop or wilt and die. Plants adjacent to infected vines rapidly follow. On removing a dead plant, its roots are found to be sound, with the exception of dull, yellow colour, which the exterior exhibits. The causal fungus invades the sap-conducting vessels, ultimately choking them and cutting off the flow of moisture.

As the fungus works in the interior of the plant, spraying will not control it, and, as the fungus lives over in the soil, rotation of crops is the only practical method of control. Plants suffering from wilt should never be ploughed under, but pulled out, dried, and burned.

Insect Pests.*

Pumpkins, melons, cucumbers, and related plants have their share of pests and diseases, but the most destructive are the leaf-eating beetles.

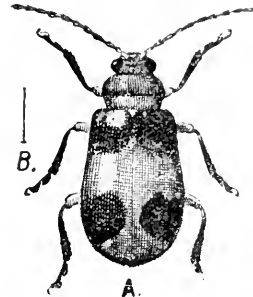
The Banded Pumpkin Beetle.

This beetle (*Aulocophora olivieri*) is particularly destructive, being perhaps the worst of all leaf-eaters that attacks garden crops. It usually makes its appearance just as the plants have made a good start, and if the season be favourable the infestation becomes so serious that the whole bed will soon be destroyed unless steps be taken to prevent it. Fortunately, the beetles are not often so numerous as this, but they must seriously reduce the returns in almost every season. In an ordinary season they appear about the middle of October, and are at their worst until the middle of

* Compiled by Officers of the Entomological Branch.

November. They swarm on the upper surfaces of the leaves, eating off the tissues till nothing but the dried skeleton remains; then they start on the next leaf. The flowers are also, attacked from the edges and eaten off in the same manner.

The adult beetle is of a general rich orange yellow colour, marked with black, and measures about a quarter of an inch in length. It is rounded on the upper surface, and can be easily distinguished from the true ladybird beetles by its general form being elongated, and the thorax forming a neck between the head and body, whereas in the ladybirds the head and thorax fit so closely into the hind portion that the whole is almost circular. As there are a number of closely-allied species, the following more detailed description will enable anyone who has the beetle before him to identify it: Colour—upper surface rich orange yellow, with the first three basal joints of the long eight-jointed antennæ yellow, and the five terminal ones black. The prominent rounded eyes are black, so also are the jaws; though the thorax is apparently all yellow, the edges are finely marked with black. The wing covers, narrow behind the shoulders, or hind margin of the thorax, are elongated and broadly rounded to the extremities, are of a rich orange yellow, with the base a broad transverse band across the lower half of the wing-covers, a faint dorsal stripe towards the tips, and the whole of the tips rich blue black. On the under surface the shanks and feet (tibiæ and tarsi) are black, with the segment between the middle and hind legs black, so that connected with the black blotches on the wing-covers it forms a continuous band round the body. The last two segments of the body are all black on the under surface, but on the upper surface the first of them is barred with yellow on either side.



A.—The Banded Pumpkin Beetle
(*Autocophora olivieri*).

B.—Indicating the natural size of
the Beetle.

The larvæ are dull whitish coloured, elongate grubs, with the hind portion yellow, and measuring about two-fifths of an inch. They are active little creatures, feeding on the stem and roots of the vines, and sometimes gnawing their way into the base of the stem. When full grown they pupate at a distance varying from 1 to 6 inches below the surface of the soil, and later emerge as the perfect beetle, ready to make a fresh attack on the surrounding vegetation.

Dusting the plants with one of the following mixtures has been found most effective:—(1) quarter of an ounce of Paris Green to 1 lb. fine slaked lime; (2) one part of tobacco dust to four parts of lime. Whichever of these mixtures is used it should be dusted lightly over the whole of the foliage (from a tin with a perforated lid or through a hessian bag). Dusting is best done in the early morning when the dew is on the plants, or, if the foliage is dry, sprinkle with the watering-can or hose before dusting. Numerous dustings may be required in order to keep the pest in check. Spraying with arsenic of lead has also been found to be effective.

The discovery a few years ago that the larvæ infested the stems and roots, and the pupæ the soil beneath, indicated another important means of control. It is obvious that if all dead pumpkin and melon plants are

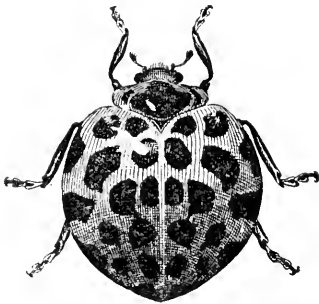
cleaned up and burnt with any other rubbish on the ground, the hibernating beetles and their eggs will be destroyed, and if the soil is turned over early in the season and thoroughly disturbed, most of the delicate larvæ and pupæ in the soil will also be killed. Nor should pumpkins or melons or related plants be grown on the same soil in successive years.

Clean cultivation and rotation are thus as important in relation to the pests of these crops as any other.

Leaf-eating Ladybird (*Epilachna 28-punctata*).

Much the same damage as that wrought by the Banded Pumpkin Beetle is done by the 28-spotted Ladybird (*Epilachna 28-punctata*). The greater part of the damage is done during the larval stage of the insect. Large patches are to be found eaten away on one surface or the other of the leaves. The surface only, however, of the leaf is eaten and the epidermis of the side opposite to the one on which the insect is feeding is left intact.

The eggs, which are pale yellow colour, are laid side by side in patches on the surface of the food plant. The larvæ when hatched are very small, but grow quickly until full grown, when they are about half an inch in length. The mature larvæ are yellow, robust grubs, thickly ornamented with branched



The 28-spotted Ladybird (*Epilachna 28-punctata*)



Portion of a Pumpkin Leaf, showing ravages of *Epilachna 28-punctata*.

black spines and light-brown patches on the upper surface of the body. When full grown they congregate in masses on the leaves of the food plant, affix themselves side by side with a sticky secretion, and pupate.

The adult insect or beetle is ovate and strongly convex in shape, orange-yellow in color, and is punctated with large black spots, generally believed to be twenty-eight in number, but usually found to vary somewhat. It must be clearly understood that although this species is very destructive, the family of ladybirds to which it belongs are almost all useful predaceous beetles, which feed on destructive scale insects and aphids—only a few species are destructive. It must not be confused with the Banded Pumpkin Beetle.

It may be controlled by dusting the plants with tobacco and lime dust as recommended above.

Other Insect Pests.

Thousands of aphides are often found upon the leaves of vines, frequenting the undersides. The most practical way when the young vines are attacked (and it is only then that curative treatment is payable) is to gather in the lateral growths, and cover the whole plant with an inverted tub, under which carbon bisulphide is allowed to vaporize.

Pumpkins and squashes are often attacked by crickets, and nothing is better for this form of attack than poison-baits made of 1 oz. Paris green to 1 lb. bran, and enough treacle to make a paste, deposited in pellets among the vines.

ASPARAGUS.

Asparagus is a branching herbaceous plant, attaining a height of 5 to 6 feet. It is a perennial, possessing a large root-stock and fleshy roots, in which it stores nutriment to tide it over the winter. It is upon the vigour of this root-stock and root system that its value depends, thus enabling it to send up, upon the return of warm weather, quantities of young sprouts, which are used extensively as a vegetable. Its period of most active growth is during the summer, it being dormant throughout the winter.

Of the edible species, there are several of what are considered distinct varieties. These are probably the result of differences of soil, climate, and culture. Of the varieties grown at Bathurst Experiment Farm, Connover's Colossal and Pride of Brunswick have proved the best. Erfurt Giant, Giant Dutch, White Mammoth, and Camden Park have also been tried. Among market gardeners the two most popular varieties are Connover's Colossal and Palmetto.

The Soil and its Preparation.

Asparagus can be grown on a variety of soils, in fact any that can be made into a good garden loam. It thrives best upon sandy loams, moderately deep, and rich in vegetable matter. River-flat lands that are moist



The Root-system of a plant of Asparagus—eight years from seed.

and well drained are considered ideal. Heavy clays, and those with a hardpan, or any that are cold and wet, should be avoided. Soils containing stones are undesirable, as they interfere with the cutting and cultivation. As asparagus requires all the sun it can get, the land should have a northerly aspect, and should not be shaded by trees and shrubs. It responds well to irrigation.

Soil which has been worked deeply and manured heavily with farmyard manure for root crops, and kept free from weeds, is most desirable. The land should be subsoiled to the depth of from 18 to 20 inches, unless it is loose and friable to that depth. The old method of trenching to the depth of 24 to 30 inches is not practicable in field culture, nor is it necessary. Asparagus is a deep-rooting plant where the conditions are favourable; the roots of the 8-year-old plant in the accompanying illustration had gone to the depth of 4 feet 4 inches. The land should be thoroughly worked during the autumn and left to mellow during the winter, when it should be again ploughed and drilled ready for the reception of the roots in the early spring.

The raised-bed method, as generally practised in garden culture, is not to be recommended under Australian conditions, and is only permissible where an abundance of moisture is ensured. The flat field culture has much to recommend it.

Raising the Plants.

Fresh seed should be sown in the spring in well prepared soil, in rows about 2 feet apart and about 4 or 5 inches in the drill. The seed germinates slowly, and if soaked in warm water for twenty-four hours germination will be hastened. Cover about 1 inch deep. The land should be well worked and kept free from weeds. By liberal treatment vigorous yearlings are produced. In setting out care should be taken not to expose the roots to the sun or drying winds. It should be done just prior to their new growth in the spring.

Only vigorous plants should be used. Select those that have the thickest, most succulent, and vigorous stems. Choose tall rather than shrubby plants. Vigorous yearlings are much to be preferred, but if 2-year-old plants are used, only those with imperfect flowers which do not bear seed should be selected. Seed-bearing is exhausting.

Planting Out.

As the beds or fields will, with proper care, last a life-time, it is important that the planting out be done carefully, and sufficient room be left for root expansion. In rich, moist soils the plants should be drilled 4 feet apart each way, and the roots set in their intersections. In light soils they may profitably be planted 5 feet each way. This allows of cultivation both ways, which is a consideration in the eradication of weeds and conservation of moisture. The drills should be opened out about 9 inches deep and the roots set in the bottom, care being taken to keep the crown upward, and to spread the roots in their natural positions. The crowns should then be covered by 2 or 3 inches of soil. If "blanched asparagus" is required the crowns should be placed about 8 inches below the surface; if "green asparagus" they should be planted shallower. The natural growth of the crown forces it towards the surface, and the original depth can be maintained by applications of abundance of farmyard manure. The drills are levelled by cultivating towards the plants.

A French Method.

A more economical method of establishing a bed, however, is that known as the French method, the seeds being sown in the fields at once, and the work of planting-out saved altogether. The system is as follows:—

After the land has been ploughed and cultivated, strike out furrows from 5 to 6 feet apart, according to the richness of the soil. The ploughing should be deep—up to 12 inches if possible—and it is preferable to plough twice in the one drill, throwing a furrow each way from the centre of the row. Then work a single-horse cultivator (closed up) in the bottom of the furrow, to loosen the soil in the bottom of the drills.

Make hills 20 inches apart in the furrow, mixing the soil of each with a shovelful of well-rotted fine manure. Sow four or five seeds in each hill, and cover lightly with good soil. The hills should then be watered and kept moist until germination, which will take about three or four weeks. After germination the plants should be thinned out, leaving only the strongest plant in each hill.

Keep the soil loose and free from weeds, and as the plants grow well-rotted manure and soil are applied, a few inches at a time, round each. The filling-up goes on steadily (care being taken not to choke the plants) until the drills are filled.

After-treatment.

After planting out, the land should be kept free from weeds throughout the summer, and frequently cultivated to conserve moisture. When the stems turn brown they should be cut down and either carted off or burned on the beds or fields. The land should be thoroughly cultivated, and where possible a liberal application of well-rotted farmyard manure applied; this can be more economically applied during winter than in the spring. Early in the spring the land should again be thoroughly cultivated, and any artificial fertiliser used should be applied then. During the cutting season it is necessary to keep down weed growth, and on large areas it is found more economical during this period to utilise a disc harrow in place of hand weeding. With this implement it is often possible to cultivate the cropped land on the day (usually Saturday) when no consignments are forwarded to market. The cultivator certainly destroys some of the young shoots, but the reduction in weeding costs, more than compensate for this loss.

The summer cultivation must be continued each year, as it is most important. During the summer months the plants are preparing fresh stores of food in their roots and require liberal treatment; neglected plants are longer in becoming remunerative. In the autumn the stems should be cut off before the seeds fall, as asparagus seedlings are one of the worst pests. Where practicable, it would be wise to go through the plants and cut out all seed-bearing stems rather than cut the whole. Later, the bed should be treated as during the first year.

Cutting.

Old established roots can be cut for about ten weeks before being allowed to run up to stem and leaf. Younger roots must be cut lightly and it is better not to make a cutting till the fourth spring. Throughout the cutting season the small as well as the marketable shoots should be cut clean away; otherwise they exhaust the roots, and reduce the marketable output. The field should be gone over and the shoots cut each day, as the leaf-buds, which form the tip, should not be allowed to open before cutting.

The method of cutting varies with the demands of the market. If "blanched asparagus" is required, it should be cut when the tops show above the ground, and about 8 or 9 inches below the surface; this system necessitates the earth being ridged over the crowns. In cutting, care should be taken not to injure other ascending shoots. For "green asparagus," the shoots are cut when about 7 inches high, cutting about 2 inches below the surface. An intermediate method is to cut when about 4 inches high, and about the same distance below the surface; the product is then half white and half green. In this State green asparagus is the most popular. After cutting, the stalks should be subjected to as little exposure as possible in the fields, and any dirt rinsed off. If the bunches are to be kept over night, they should be dipped in clean water and stood on end upon clean straw which has been thoroughly wetted. The bunches should be from 8 to 9 inches long, and tied with raffia, fibre, tape, or string. If for local market, one string is sufficient; if to travel any distance, two are preferable. The stalks should be graded into different qualities.

Manuring.

Asparagus, to be profitable, should be forced, and quick-growing succulent shoots should be aimed at. To ensure such, the manuring must be liberal. Large quantities of farmyard manure mixed throughout the lower layers of the soil are not necessary, excepting when required to ameliorate heavy soils. Fifty or sixty tons of well-rotted farmyard manure to the acre is a fair dressing, and can be applied most economically after the stems are taken off in autumn. It should be well rotted previously, to destroy seeds of weeds. Applications of commercial fertilisers should be made in the



Average bunches of Asparagus grown at Bathurst Experiment Farm.

spring, directly after the cutting is finished, and prior to cultivation. Applications of the following have given good results upon many soils:— 250 lb. nitrate of soda, 400 lb. superphosphate, and 150 lb. muriate or chloride of potash per acre.

Common salt is now but little used by commercial growers except to control excessive weed growth.

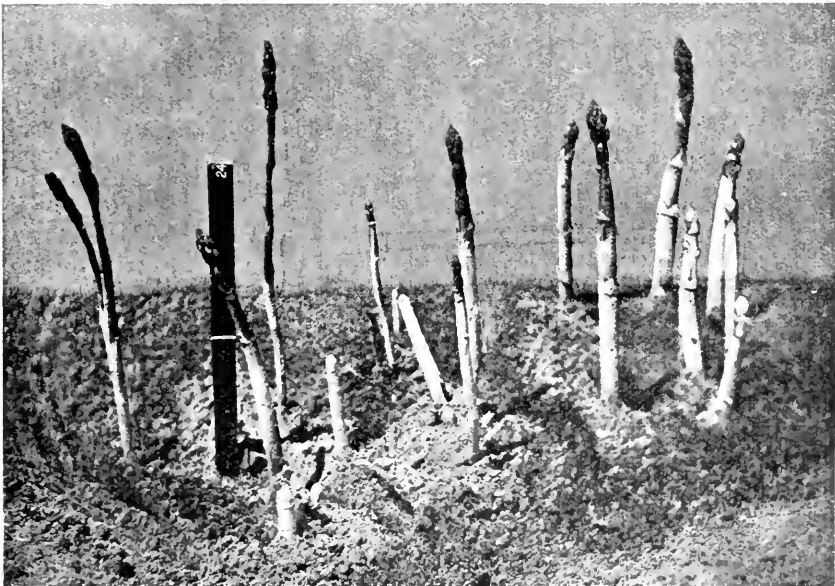
Asparagus Culture in the Goulburn District.

This crop has proved a profitable side-line to orcharding in Goulburn district. The asparagus is planted in single rows between the rows of trees, and the beds are now a few feet wide. The asparagus is cut in the morning, and graded, bunched, and packed during the afternoon, so that the produce is on the Sydney market early the following morning. The bunches, when tied, are tightened by pushing in a few extra sticks, and are then placed upright in shallow trays of water, in order to keep them fresh; each bunch is carefully scrubbed clean with a brush before packing. When packing into boxes, moistened paper is placed at the butt of each bunch, and each layer of bunches is separated by a sheet of moist paper; consequently the asparagus arrives at its destination in a very fresh condition.

Beds near Sydney.

A considerable quantity of asparagus is grown in the metropolitan district, chiefly in the vicinity of Mascot, where the soil is of a sandy nature. The crop is also grown in the Gosford and Camden districts with good results.

At Mascot the asparagus is planted in single rows either 3 feet or 4 feet apart, but these distances are considered too close when the plants are fully grown, and do not allow of earthing up. As the roots cover a wide surface a large number of shoots are eventually found in the pathways. A better distance to plant is 5 feet. Usually the pathways between the beds are filled with long-strawed stable manure to prevent evaporation. The beds are given an application of salt occasionally.



A Prolific Plant.

The growth from a 14-year old plant. The earth has been scraped away to show the number of shoots since the cut two days previous.

The cutting of the grass is done with an asparagus knife (usually home-made), which consists of a saw-edge of a few inches long on the end of a knife-blade. A small bread-saw with the end 2 or 3 inches filed, and given a fine serrated edge, acts admirably.

In this locality the bunches, after having been tied with home-grown New Zealand flax, are made tight by placing a large butt of asparagus, cut wedge-shaped, into the end of the bunch. This is a practice that should be discouraged in favour of tightening with full sticks. The best "grass" is tied with two bands. The use of raffia, strips of New Zealand flax, or red tape is recommended, as giving a better appearance than binder twine.

Duration of Beds.

As an instance of the lasting qualities of the crop when properly tended, it may be mentioned that a small bed of this crop belonging to Mr. Edward Twynam, of Goulburn, is still bearing heavily, although it was an established bed when Mr. Twynam purchased the property in the year 1868. This makes the bed now at least fifty years old.

On the other hand, the Chinese growers at Mascot cut the crop for too long a period each season, and do not allow sufficient top growth for recuperation, with the result that the beds remain in cultivation for only a few years.

RHUBARB.

Rhubarb is a perennial plant, having thick acid stems, which are largely used for pies and tarts. It requires rich soil or heavy feeding by fertilisation, chiefly in the shape of organic matter, such as stable manure. It is essential that the root crowns be fully formed before large pullings of the leaves are made. Many people make the mistake of drawing on the plant almost as soon as any large leaves have formed. As with asparagus, this treatment does not allow of the development of the plant; and consequently large yields cannot be expected for any length of time.

For planting out, the roots of older plants may be divided and set—care being taken that each root-piece contains a bud or crown—or one-year-old roots may be used. These can be purchased from any seed merchant, or the plants may be raised from seed. The latter method takes a year longer in establishing the plantation, but it is the cheaper of the two.

If this method is adopted, the seed should be sown in the spring in prepared seed-beds containing very rich soil. It should be sown in shallow drills about 1 foot apart, and when properly up the plants should be thinned to a distance of 6 inches apart in the row. Every care should be given and the plants induced to make growth by watering with liquid manure as occasion demands. These should be fit for transplanting to the field by the end of winter or early spring. The plants should be set at distances of 4 feet x 4 feet apart, or even more. Unless the soil is naturally rich, such as is found on the alluvial flats adjoining a number of our rivers, the places in the field where the plants are to be set should have been fertilised with well-rotted stable manure prior to planting.

The first year's cultivation in the field should aim at keeping down weed growth and stirring the soil, and no pullings should be made. During the following autumn or winter each plant should be given a dressing of farm-yard manure, which, later, should be dug in around the plants. A light

pulling may be made the next year if the plants have been well tended during the previous year, but it is better to defer this until the following season. Each autumn the crop should be well manured and the soil kept loose between the plants throughout their growth.

When the crop is in bearing only the larger leaves should be pulled, and this is done by holding the leaf stem well down towards the crown and making a straight pull, or making a jerk downwards while, at the same time, giving the stalk an outward twist. The leaves should be tied in bunches of suitable size for marketing, and the stems in the bunches should be of one grade. The smaller leaves are allowed to grow, in order to recoup the plant for some of the loss occasioned by the pulling of the larger leaves. Should the plants attempt to run to seed, the seed heads should be immediately cut out as seed-bearing is very exhausting. If it is desired that the bed should last for any length of time, pulling must only be carried out during a few months of the year, and not too many stalks should be pulled from the plant at the one time.

In order to obtain extra long stems it is usual to place half barrels or boxes without tops or bottoms over the plants, and thus, by partially excluding the light, to cause elongation of the stems.

Of the several varieties on the market the following may be mentioned as among the best:—Myatt's Victoria—large, red stemmed, very productive, good late sort. Topp's Winter and Sydney Crimson Winter—both good varieties used to supply the late autumn and early winter demand.

CARROTS.

The carrot is one of the most easily grown vegetables, but it is not cultivated in this State to the extent that it deserves, more especially by the householder with a small allotment. Where the garden space attached to the house is limited and required for greenery and flowers, there is no reason why the carrot should not be given a place as a border plant, as its foliage is well suited for the purpose.

Almost any soil can be brought into a fit condition to grow this crop, but a deep, sandy loam is best. A fine tilth should be produced, and care must be exercised in the manuring. Farmyard manure should not be incorporated with the surface soil just prior to planting, but a plot may be selected which had been well manured for some previous crop. Farmyard manure may, however, be used, provided it is covered to a depth of about 9 inches, and if this is done it is not likely to cause any serious branching of the roots, and will be found of great benefit to the crop. Artificial fertilisers will also prove beneficial, especially on poor soils. A mixture of superphosphate and sulphate of potash, in the proportions of four parts of the former to one of the latter, should give satisfactory results when applied at the rate of 2 or 3 cwt. per acre, but the quantity required depends, of course, on the richness of the soil. Artificial manures, in conjunction with a plentiful supply of water, result in early maturity and crispness—the latter being a most important factor.

The soil should be deeply tilled to allow of the full development of the roots. Early preparation of the land is recommended, but the surface should be loosened just prior to the sowing of the seed. For spring sowing it is always desirable to have a winter fallow. The rows can be sown fairly

close—usually a distance of from 12 to 15 inches. This permits of the use of hand wheel hoes for cultivating. The seed can be sown either by hand in a shallow furrow, raking a light covering of soil over it, or by means of a hand seed-drill, planting to a depth of about half an inch. Fresh seed should be used and may be mixed with sand to allow of a uniform sowing—the seeds having a tendency to stick together on account of being slightly hooked. If the germination is good it will be necessary to thin the plants lightly to prevent wedging, and as the roots develop the larger ones should be removed as soon as they become large enough for use. By this means the usefulness of the bed is also increased. A spring sowing should provide carrots fit for use from a few months after planting right on throughout the winter. When growing for market it is better to make successive sowings, and thin to about 3 inches apart while quite young, thus allowing of a more even development of the roots and a consequent uniform harvesting. The spring sowings are the most satisfactory, as the plants become properly established before the hot weather is experienced. Sowing can, however, be carried out during the summer months, and with proper care and attention to watering and cultivation good crops may be obtained.

Carrots are sometimes grown as a field crop, more especially on sandy alluvial river flats, of which portion of the Hawkesbury district is typical. They are also grown for stock feed, but under these conditions it is usual to plant a coarser variety, such as White Belgian, and to make the rows from 30 inches to 3 feet apart. About 4 lb. of seed per acre is required for this purpose.

The harvesting is a simple matter where the soil is of a light texture, the crop being very easily pulled out of the ground. But should the soil be at all compact or hardened or the carrots very long, it will be necessary to loosen the soil with a fork. The crop is usually marketed in bunch form, but may be sold loose by the bag. For the best returns it is advisable to wash the roots before selling.

For the earliest crop, and on shallow soils, the shorthorn type (Early Shorthorn) is preferred; for main crop, and on deep soils, the longer varieties are best suited, namely, Intermediate and Altringham.

During the cool months the roots may be stored by pitting in sand, something after the method of storing potatoes in pits. It is usual to cut off the top growth before heaping.

PARSNIPS.

The early cultivation of this crop is very similar to that of the carrot, the greatest difficulty being to obtain a proper germination of the seed, which must be fresh, or the result will be disappointing.

As the parsnip is a deep-rooting plant it is obvious that a deep soil, and one that is free from "hardpan" is the most suitable. Even where the soil is of a shallow nature the crop can usually be grown successfully, provided that the land be deeply worked. A sandy loam, if not too light in character, is the best for the cultivation of this crop, but fair results can be obtained in almost all soils with proper methods of cultivation.

Manuring of the surface soil with organic fertilisers immediately previous to planting is apt, as in the case of carrots, to cause branching and distortion of the roots, thereby making them unsaleable except for stock

feed, and then at a reduced rate. Hence, a good plan is to work parsnips into a rotation so as to follow a heavily manured crop, such as cabbages. When planted in spring, the parsnips are ready for use in early autumn, but, if so desired, can be left in the ground throughout the winter. It is usually considered that a frost before harvesting improves the eating quality of the vegetable.

Sowing during the hot months of the year is not likely to succeed to the same extent as the spring sowing, as in the former case the young plants have a chance of becoming firmly established before the hot weather sets in.

Owing to its poor germinating qualities the seed should be sown very thickly. It is planted in rows 15 to 18 inches apart and covered to a depth of about 1 inch. The thinning of the crop when necessary is different to that of carrots, and should be carried out in the one operation as soon as the young plants are of sufficient size. A distance of 4 or 5 inches should be left between the plants. The tops will quickly make a strong growth, and the only attention required will be the keeping down of weeds and a thorough cultivation between the rows during the early stages of growth.

On deep soils this crop lends itself to field practice, and under these conditions from 6 to 8 lb. of seed per acre will be sufficient.

The crop is harvested as required and, as already stated, the roots may be left in the ground throughout the winter with perfect safety; but if the land is needed for other crops, storing in pits in a cool situation will be found quite satisfactory. For lifting, it will usually be found necessary to loosen the ground with a fork. For marketing, the roots should be washed, and may be bunched or forwarded loose in bags. It is always advisable to grade the produce.

The most popular variety is Hollow Crown, but Student is also largely grown and gives excellent results under vigorous cultivation.

BEET.

Beet-root cannot be classified as one of the important vegetables, but it may be considered as well within the second group, being a favourite summer vegetable.

It can be grown almost anywhere and on practically all soils, but those of a heavy clayey nature are the least suitable, and good crops of best quality can only be expected under the best conditions.

The preparation of the soil should be similar to that of carrots and parsnips, as the beet also has a tap-root, and therefore requires deep working of the soil. Very rich soils are not altogether suitable, as with this crop extra large roots are not popular. For the same reason it is well not to over-plant too early in the spring, as if not quickly used, they become too large before the season is over. Smaller successive sowings will be found to answer requirements much better. The seed can be planted throughout the year, except during the cold, wet, winter months. For good quality, the crops should be quickly grown, as otherwise they become somewhat tough, woody, and coarse flavoured.

The position should be a sunny one, and, for household plots, rows 12 inches apart are sufficient. For commercial culture the rows should be spaced not less than 15 inches apart, and even up to 30 inches. The seed

as purchased is fairly large and has a corky appearance; this is really the seed fruit which contains several seeds. The germination is sometimes disappointing, but this is mostly due to faulty sowing. Should the surface soil be dry and light in texture, the seed must be planted deep in order to reach the moisture, but should the surface soil be damp a depth of about 1 inch is sufficient. To get the moisture through the corky covering of the seed is always very difficult, and to overcome this it is usual to soak the seed overnight previous to planting. Where possible the seed should be spaced about 1 inch apart in the drills and thinned to at least 6 or 9 inches apart, according to the variety. When young, the plants can be transplanted if carefully handled so as not to interfere with the roots, but this course is only recommended where there are wide spaces in the rows as the result of faulty germination; the plants from the thicker portions of the field may then be utilised for this purpose. The crop needs little attention other than cultivation to keep down weeds and a sufficient supply of moisture. The roots can be used for household purposes as soon as they are large enough, but they should not be forwarded to market until more fully developed.

Great care must be exercised in harvesting, as bruising or breaking of the tap-root is a serious drawback, causing bleeding to take place in cooking, which leaves the vegetable very pale in colour. The beet is rich in sugar, and if allowed to bleed a large quantity of this constituent is also lost. In cooking, if the utensil is large enough, it is always advisable to allow the tops to remain, but if the vessel will not permit of this, screwing off the tops is preferable to cutting them.

The long varieties are not favoured by housewives on account of the difficulty of accommodating them in ordinary pots; for this reason the turnip-rooted sorts are more popular. Varieties recommended are:—Eclipse—turnip-rooted, early, smooth-skin, globular shaped, with a highly coloured flesh. Egyptian—turnip-rooted, very early, roots rounded and flattened, and resting on the surface of the soil, suitable for shallow soils, skin smooth, violet or slaty red, flesh dark blood colour. Silver Spinach—this is a variety of beet-root, the leaves of which have been developed for culinary purposes. The cultivation is identical with that of the ordinary beet, except that the plant should be spaced at a distance of not less than 15 inches apart. The leaves are used as required, and are boiled and minced the same as ordinary spinach.

SECTION X.

Grasses and Pastures.*

It is only during the past fifty years that grasses common in other countries have been introduced into New South Wales. Up to that time native pastures provided by far the larger proportion of animal food: now, however, native grasses have been replaced very largely by introduced grasses (paspalum, rye grass, &c.) on the coast, and by introduced herbage (trefoil, crowfoots, &c.) in the wheat-growing districts. In the interior, beyond the wheat-belt, the native grasses are still supreme.

But it must not be assumed that native grasses find no place on the tablelands and coast. In certain positions—for example, on poor soils, or on slopes where cultivation is impracticable—the native grasses are indispensable. It is questionable whether, under any process of tillage or cultivation, any introduced grass could be found superior to our native couch on poor, sandy soils, or in the Cumberland district in general. If, again, the seed of our native grasses were capable of easy germination, and on the market, it would be a difficult matter to replace such grasses as water couch (*Paspalum distichum*), Paddock love grass (*Eragrostis leptostachya*), Slender panic grass (*Panicum gracile*), and many others.

However, it is generally recognised on the coast and tablelands that where the soil is suitable and where cultivation is practicable, the laying down of introduced grasses substantially increases the carrying capacity of the area, and produces a greater revenue. Particularly is this the case with newly-cleared scrub lands. In such positions the best of the native grasses would soon be eaten out after clearing, and their places taken by the more worthless grasses and weeds. A surer and quicker revenue is produced by laying down to paspalum, Rhodes, or other introduced grasses, where the rain, falling on the newly-formed ashes, renders the seed capable of easy germination.

A Good Pasture.

Best results are obtained from those pastures which are re-cultivated and re-sown after a certain period; without treatment a pasture cannot be expected to give satisfactory results after a number of years. Many farmers take no cognisance of the comparative values of various grasses, "plenty of grass" being applied to any thick growth irrespective of its nature. As a rule, however, good land generally grows nutritious and palatable grasses, while poor land grows the harsher and more innutritious kinds. It is just as advisable, however, for a farmer to increase the quantity of nutritious grasses on his good land as it is for him to increase the carrying capacity of his poor land. If he has good land carrying a sheep per acre, for example, he would value the land at producing, say, £1 per acre: it is often possible to double this carrying capacity by introducing heavier yielding grasses, and the land would then return him £2 per acre, or an increase of £1 per acre. On the other hand, if his poor land carries one sheep to 3 acres, and he manages to double this, he is only increasing the value of his land £1 for 3 acres.

* E. Breakwell, B.A., B.Sc.

Good grasses should be characterised by the following features :—

- (1) Permanence (particularly under stocking).
- (2) Succulence, palatability, and high nutritive qualities.
- (3) Vigor of growth and good carrying capacity.
- (4) Good seeding habits (generally).
- (5) Resistance to adverse climatic conditions, such as frost and drought.

Bad grasses will be characterised by the following features :—

- (1) Short-lived character.
- (2) Harshness of leaf and unpalatability.
- (3) Too vigorous seeding habits, which often cause them to spread into cultivation.

A good pasture should provide succulent feed all the year round. This is impracticable in many localities, as the summer grasses prove too vigorous and crowd out the winter grasses. In such circumstances there should be distinct paddocks of summer and winter pastures. Good pastures should also be free from weed and fungus growth. Allow weeds to obtain a hold on a pasture, and it will be practically impossible to bring it into good condition again without re-sowing. Land should first be sown to a strong-growing crop and then fallowed before being laid down to pasture. By working the land occasionally during the fallow most of the weed seedlings can be destroyed.

Mixtures.

An ideal pasture is one containing as great a variety of good grasses as possible, combined with leguminous plants like clovers, trefoils, &c. Only by such a combination (that is, the supplement of the carbohydrate content of the grass by the protein content of the legume) can the ideal balanced ration be provided. Paspalum pastures would lose a great deal of their present value were it not for the fact that White clover grows abundantly with it in most situations. Under natural conditions many different species of plants intermingle; different plants require different soil constituents, or similar constituents in different proportions, and the plant-food in the soil that is not utilised by one grass may thus be absorbed by another.

A combination of grasses not only provides a more varied ration for stock, but the varying habits of the different grasses ensures a more satisfactory pasture in other ways. To lay down pastures of individual grasses is very unwise. For example, if a pasture of cocksfoot alone be laid down, the tufts produced are not only unsightly, but coarse, whereas when cocksfoot is mixed with clover and rye grass, a more uniform sole is produced, and the pasture is improved in quality. It must be confessed however, that the number of grasses that can be used in a mixed pasture in this State is very limited. For example, cocksfoot, rye, and prairie grasses, and clover will grow in association in many parts, while the other English grasses mixed with these die out after a couple of years. They are either too sensitive to our hot and dry summers, or stock show a decided preference for them and being weakest in growth they succumb.

It is recommended that grasses be mixed wherever possible, but only by experiment can the suitable ones be determined. Certain grasses, like paspalum, kikuyu and couch, are generally so vigorous that to sow other grasses with them is useless. In such cases, separate paddocks of different grasses are required if a variety of feed is desired. In all cases clover should be sown with the grasses. White clover is generally used, but Red clover is suitable in certain mixtures.

Palatability.

Stock of all kind show a distinct partiality for certain grasses when they become accustomed to them. As a general rule the palatability and the nutritive qualities of a grass are closely co-ordinated—that is, high palatability generally indicates high nutritive qualities. The palatability of a grass varies considerably according to (*a*) soil, (*b*) stage of growth, and (*c*) climatic conditions. The poorer the soil the less palatable and less nutritious the grass. As a rule grasses are more appreciated in their young stages than when mature; this refers particularly to those grasses which develop harshness and woodiness in the advanced state, in which category come paspalum, Rhodes, cocksfoot, and Sudan grass. The nutritive qualities of a grass, however, are generally higher at the flowering stage. An excess of growth can therefore be utilised as hay which is generally more appreciated by stock than the mature growing plant. Climatic conditions affect the palatability of grass, inasmuch as too much drought or too much rain effect its normal development. The greatest succulence results from good rains at the right periods.

It is often extremely difficult to determine whether it is better to lay down a pasture containing grasses which yield heavily, or grasses which yield less but which are more palatable and nutritious. Paspalum is a grass which is not considered as palatable or as nutritious as some others, such as rye grass, but no dairy-farmer would lay down a pasture of rye grass on the northern rivers in preference to paspalum, owing to the heavy carrying capacity of the latter. It is often possible, however, to lay down a pasture with grasses containing both characteristics.

Introduced Herbage.

If all the growth of herbage in good seasons could be utilised, much more feed would be available for stock than under the old conditions, when native pastures and herbs grew on the flats and loose soil generally. During the spring of 1920 an average of at least 10 tons of greenstuff per acre could be obtained anywhere in the wheat growing districts. For two months of the year (September and October) fifty sheep per acre could be carried without making any impression. There never has been, nor is there likely to be, a native grass that will produce such an enormous amount of feed. No native pastures have yet been known to carry more than two sheep per acre, and one sheep per acre right throughout the year is considered good. But the life of the herbage is very short, and after October it soon withers and leaves the ground extremely bare, except for the burs in the trefoil country. It follows therefore, that if the grazing of the herbage alone is relied on, the sheepowner is worse off than if in possession of native pastures which persist throughout the year.

In drought periods the native grass country scores easily. The herbage will not respond unless supplied with a good rainfall, whereas the *Danthonias* and *Stipas* will stand an extraordinary amount of dry weather. For example, in Dubbo district at the breaking of the two years' drought in June, 1920, investigation of the *Danthonia* pastures on the hillsides showed the tussocks, to all appearances dead before the rain, reviving in a wonderful manner, and out of forty clumps in three square yards fully 50 per cent. retained their vitality.

The *Danthonia* pastures in the Riverina district during the drought were the main source of feed, and sheep running on these paddocks were among the small number not sent for agistment to more favoured localities. At

Wagga Experiment Farm the sheep running in the *Danthonia* paddocks kept in better condition during the spring of 1919 than any other sheep in the district. In fact, the *Danthonias* and the *Stipas* provided feed right throughout the wheat districts, where the crops and introduced herbage absolutely failed.

It follows, therefore, that unless the large amount of herbage which grows in an ordinary season is conserved and not allowed to run to waste, the farmer who owns herbage country alone is at a disadvantage compared with the farmer who has native grass pastures; though, if the excess of growth of herbage could be conserved, the amount of feed thus produced would probably be much greater than from native pastures. Yet very few wheat farmers conserve such fodder, the causes of failure to do so being (1) want of labour and machinery, and (2) a disinclination to provide for the future when plenty of feed exists. The first is a legitimate objection, for the herbage must be cut quickly when it is at its best, and labour must be readily available. If the cutting is delayed or protracted, the vegetation loses its nutriment, and becomes unsuitable, either for hay or silage. The labour is required only for a short period; a fact that makes it the more difficult to obtain. Regarding machinery, very few wheat farmers, except those who grow lucerne, possess the mowers or rakes necessary for cutting the herbage, despite the fact that it would certainly pay to have such implements on herbage country. Excess herbage can be conserved either in the form of hay or pit silage. The latter method is recommended as the most economical and practical one, and most of the herbage is particularly adapted for this mode of treatment. Yet the number of farmers taking advantage of this method in good seasons is ridiculously small, and thousands of tons of good feed are going to waste every year.

A much increased carrying capacity of sheep would be possible in the wheat-growing districts if the right methods were adopted. The short grasses and cereal crops are more adapted for grazing sheep than large stock.

A limited number of large stock can, however, be maintained on such crops as lucerne, Sudan grass, and introduced herbage in a good season, but in a dry year under these conditions, hand-feeding or agistment must be resorted to.

Grass Seed.

Strictly speaking, a grass seed is the grain with all the husks (or glumes) removed. It is only in the case of a few genera, however, that the seed of grasses as bought from the seedsman consists of pure grain without husk; usually some part of the husk remains attached to the grain and is only removed with difficulty. Sometimes one side of the grain is exposed, as in the *Brome* grasses; at other times the grain is completely concealed as in the *Paspalum* grasses. In the latter case it is extremely difficult to determine from its appearance whether the so-called "seed" contains grain or not. Very often the seed is harvested when immature and very little grain is present. As a rule, all seed which falls voluntarily or with little effort from a grass plant is ripe, that is, it contains grain. Thus the "best hand-shaken" *paspalum* seed that some seedsman advertise means that the immature seed was not stripped from the plant, but only the seed taken that fell off easily. Examples of unripe seed which is often placed on the market are Rhodes grass, Kentucky blue, Sheep's fescue, couch grass, and sometimes even cocksfoot. In such cases it is often advisable to test the grain of a few seeds by pressing with the sharp point of a penknife; a fair amount of resistance is probable due to the presence of grain.

Grass seed may be rendered impure and dangerous to sow (*a*) by the presence of fungus diseases, such as Smut and Ergot, and (*b*) by the presence of weeds. Smut takes the form of a blackish powder, often found on the seed of such grasses as prairie grass; Ergot is evidenced by small, black, rod-shaped fungus growths attached to or taking the place of the grain in the seed. Ergot has become fairly common in this State and now occurs on Rye, Fescue, Andropogon, and Brome grasses.

Weed seeds are more common in some grasses than others. In the cases of vigorous-growing grasses like paspalum, rye, prairie, and cocksfoot seed is often fairly pure, and the quantity of weeds is very small. In weaker-growing grasses, however, such as Kentucky blue, the Bent grasses, &c., weed seeds are often found in great abundance.

The germination or vitality of seeds refers to the capacity of the germ in the grain to develop under certain favourable conditions into a living plant. The power of grass seed to germinate may be affected by

- (*a*) age (it may be too old or too young);
- (*b*) injury done to grain through exposure to certain harmful conditions, such as moisture, heat, &c.
- (*c*) immature state of grain through being harvested too soon.

As a rule the grain of grass is capable of developing into healthy plants for a considerable period after being harvested, and very little deterioration results in any grass seed for at least a couple of years. Some introduced grasses like rye, cocksfoot, and Fescue then appear to deteriorate fairly rapidly. Seeds of many grasses like paspalum and couch require a resting period before germinating.

Seed is often injured in transit. This is particularly likely to occur to seeds stored in loosely-fitting tins, or packed near or in a hot chamber. Moist seeds are affected much more easily by temperature conditions.

Seed harvested in an immature state is likely to wrinkle and render the seed coat more susceptible to moist and other climatic conditions and the germ is thus more easily affected. Affected seeds that develop are likely to produce weaker seedlings and consequently weaker plants.

Methods of Sowing.

Three methods are employed in the seeding of pastures, namely—

- (*a*) sowing seed in well-cultivated, prepared ground.
- (*b*) sowing seeds in "burns"; and
- (*c*) scattering seed broadcast.

Sowing on Prepared Ground.—An ideal pasture is best obtained by sowing on a thoroughly prepared seed-bed. It is a serious mistake to assume that grass seed can be sown on ground rougher than that required for other crops. As a matter of fact, the more thorough the ploughing, cultivation, and harrowing, the better will be the results. As much weed growth as possible should be eliminated before sowing. Broadcasting the seed—either by hand or by some mechanical contrivance which distributes the seed regularly—is the method generally adopted. A fine day should be chosen for the purpose, and it is a good practice to sow the clover seed at right-angles to the grass. By this means a more uniform distribution is obtained.

For certain grasses like *Phalaris bulbosa*, Fescue grasses, cocksfoot, and rye grass, drill sowing can be recommended. A better germination, and a more uniform stand is invariably obtained by this method.

It is an uncommon practice in this State to sow grass seed with any other crop; but the results that attend the method are often satisfactory. Italian rye grass, sown with a light seeding of oats, produces in the spring a good body of feed which can be utilised for hay. The aftermath of the grass can then be grazed practically to the end of the year. Other grasses used in this way with good results are Kentucky blue grass and cocksfoot.

Sowing in "burns."—A good deal of this is done in rich heavily-timbered country. The ashes of the burned timber provide a good seed-bed for many of the grasses, the principal of which are paspalum, Rhodes, cocksfoot, rye grass, and Bokhara clover, all of which have given good results where tried. A wet cool season should be chosen for the purpose, as the fine ashes quickly dry out, and the seed or seedlings become injured in the process. Volcanic soils, owing to their loose nature, and to the protective growth afforded by shrubs and large tree stumps, are particularly adapted to sowing in "burns."

Scattering Seed Broadcast.—This method of sowing seed is not recommended, except for native pastures in the west where cultivation on a large scale is impracticable. A great deal can be done by scattering good native grass seed over the area (just after rain, if possible) and tramping it in with sheep or other stock. The black soil area is particularly adapted to this primitive method of sowing, owing to the fact that the cracking of the soil allows the seed to be buried with very little difficulty. The method is not as certain on hard soils such as in the Riverina, and red soils in general, in which maybe only a very small amount of seed will germinate, and then only after resting for a long period. The pasture can be maintained, however, by this means. Some pastoralists always have native grass seed in their pockets, and scatter it over the bare patches as they are travelling round their estates.

Time to Sow.

English grasses on the coast and tablelands are best sown in the autumn, say, March or April. In the more elevated tablelands, however, and where the spring and summer rains are constant, good stands are often obtained by sowing any time during the winter. Most English grasses, though little affected by frosts, make slow growth in the winter months. The root system, however, becomes well established during this period, and, when the warm spring arrives, the grasses make rapid growth.

Summer grasses like paspalum, Rhodes, kikuyu, and Sudan are best sown in the spring. Some farmers sow paspalum at any period during the summer months, but there is a risk attached to this, owing to the quickness with which the soil surface dries out, thus affecting germination.

Rate to Sow.

To a large extent this depends on the size and weight of the seed. Some seed has a much higher vitality than others, rye grass, for example, always produces a stand wherever sown. Again, heavy seeds require a heavier seeding than light seeds. A mixture of cocksfoot, rye grass, prairie grass, and Cow grass clover, for example, can be seeded at the rate of about 30 lb. per acre, whereas light grass seed like that of Rhodes grass would only require to be sown at the rate of 4 to 5 lb. per acre. This would mean $2\frac{1}{2}$ million seeds of Rhodes grass as against 10 million seeds (approximately) of the cocksfoot-rye grass mixture. Owing to its creeping character, a Rhodes grass plant will easily occupy an area equal to that occupied by three or four plants of the mixture, so that the seeding works out fairly accurate. Vigorous

grasses like paspalum, although they may not germinate as well as English grasses, will cover the ground and smother weed growth better than the latter.

Clovers should never be seeded as heavily as the grasses in a mixture. This is because (1) the seed germinates more satisfactorily than that of the grasses, (2) the protein content of the pasture would become too high in proportion to the carbohydrate content, and (3) the growth of the clover is often more vigorous than that of the grasses. In a mixture, 4 lb. per acre is considered the maximum quantity for clovers.

GRASSES RECOMMENDED FOR DIFFERENT DISTRICTS.

The merits of different grasses often form the subject of considerable controversy among farmers. For example, in cold localities, *Phalaris bulbosa* is considered one of the best winter grasses yet introduced, while in other parts (the South Coast, for example) some farmers are averse to it owing to the fact that it is not permanent under stocking. Many farmers, again, condemn a grass because stock do not relish it when grazed for the first time on the mature growth, forgetting that their stock have become accustomed to a certain class of feed and that a new plant, particularly when mature, may not appeal to them at first. Lack of permanence in a grass may be due often to defective management, such as overstocking, in its early stages. This particularly applies to Rhodes grass and *Phalaris bulbosa*. There is also sometimes a definite variation in the palatability of a grass, owing to its being affected by soil and climatic factors.

Few farmers have exact data concerning the value of various grasses they have tried, and although the Department of Agriculture has done a considerable amount of work in testing the various grasses at Government farms and in co-operation with farmers, considerably more data are necessary before definite information can be provided for specific localities. It has been proved to be a good plan to try various grasses on a small scale when little is known about them before laying down large areas. The following mixtures are recommended for different parts of the State with a fair degree of confidence that they will prove successful on good or medium-class soils:—

NORTH COAST.

Summer Pastures.

- (1) Paspalum and White Dutch clover.
- (2) Rhodes grass and lucerne.
- (3) Kikuyu grass and elephant grass.
- (4) Couch grass.

Winter Pastures.

- (5) *Phalaris bulbosa* and Bokhara clover; Egyptian clover (particularly as a rotation crop).

No. 1 should be sown in early autumn (February or March), or in spring (September), at the rate of 12 lb. of hand-shaken paspalum seed and 4 lb. of clover per acre. The paddock should be ploughed after a period of about five years, and sown to a summer crop such as maize or sorghum, and then allowed to revert to paspalum. Only by this means can the maintenance of a good paspalum pasture be guaranteed.

No. 2 should be sown in early spring at the rate of 4 to 5 lb. of Rhodes grass and 2 lb. of lucerne per acre. These two plants grow well together, and a balanced ration is provided. The lucerne also provides good winter feed. Rhodes grass should be allowed to become fairly well established before being grazed. Under judicious treatment this mixture should last for five or six years.

No. 3.—Elephant grass is especially suited to the medium or poorer class of soils. Kikuyu grass will thrive luxuriantly when planted alone. Its rate of growth is much more rapid than that of elephant grass, and therefore when combining these two grasses the elephant grass should be allowed to become well established by being permitted to grow to a height of about a foot before the kikuyu is planted. The elephant grass roots should be planted 6 or 8 feet apart, with the rows the same distance apart. The kikuyu grass roots should be planted between the elephant grass roots a couple of feet apart. The planting is easily carried out by making shallow furrows with the plough in the cultivated ground, dropping the roots or cuttings in the furrows, and then covering with the soil.

No. 4.—Where couch grass does not occur spontaneously it is not practicable to go to the trouble of laying down a pasture, as the seed germinates badly and root-planting is necessary. On the river flats of the coast, and also on other good soil, couch grass provides excellent pasturage, and in some instances, as on the Clarence and Macleay Rivers, farmers are disinclined to replace it by paspalum.

No. 5 is a mixture that does well on soils where paspalum and couch have not obtained a good hold. Sow in autumn at the rate of 6 lb. of *Phalaris bulbosa* and 5 lb. of clover per acre. The pasture should not be grazed until it is well established.

MIDDLE COAST (Manning, Hunter, and Hawkesbury Rivers).

Generally speaking, the mixtures recommended for the North Coast can be used for these localities. Shearman's clover does well in moist situations and Chilian clover (a strain of Red clover) has also proved satisfactory.

SOUTH COAST.

Summer Pastures.

- (1) Paspalum and White clover.
- (2) Rhodes grass and lucerne.
- (3) Elephant and kikuyu grass.

Winter Pastures.

- (4) Cocksfoot, Perennial rye, and prairie grasses, and Red clover.
- (5) *Phalaris bulbosa*, White clover, and Tall oat grass.

Nos. 1, 2, and 3 can be sown and treated as on the North Coast.

No. 4 should be sown early in the autumn (March or April) at the rate of 10 lb. cocksfoot, 12 lb. Perennial rye, 6 lb. prairie, and 4 lb. Red clover, per acre. This pasture provides good feed in the early spring.

No. 5 should be sown in early autumn at the rate of 6 lb. *Phalaris bulbosa* 4 lb. White clover, and 6 lb. Tall oat grass per acre. Both *Phalaris bulbosa* and Tall oat grass are excellent winter grasses and are not affected even by the heaviest frosts.

NEW ENGLAND AND NORTHERN TABLELAND.

It has been proved that the coarse native grasses like Kangaroo grass Wild Sorghum (*Sorghum plumosum*), and Tussock poa (*Poa cespitosa*) are very unsuited to sheep. Much better results are obtained from finer native grasses, such as the Danthonia, Chloris, and Eragrostis grasses. The Danthonia grasses are the best native winter grasses of New England. They should be encouraged by being allowed to seed at periodical intervals and by scattering the seed over denuded areas.

Several introduced grasses have proved successful on the Northern Tableland. The most important are cocksfoot, Perennial rye grass, *Phalaris*

bulbosa, Giant fescue, Tall oat grass, *Bromus inermis*, Kentucky blue grass, and Red and White clover. Kikuyu grass is also promising well. The following mixtures are recommended:—

- (1) Cocksfoot, Perennial rye grass, and Red clover.
- (2) *Phalaris bulbosa* and White clover.
- (3) *Bromus inermis*, Red clover, and Tall oat grass.
- (4) Perennial Rye grass and Kentucky blue.

No. 1 should be sown in autumn at the rate of 10 lb. cocksfoot, 12 lb. Perennial rye, and 4 lb. Red clover per acre. The Perennial rye grass will be seriously affected in a very dry season.

No. 2 also should be sown in autumn at the rate of 8 lb. *Phalaris bulbosa* and 4 lb. White clover per acre. This mixture is very fattening to sheep, and will probably carry more stock than No. 1.

No. 3 should be sown in March at the rate of 12 lb. *Bromus inermis*, 4 lb. Red clover, and 6 lb. Tall oat grass per acre. *Bromus inermis* (a very palatable grass) makes the best growth a year after it is sown. Tall oat grass is not as palatable as other grasses, but it is readily eaten in a mixture.

No. 4 (also March sown) should be seeded at the rate of 16 lb. of rye grass and 12 lb. of Kentucky blue grass per acre. A strong covering grass like rye grass is necessary for the Kentucky blue grass, as the latter is slow in becoming established.

CENTRAL TABLELAND.

* Owing to the lower elevation and drier climate, many of the English grasses like rye grass and Timothy are unsuited to these localities. Very few cultivated pastures are laid down by farmers on the Central Tableland, and few data are provided by actual experiment. The following can be recommended, however, Nos. 1 and 2 having done well at Bathurst Experiment Farm and No. 3 at Cowra.

- (1) *Phalaris bulbosa*.
- (2) Giant fescue and cocksfoot.
- (3) A mixture of the native grasses *Panicum prolatum*, *P. flavidum*, and *P. decompositum*.
- (4) Sudan grass.

No. 1 should be sown in March at the rate of 8 lb. per acre.

No. 2 should be sown in March at the rate of 12 lb. Fescue and 10 lb. cocksfoot per acre.

No. 3. It must be borne in mind in this case that such native pastures only become established when the right climatic conditions ensue for the germination of the seed. All these grasses are very drought-resistant and provide excellent summer feed. They should be sown in the warm season.

No. 4. Sudan grass is one of the surest of grasses. It should be sown in October at the rate of 6 to 8 lb. of seed per acre. A paddock of this grass can be used for pasture, hay, or ensilage.

SOUTHERN TABLELAND.

The most important grasses for these localities are the Danthonia grasses, and in the colder parts the Snow (*Agrostis*) and Fescue grasses. These are native grasses and should be encouraged.

WESTERN DIVISION.

† On the slopes and in the Riverina introduced grasses like Rhodes grass and Sudan grass have proved successful, and a mixture of Sudan grass 6 lb. and Rhodes grass 3 lb. per acre is recommended. The Sudan grass

acts as a cover crop to the Rhodes until the latter is thoroughly established. Certain native grasses like Coolah, Warrego summer grass, Native millet, and Wallaby grass have also proved promising under cultivation.

Generally speaking, however, the success of our native pastures in the west depends on—(1) an intelligent conception of the good and useless varieties; (2) the subdivision of paddocks and their judicious stocking; and (3) the prevention of overstocking, particularly after a drought period. Good grasses should be encouraged in every possible way.

Danger of Overstocking.

It is evident that no hard and fast rule can be laid down as to the exact number of stock a given area will carry. Observation of the condition of the pastures themselves must guide the owner. There is no doubt that subdivision of paddocks is necessary—(1) in order to provide a change of succulent feed; (2) to allow the grasses to seed and thicken up; and (3) to prevent the better grasses from being eaten out by allowing the stock to remain in too long. If the grasses are not allowed to seed at least once in a year, or if any spot or spots are allowed to be completely depastured and the grasses to be replaced by thistles or other weedy herbage, the land is certainly being overstocked, and few seasons are needed to see the consequences. The good grasses become less and less in number, and as they are replaced by weeds, the stock avoid the worthless plants and continue to eat out the few good grasses that remain. The natural consequence is the substitution of weeds and noxious grasses for good pasture plants.

An interesting experiment has been conducted at Coonamble Experiment Farm over the last five years to determine the effect of overstocking a small native pasture. Two sheep per acre have been on the pasture continually. When the experiment commenced a good quantity of *Danthonia*, *Chloris*, *Sporobolus*, and other grasses was present in the pasture; there were also present Creeping saltbush, *Alternanthera triandra*, and other herbs. At the present time all grasses have completely disappeared, and the whole of the vegetation is confined to burr, trefoil, and saltbush. On a similar area which has been protected from stock the grasses have increased considerably since the beginning of the experiment, and the pasture now comprise a fine grass mixture, supplemented by trefoil in the winter months.

In stocking a pasture, the following points should be kept in mind:—

1. Any weeds existing should not be allowed to seed.
2. When stock are showing a partiality for the finer grasses, with the result that they are being eaten out, the animals should be removed and the grasses allowed to recover.
3. If the pasture shows indications of becoming thin it should be allowed to seed at intervals.
4. Change of pasture, by the provision of different paddocks, is necessary for the well-being of any grass land.
5. The sowing of good strong grass seed should never be overlooked.
6. Grass seed like paspalum, Rhodes, and couch grass seldom contains many impurities, mainly owing to the fact that the pastures from which such seed has been gathered are generally clean. In the case of the finer grasses, however, impurities are often present, and in the case of grass seed from other countries there is also need for caution.

Burning Off.

The question of the advisability of burning off any excess of grasses is a much vexed one. It has to be remembered (1) that burning off the dead material reduces the amount of humus and organic matter which a pasture ultimately contributes to the soil, (2) that sometimes the finer grasses are destroyed, and (3) that sour land is not improved by burning. On the other hand, spear grass country is invariably benefited by a good burning off when the grain is in seed, as is also a weedy pasture, particularly a pasture infested with thistles, &c., which should be burned to destroy seeds or to prevent seeding. Much of the wheat land in this State is of the last-mentioned nature, and burning is advocated in such cases. Where a good "sole" of nutritious grasses exists, however, one would feel disinclined to burn off owing to the destruction of the organic matter that takes place.

Weeds in Pastures.

Pastures composed of strong vigorous grasses generally contain few weeds. For example, the cleanest pastures on the coast are paspalum and couch grass pastures. These prove too strong for weed growth, and are, indeed, often laid down on old cultivated land which has become rather dirty through weed growth. Kikuyu is another grass that will usually smother weed growth. Weeds become rampant, however, on pastures comprising the finer grasses, such as rye grass, Bent grass, foxtail, Kentucky blue, and others, if such pastures are not treated in a judicious manner. The causes of weed growth in pastures are (1) incomplete preparation of the land prior to seeding, (2) sowing at the wrong time, (3) a poor "catch" from seeding, (4) injudicious stocking, and (5) sowing seed containing weed impurities.

Incomplete Preparation of the Land.—Old cultivated land requires much more preparation for the reception of grass seed than virgin native grass land. This is because weed growth has been more rampant in old cultivated land, and the soil has become a repository for all classes of weed seeds. Such land should be given a fallow and constant cultivations prior to sowing.

Sowing at the Wrong Time.—The prevalent weeds of the district and their periods of growth should be familiar to the farmer before sowing his seed. For example, if autumn sowing is necessary, such weeds as Cape weed, sorrell, spurry, and chick weed need to be taken into consideration. The seed should be sown either long before the ordinary time of arrival of these weeds so that the grasses may become thoroughly established and be able to combat the weeds, or it should be deferred until the weed seedlings have appeared, after which the land should be cultivated before the grass or clover seed is sown.

A Poor "Catch" from Seeding.—Owing to temporary dry conditions, infertile seed or other causes, pasture seeds often fail to germinate satisfactorily and a bad stand results. A poor stand of grasses generally means the subsequent encroachment of weeds, and such a pasture should be ploughed up and resown as soon as practicable.

Injudicious Stocking.—If stock are turned on to the grasses too soon they prevent the grasses from developing properly, and the small and weak growth of the grasses is insufficient to smother the weeds. It is always a good plan to stock lightly at the first grazing. This encourages stooling, and a more even pasture results. In feeding off a pasture it should neither be understocked nor overstocked. Understocking sometimes results in the grasses remaining dormant, and weed growth reaching perfection, and being allowed to seed. Overstocking, on the other hand, generally results in the finer grasses and other plants being eaten too closely and the noxious weeds and other growth being allowed to grow.

SECTION XI.

Silos and Silage.

THE disastrous drought of 1902 was repeated in 1919 with more or less severity throughout the whole of New South Wales. As a matter of fact, almost every year some portion of the State feels the effects of a prolonged absence of rain, or of a cold winter, when little or no feed is available for stock. During these droughts and times of shortage of feed, farmers and graziers alike talk of the need of fodder conservation, resignedly taking the consequences of not being prepared, and swear that they will not be caught again—only to forget their good resolutions when better seasons and times of plenty come again.

For the Department to preach conservation of fodder in the midst of times of distress is useless, but when times are normal and the harvest a bumper one, the wisdom of a careful consideration of the advantages of silage as a means of averting, or at least minimising, the disastrous effects of drought, is urged upon farmers, dairy men, and pastoralists.

By converting into succulent and nutritious fodder, material (such as surplus grasses, herbage, and crops) that would not otherwise be used, silage effects a saving, which, if the practice was universal throughout the State, would be of almost incalculable value, the more so, as silage can be made anywhere in New South Wales, and is adaptable to the particular conditions obtaining in every part.

It is inexpensive, even though the cost of installing the silo, in the event of one being necessary, may seem to some to be large. A brief survey of the losses of stock and of the money paid for fodder at famine prices will soon bring conviction as to the wisdom and economy of the practice of silage making. And there is no possibility of waste even though the silo remain full and unused by reason of good seasons for several consecutive years. It has not been necessary in this country to keep silage for any length of time, but in the United States it has been successfully kept without deterioration for thirteen years.

The feeding value of silage is high; it enables dairy cows to produce milk and butter-fat more abundantly; it produces fat beef more quickly than pasture, and more economically than dry feed; and it is of inestimable value as succulent feed for lambing ewes and for fattening young lambs and calves.

A silo will also enable feed to be utilised that by reason of a rainy season cannot be converted into hay. Altogether it is estimated that the use of silage will increase the carrying capacity of an ordinary farm by 25 per cent.

Considering all its merits, it is rather inexplicable that more silage is not made by farmers. Apparently the chief reason is because it is thought that the making is a complicated process, in which special skill and knowledge are required. As a matter of fact, it is simpler and easier to make than hay. In haymaking a considerable amount of judgment is required, as it is easy to make a mistake in putting it in before it is properly dry. The difficulty seems to be that farmers, being used to making hay, cannot realise that good feed can be made from green, sappy material. The processes of silage-making and haymaking are somewhat analogous to fruit canning and fruit drying. If the farmer, knowing that his wife cooks the fruit and then puts it in a

bottle and makes that bottle airtight, would just realise that when he puts green material into a silo it naturally cooks itself, so to speak, he could go ahead with greater confidence.

If certain simple instructions are followed boldly there is practically no danger of failure.

The General Principles.

“Ensilage” and “silage” are the terms usually applied to the foodstuff obtained by “ensiling” or storing succulent green fodder in a receptacle or stack in such a manner that it retains its succulence and most of its colour. The process of ensiling consists of storing the forage plant under pressure in a silo, stack, or pit, and regulating the resultant heat so as to prevent rotting or decomposition, but yet to allow of a certain amount of fermentation. It is this fermentation which causes the odour which is peculiar to silage.

The fermentation of plants is mainly due to the action of micro-organisms, and the principle of ensilage is to encourage the action of these micro-organisms up to a certain stage, and when this stage has been reached to check or destroy them. When green plants are heaped together fermentation soon begins, and the temperature increases rapidly. This increase of temperature causes a very great development in bacterial activity, and fermentation proceeds very rapidly until the temperature goes somewhat above 125 deg. Fah. When a temperature of about 140 deg. Fah. is reached many of the organisms that have produced fermentation are destroyed, and hence fermentation proceeds more slowly until a temperature of (say) 160 degrees is reached, when all the organisms are destroyed, and spores or seeds only remain alive. Fermentation then stops, and not until the temperature decreases considerably and air gains access to the fodder can a secondary fermentation begin. Thus the food is preserved.

The organisms that produce acid cease to do so at a high temperature, and the amount of acidity produced will depend on the length of time at which the silage remains at a temperature below (say) 130 deg. Fah. If the fermentation is slow, and the heat develops slowly, more acid will form than if the fermentation is rapid and a high temperature is quickly reached, and generally sour silage will then be produced.

Sweet silage is obtained by filling the silo slowly, thus allowing sufficient oxygen to remain in the heap to enable the heat-loving organisms to set up a brisk fermentation, form considerable heat, and practically check all fermentation and decay. By adding further fodder more weight is added, thus shutting out fresh oxygen, and checking and controlling the amount of fermentation and heat. Pressure then is the main agent for controlling the temperature, and hence the fermentation.

If the silo is a good depth, the weight of the fodder is of itself sufficient for the lower half of the silage, but the upper portions, especially the 5 or 6 feet near the top, do not receive sufficient pressure to ensure a proper fermentation and preservation, and as a result this portion may become mouldy, dry, and practically useless. By covering the top of the silo with some such substance as wet chaff, the air is excluded, and the top of the silage, even though unpressed, is improved. Still further improvement can be produced, if, in addition to covering to a depth of about 1 foot with damp chaff, some pressure is applied, the main thing being that the pressure shall be constant. Any method of pressure which requires daily attention, such as screwing up, cannot be constant, and hence is not so effective. Silage pits have been

pressed with very good results by placing planks on the top and weighting these with large stones; sand-bags have also been used for this purpose with success. Any simple method of continuous pressure which the farmer may devise will be of use, and each farmer should use the system of continuous pressure which is most easily obtainable.

Any bushman can rig a contrivance for protecting a self-registering thermometer, which can be used for ascertaining the temperature of the contents of the pit from time to time. A simple yet practical way of determining the temperature is to run a $\frac{3}{8}$ th or $\frac{1}{2}$ -inch pointed iron rod into the contents of the pit; leave it there for a time; if on drawing it out the rod is too hot to hold in the hands, the temperature is too high; if only fairly warm, the temperature is too low; whereas if it is just about as hot as one can bear, the temperature is about right. If the heat is too great it can be reduced by consolidating the contents and excluding the air. If, on the other hand, the temperature is too low, the filling of the pit should be temporarily stopped to enable the requisite temperature to develop.

A safer plan would be to screw a point on to a length of inch piping, which could be thrust deeply into the mass, and in, say, ten minutes a thermometer could be lowered into the pipe.

Value of Silage as Food.

Silage is eaten eagerly by sheep and cattle; mares also, with foal at foot, take to it, but, speaking generally, it is not suitable for horses. There is often considerable loss in ewes near lambing from constipation, and in lambs after lambing from the ewes going dry—in both cases owing to the dryness of the natural feed. These losses can be avoided by giving the ewes a small daily ration of silage, the laxative effect of silage being greater, if anything, than that of green feed, and the milk-producing quality being equal to that of green feed.

While there is any dry feed about, a ration of 1 lb. a day will be quite sufficient for sheep; but as the dry feed disappears, it will be advisable to gradually increase the ration to 3 lb. a day. At these rates, 1 ton of silage will give a daily ration of 1 lb. to 2,000 sheep, allowing a fair margin for possible, but not probable, waste, while 3 tons will give a full daily ration. When it is remembered that, in drought times, if chaff or hay can be obtained at £8 per ton it is considered very reasonable, and also that dry feed is not nearly so suitable for either breeding ewes or milch cows as silage, the value of silage is much greater than its moderate cost. In fact, once green feed has disappeared, there is nothing within the reach of the sheep-farmer which approaches silage as a cheap and satisfactory food for sheep.

Silage is ready for use in two to three months. It is practically indestructible, and does not deteriorate by length of time: so that, if not wanted for a number of years, it is as good when opened up as when first ready for use. Further, there is no danger of loss from fire, flood, rabbits, mice, &c., the silage (when not chaffed) being a solid mass that must be cut out with a strong hay-knife or a broad axe.

Material for Silage.

To make good silage it is essential that the material used should contain the right amount of sap. If it is too dry it is likely to mould or to char—that is, the heat which is generated will, although not causing actual burning, produce a charred condition of the material and render it useless.

If, on the other hand, it contains too much sap, a mushy, evil-smelling product will be produced, the condition being so bad in some cases as to make it valueless. Crops of wheat, barley, or oats which have made good growth and have not been withered by heat or drought are in the best condition just after the ears appear. These crops, even when they have made rank growth, do not contain too much moisture. At Coonamble Experiment Farm silage of extra good quality has been made from barley grown on black soil, which had lodged so badly through rank growth that it was extremely difficult to cut. This crop was cut before it had all eared in August, and was put straight into pits. At Condobolin Experiment Farm barley was also used; and at Trangie and Nyngan Farms silage has been made from wheat, and in every case the silage was excellent in character.

Maize and sorghum make good silage when cut at the time the cobs are well formed in the former and when the heads are well out in the latter. Rape cannot be converted into silage owing to its great sappiness. Even stray plants of rape mixed with barley put into the silage pit at Coonamble came out mushy and useless.

Among natural herbage, trefoil and variegated thistles make good silage, but it is as well to let the material wilt a few days before putting it into the pit. It is doubtful whether very succulent herbage such as crowfoot will make good silage. It contains so much sap that it would be risky to make; but if it were allowed to dry somewhat, and could be mixed with drier material, it might turn out satisfactorily.

In the wheat-growing belt it will pay the farmer best to grow crops especially for silage, as on the red-soil country heavy growths of natural herbage rarely occur. Barley and wheat are very suitable, and crops infested with oats can be utilised.

In raising crops for silage early sowing should be practised. By doing this a heavier growth is usually obtained, as advantage is taken of the early autumn rains, and in addition the crops can be handled before haymaking is due. In many cases the most satisfactory crop is Cape barley, as it makes a very strong growth and gives a big yield.

Types of Silo.

Various means are used for putting up silage. In the dairying districts the usual and most convenient method is properly constructed tub silos. These vary both in shape and in the material used in the construction. It is also put up in stacks, which are generally weighted, often in ingenious ways, to exclude air and prevent loss. Even when the greatest precautions are taken, however, this is a very wasteful method, both of labour and of feed.

In the wheat-growing districts, especially where the silage is intended for sheep, the pit method is undoubtedly the best. By this means silage can be made with the least amount of labour, and with a minimum loss of material. It is not rivalled even by the most up-to-date silo, as when the latter is used the material must be chaffed, and this means greater expense in making the silage, and when it is being fed to stock troughs of some kind are required as feeders, whereas the crop is put into the pit whole and when the silage is taken out it needs only to be spread over clean ground for the stock.

STACK SILAGE.

Of the three distinct methods of conserving green fodder in the form of silage, that of stacking in the open is generally regarded as the most wasteful and the least to be recommended. There are modifying influences existing in certain districts, however, that render the use of any other system almost impracticable. The making of ensilage is still regarded in many localities in the light of an experiment, and farmers in such districts are naturally disinclined to invest, without some experience, the amount of money involved by the high cost of materials and equipment in the making of a tub silo. Moreover, while the pit silo is an ideal type for the drier areas of the State, it is never likely to become popular on the coast, mainly because of the heavy rainfall experienced, but partly owing to the fact that excavating machinery is only in the most rare instances included in the equipment of the farm.

None of these objections are, however, applicable to the stack silo. As appreciation of the advantages of conserving green fodder becomes more general, it may be anticipated that silage will come into very general use; meanwhile, any cheap and reliable method that will appeal to farmers generally, gaining for silage the esteem that it deserves and paving the way to the installation of the fully equipped tub silo, is to be welcomed.

Several effective methods can be adopted to make stack silage. These can only be determined by local conditions. In all cases provision should be made to render the stack weather-proof from the top to exclude rain. If a shed be used, with a good floor and well drained, a space of 16 ft. x 14 ft. will provide for 100 tons with a stack 22 to 24 feet high. The first consideration, after having determined to select the stack as a means of conserving the crop, is to secure a site in close proximity to the milking or feeding sheds. An elevated spot is best, with natural drainage and a firm dry surface layer of soil to start on, and, if possible, sheltered from prevailing winds.

In some instances it may be expedient to build stacks in the paddocks where the crop is grown. Care should be exercised in selecting a well-drained site. Soil may be used to weight the stack, but in using this special precautions should be taken to secure a level, evenly-balanced surface.

Four stout posts at either corner of the stack would assist in keeping it plumb. The material should not be allowed to jamb at the posts to interfere with its settling. Stacks of green material very often tilt over to one side on account of uneven drying. The wind may dry one side more than the other and prevent its settling uniformly. A stack may fall over if not watched. A tarpaulin may be hung against the side to protect it from the wind. Water also could be applied to the drying side.

It is of the utmost importance to build each layer evenly and upwards, maintaining a regular and unbroken contour, to ensure an equal distribution of weight, so that the stack will shrink evenly and maintain its shape. The main principle to observe in all cases is to keep out the air, and to obstruct its ingress during the curing stage.

Apart from the object of excluding and getting rid of entangled air, a danger to obviate is the opening up of the stack through uneven settlement and shrinkage during the fermentation processes later on.

It is essential to surround the stack with a fence sufficiently substantial to prevent stock of any kind reaching the fodder. Without this, calves, pigs, horses, and cattle, are always attracted; they draw out stalks all round to get at the edible portion, and by this means admit air to the stack, check the fermentation changes, and spoil it for fodder. The crop should be stacked immediately after cutting.

Crops Most Suitable.

In making recommendations as to suitable crops, especially on the coast, two points demand consideration. The almost complete absence of harvesting machinery on the coast greatly restricts the number of crops that can be ensiled economically, compelling small areas of bulky crops, while the humid summer and autumn, with the resultant plentiful supply of fodder, and the comparatively dry winter and spring, with their corresponding period of shortage, also comprise qualifying factors.

While most fodder crops included in the economy of the coastal farm are suitable for silage in a greater or less degree, there are many reasons why maize should invariably be selected for the silage crops. Maize produces the greatest bulk of fodder, is easy of production and handling, and its silage is of the most nutritious and palatable nature. Further, as there is usually no shortage of fodder on the farm during the growing season of maize, the crop can be well spared for purpose of silage, and when the maize crop has been cut for silage, ample time remains to fit the soil for a winter fodder crop, especially if the maize has been sown in drills and cultivated.

Sorghums and millets are also eminently suited for silage purposes, but although producing a finer stalk than maize, and thus being comparatively free from the possible coarseness of the latter, they cannot usually compare with it in point of yield, except in the case of sorghum upon inferior soils. The high sugar content of sorghum, however, causes a corresponding development of acidity when subjected to the fermentative changes in the silo, resulting in the production of sour or acid silage, which is regarded (particularly in the northern areas) as being slightly superior to sweet silage for milk production. There is an element of risk with sorghum on account of its poisonous tendencies, and if it should be necessary to ensile an immature crop or one stunted by drought conditions, particularly in cloudy weather, it is advisable to cut it twenty-four hours before stacking.

Paspalum, cowpeas, Sudan grass, the various winter green fodders, &c., may all be included in the list of silage crops but for reasons specified above they are unlikely to ever gain the popularity of maize for this purpose. While discussing winter green fodders for silage, however, special mention should be made of the combination crops, that is, mixtures of wheat or oats with field peas or vetches. Yields of 15 tons of green fodder per acre are not uncommon with these crops, and, although when at their maximum there is commonly a pressing need for green fodder, at the same time any surplus can well be conserved as silage where the requisite machinery is available. The mixture of cereal and legume is usually so complete in these combination crops as to entirely avoid all risk of uneven settling—a risk that has to be guarded against when mixing one or more crops in the stack.

Lucerne is not recommended as a silage crop. It is much more valuable conserved as hay than as silage; but, as is frequently the case in districts of copious rainfall, when lucerne hay becomes rain-damaged during the process of curing it can be converted into silage with advantage.

Harvesting.

To secure maximum yields and, to facilitate harvesting, crops such as maize, sorghum, &c., should be drill planted and level cultivated, all hilling being avoided. The maize harvester is, of course, the last word in harvesting for silage, but the slide and scythe-blade will be found useful.

For small areas, broadcasted crops and steep and rocky situations, the crop may be handled successfully with a sugar-cane knife or light hand hoe, but whatever system is adopted it is essential that the stalks be kept parallel in the bundles. For transport to the stack, ordinary slides will be found most economical; a rope sling should be placed across the floor of the slide before loading, and in due course secured around the bundles, thus serving to keep the load in place and providing a grip for the lifting gear at the stack. In the cases of large slides or heavy material, it may be advisable to split up the "lift" by utilizing two or more slings on each slide.

The crop should be harvested when it has reached its maximum vegetative growth—in the case of maize, when the husk and lower leaves on the stalk have turned brown, and the grain has assumed its natural colour and shows its indentation but is still milky. Sorghums and millets are at their best when their seed is distinctly set. Absolute adherence to rules is, of course, impossible under field conditions, and the time of harvesting must of necessity be somewhat flexible, but these facts must be observed: harvesting in an immature condition results in loss in bulk and in nutritive value, while if delayed beyond the point recommended above, there is serious risk of extreme development of heat, and the production of charred and altogether inferior silage.

Elevating the Bundles.

The elevation of the bundles presents some little difficulty, but this can be easily overcome by several methods; a mast and spar can be used, or a block and tackle operated from an overhanging limb of a convenient tree; but the system most to be recommended is the "whipstick," as illustrated. (Fig. 1.) The length of the "whip" is, of course, determined by the height of the stack, but usually a pole of about 30 feet in length will fulfil all requirements. The "whip," like the block and tackle, can be worked from an adjacent tree, or, as is more usual, a stout pole can be erected for the purpose at the end of the stack-framework. Fig. 2 shows a pair of clutching-dogs, which any local blacksmith could make, for gripping the bundles of greenstuff.

Building the Stack.

In the accompanying illustrations the various stages of the building and curing of a stack of sorghum silage at Hawkesbury Agricultural College are depicted.

In completing this particular stack, the aim was to shape the roof so as to exclude rain, to keep the stack intact, and to resist wind. No thatching was designed, and no special materials were utilised. The sheaves of sorghum were laid transversely, and when the ridge was reached the whole was kept firmly in position by passing across every 4 feet fencing-wire weighted on each side to heavy fencing-posts hanging loose. In this way, as shrinkage set in and the stack fell, the fencing-posts hugged the stack closely, and kept the wires tight and in close position until the whole mass condensed and became solid and stationary.

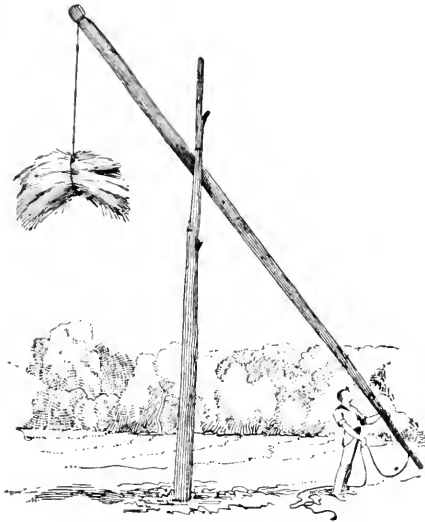


Fig. 1.—A well-made Whip-stick.

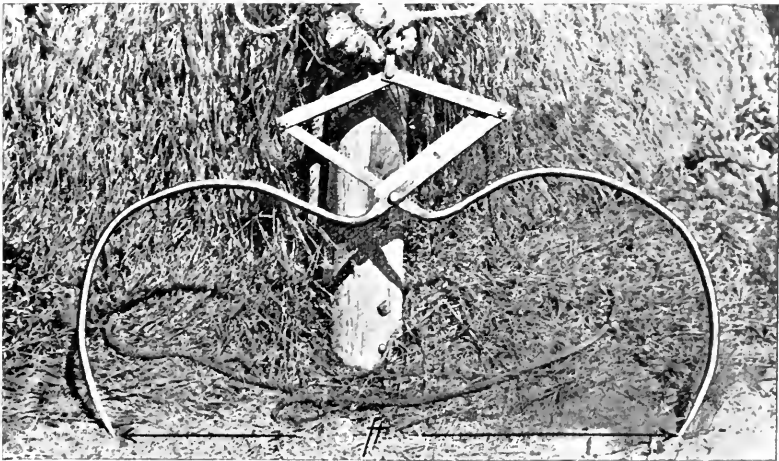


Fig. 2.—Clutching-dogs for gripping and hoisting bundles of Silage.

It was estimated that approximately 130 tons of green sorghum were dealt with. The following measurements were recorded six weeks after the completion of the stack:—

Average length of stack	...	...	...	...	...	ft. in.
" width	"	...	...	...	...	27 6
Height from ground to eaves	...	...	...	...	...	20 0
" " " ridge	...	...	...	...	...	11 0
Length of ridge	...	...	...	...	...	18 0
Computed total volume	...	...	...	...	...	24 0
						7,894 cubic feet.

A rough estimate of 32 lb. per cubic foot being accepted, the total weight of the stack would be 113 tons. This estimate of 32 lb. per cubic foot was arrived at by taking into consideration the shrinkage of the stack to about two-thirds of its former size, and the actual weight of the cured silage, as obtained at a later date, at 47·37 lb. per cubic foot. It is thus evident that the original estimate of 130 tons of green crop was somewhat too large.

Eight months later this stack was remeasured when curing was complete with following result:—

Average length	...	...	...	...	...	ft. in.
" width	...	...	...	...	...	26 9
Height from ground to eaves	...	...	...	...	...	19 6
" " " ridge	...	...	...	...	...	8 6
Length of ridge	...	...	...	...	...	11 6
Computed total volume	...	...	...	...	...	24 0
						5,189 cubic feet.

The stack was opened shortly afterwards, and as the centre was approached measurements were again taken to ascertain approximately the waste.

It was decided to allow for waste—

18 inches	all round the stack or the sides.
12 "	over the top or roof.
6 "	for the floor or bottom.

This reduced the measurements of available fodder, or good silage, to—

Length	...	...	...	...	...	23·75 feet.
Width	...	...	...	...	...	16·5 "
Height from ground to eaves	...	...	...	...	...	7 "
" " " ridge	...	...	...	...	...	10 "
Length of ridge	...	...	...	...	...	21 "
Total volume	...	...	...	...	...	3,308 cubic feet.

The exact weight per cubic foot was next determined by carefully cutting out a cube, measuring and weighing it—*i.e.*, the cavity from which the cube was removed was measured, and the cube weighed. This gave:—

Contents of cube	...	...	...	...	6,925 cubic feet.
Weight of cube	...	...	...	...	328 lb.
Weight of 1 cubic foot	...	...	...	...	47·37 lb.

Using this weight per cubic foot, the total weight of the cured silage was—

$$5,189 \text{ cubic feet} \times 47\cdot37 = 245,803 \text{ lb.} = 109\frac{3}{4} \text{ tons nearly.}$$

Deduct the waste on the top, sides, and bottom, and the result is—

$$3,308 \text{ cubic feet} \times 47\cdot37 = 156,700 \text{ lb.} = 76 \text{ tons nearly.}$$

An examination of the 6 inches of waste on the bottom showed that while the fodder was not equal in standard value to the other for milk cows, it was readily eaten by dry stock, and hence $2\frac{3}{4}$ tons was added to the total edible silage, bringing the total to $72\frac{3}{4}$ tons.



Fig. 3.—Stack finished and weighed down with old fence-posts suspended from wires across the top.



Fig. 4.—Same stack, nine months later, just before being opened up for use.

The actual loss in food material from waste was thus found to be 37 tons.

The loss of moisture in the curing stage was the difference between 113 tons and 109 $\frac{3}{4}$ tons, or 3 $\frac{1}{4}$ tons.

No difficulty was experienced in cutting the silage with the ordinary hay knife, as the accompanying illustration (Fig. 5) shows.



Fig. 5.—View of open cut face of same silage stack, showing benefit of placing material in even layers and having a uniform pressure.

The larger the stack the less the waste in proportion, and hence a large square stack is more economical. A stack may be made of any size, and so can be built to suit the amount or weight of the crop. Avoid making the base too big.

Cutting and Feeding.

In opening a stack silo the point to be observed is that silage moulds very rapidly when exposed to the air, and the correct mode of procedure is to expose the smallest portion of the inside surface and to endeavour as far as possible to renew this inside surface daily. It is usual, therefore, to open the stack at one end, and at the same time to disturb the covering and weighting system over as small an area as possible. Only small benches should be opened up, so that they can be cut right out as soon as possible. It is absolutely essential that no more than the day's ration be cut at one time, and that the cutting be clean and free from tearing. For best results the cutting should be done with an ensilage knife, but in the event of this implement not being available, a sharpened spade or an old squaring axe, or even an ordinary chopping axe, may be successfully used.

It is not advisable to open the stack earlier than fourteen to sixteen weeks from the time of stacking, in order that the fermentative processes of curing may have time to complete their work.

It is unusual for any difficulty to be experienced in inducing stock to eat good silage; in fact, it has been observed that even the waste from the stack is readily devoured, especially when stock have become accustomed to silage. It is not recommended that cows in milk should receive any of the weathered portions. The daily ration of silage is about 40 pounds, but for obvious reasons this point must be left to the discretion of the feeder, for if the silage is supplemented by other foods this amount would be materially reduced. Most silage is rather deficient in protein, and the addition of a little lucerne or oaten hay, copra or linseed cake, bran, or (in sugar-growing districts) small quantities of molasses, will be found advantageous, especially in feeding young or growing stock.

A New Type of Stack.*

A factor that has exerted a retarding influence upon the development of stack silage on the North Coast is the difficulty frequently experienced in securing the services of competent stack-builders. As little or no hay is produced in this district, opportunities for practising stacking are correspondingly few. Farmers are aware that bad stacking means increased waste, and realise that the collapse of the stack after completion would mean silage wholly spoiled—considerations which naturally make them somewhat cautious. In order to overcome these objections and to assist in bringing ensilage into more general use, a system of parallel stacking, as distinct from the square system of crossed bundles, has been evolved. This new method has achieved much popularity in Queensland, and has also been practised successfully on the North Coast of New South Wales.

The advantages of the new system are, briefly, as follows:—

1. Practically all risk of collapse consequent upon bad stacking is eliminated, no skilled labour being required and the construction of the stack being such as to prevent collapse or canting.
2. Weather waste is minimised. Maize and sorghum are the crops almost invariably used for silage on the North Coast, and, as under the new system the bundle or sheaves are laid in the one direction, a much better compaction is obtained.
3. Good samples of silage can be made from amounts of material much too small for utilisation by the old method.
4. Some advantage is derived from the fact that when feeding the silage there are no great inequalities in length of stalk.

Building the Frame.

The new method is designed chiefly for handling maize or crops of similar habit of growth, such as sorghum and millet. It usually consists of an oblong stack, supported along both sides in order that the bundles may be laid in the one direction, the need for cross layers being thus entirely avoided.

* G. C. Sparks, Inspector of Agriculture.

The dimensions of the proposed stack must first be estimated, after which a row of bush poles is erected along each side of the selected site, as shown in Fig. 6. Great weight of timber or strength of framework is not absolutely essential, as the pressure is mainly downwards; and as the stack settles it contracts from the framework, which, if necessary, can ultimately be removed. The length of the poles is, of course, fixed by the height to which it is proposed to stack, but their diameter should be about 3 to 4 inches at their small end. The large ends should be inserted 30 to 36 inches into the ground, and the tops braced by a light pole, to which the uprights are wire twitched. The exact distance between the posts is determined by the length of the material to be stacked, well grown maize or sorghum usually being safe with a space of 36 inches between uprights, and 24 inches being recommended if a shorter growth has to be treated. The

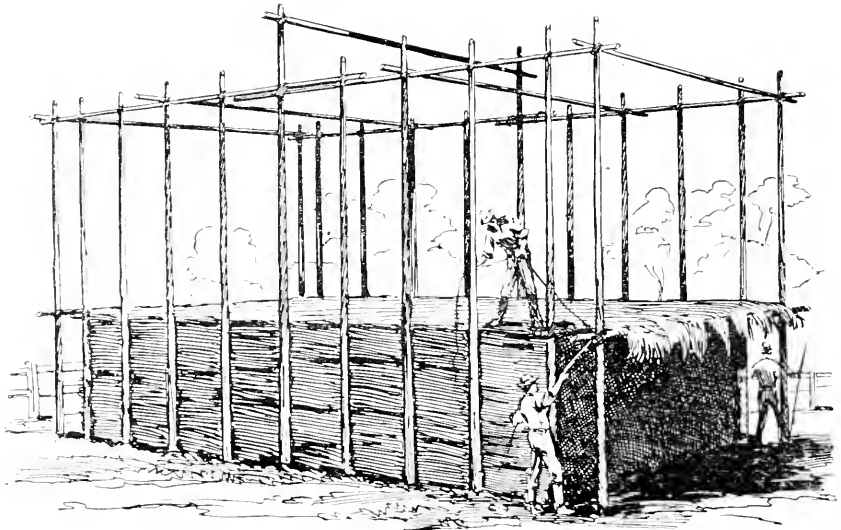


Fig. 6.—A Stack Silo suitable for Coastal Conditions.

framework should be braced across the ends and the middle at the top, and if possible, the poles carrying the centre brace should be sufficiently high to allow ample head room for the stacker to work as the stacks near completion. A pair of light poles should be erected at end of the framework, and a light cross-piece provided to carry the heads of the end rows of bundles during stacking (as explained later).

The site selected for the stack should be a dry one, and it should be so located as to be convenient to the crop that is to be ensiled, and also to the point at which the material is to be fed to the stock.

It is always advisable to ensile as large a quantity of material as possible in one stack, as the larger the stack the smaller will be the percentage of waste. For general purposes a framework of about 25 feet long x 15 feet wide x 20 feet high is to be recommended. This space should hold enough

green fodder to produce approximately 80 tons of silage, and at a safe estimate it should be filled by the product of from 5 to 6 acres of maize. If, however, larger supplies are available, better results are likely to follow with a stack containing 100 tons or upwards.

Directions for Stacking.

A foundation of about 18 inches of grass or any coarse material should be placed to receive the first layer of bundles, and a start made by placing the first row of bundles with their butts in line with end pair of uprights in the framework. Under no circumstances, however, should a timber foundation be used, as this allows air to penetrate the bottom of the stack. Successive rows of bundles, each overlapping the last, are laid until the entire floor of the framework is covered, the heads of the last row protruding from 30 to 36 inches beyond the last pair of uprights. In placing the second layer, the heads and butts are reversed, and the stacking continued in this manner. When a height of approximately 20 inches has been reached, a rough "straightedge" should be laid across the ends of the stack on the outside edges of the last pair of uprights, and the protruding heads of the bundles cut off and thrown back into the body of the stack. This practice may not be absolutely necessary, but is strongly advised, an unbroken and compact face being thus presented to the weather, while the heads of the alternate end rows of bundles are preserved and made to swell the stack instead of being permitted to go to waste. After the first trimming has been made, the light cross pieces referred to earlier are placed in position against the additional pair of uprights at the ends of the framework so as to carry the protruding heads of the bundles of the ensuing layers. These cross-pieces carry little weight and should be easily adjustable; they can be held in place by a pair of stout forks or wire twitched to their supports. After a further 30 or 36 inches of material has been stacked the ends are again squared off with the straightedge and the cross-pieces elevated accordingly, and so on until the completion of the stack. Under ordinary conditions this operation would not be necessary more than once daily.

For satisfactory results, a depth of not less than 30 inches over the surface of the stack should be put on daily; liberties in this direction can be taken with immature material, but with more matured crops speed in handling is imperative. If a portion of the crop is drier than the rest, it is advisable to place it on, or near to, the bottom of the stack, and to have the heavier and greener portion near to the top, in order that the drier portion may be subjected to the greatest pressure, and that its deficiency of moisture may be rectified by the soakage from the upper layers of the stack. Unlike hay, silage suffers no damage from rain during stacking, and save for the inconvenience caused thereby the work may proceed under moist weather conditions without detriment to the product; it is, in fact, sound practice to apply water when stacking a crop that has attained an advanced stage of maturity. In completing the stack the aim should be to leave the centre slightly higher than the sides in order that a depression may not be formed by the more complete heating and settling of the central portion: this point must be carefully observed when two or more classes of crop are ensiled in one stack, and complete layers made of each.

If the bundles are placed with average care, the weather waste on the exposed surfaces should be comparatively slight; heaviest waste will necessarily be towards the top of the stack, and this can be materially reduced by the application of even a light pressure. Good results may

be obtained by regular attention to some form of winding gear, which can be successfully operated from the ends of logs embedded beneath the foundation of the stack, the weight being applied by the usual wire ropes and distributed over the surface of the stack by means of a framework of light poles; but almost anything that can be easily and conveniently handled (such as logs, stones, bags of sand, or even loose earth) will give results more or less satisfactory. Whatever system of weighting is adopted, it is essential that the pressure be evenly distributed over the stack surface, and that a thick layer of grass or straw be placed directly on top of the silage. The stack can be further protected by a layer of grass on top of the weighting material, and by ridging this last layer well down the centre of the stack, an unbroken surface is presented to the weather. Experience indicates that this additional covering requires no holding in position except in exposed situations, as under the usual North Coast weather conditions, the grass "mats" very rapidly; where necessary, however, a few strands of fencing wire will give all the support necessary. When loose earth is used for the top-weight the need for the upper covering is avoided, but the low protective layer should be increased in thickness to prevent ingress of soil from above and poles laid around the top of the stack to hold the earth in position. For obvious reasons this system of weighting is not recommended when any other is available.

PIT SILOS.*

As a comparatively inexpensive and quite effective way of conserving fodder the pit silo is preferred by many farmers in western districts, including the managers of one or two experiment farms. The cost of excavating the pit is not great, and the loss of material is very much less than in the open stack, provided, of course, that a thoroughly suitable site is chosen and that the material is properly filled in so as to exclude air. Moreover, the pit is very easily filled, the teams and drays being drawn through for the material to be unloaded, and thus each time trampling down what has been previously deposited.

In days when stock were cheap the cost of carrying them through drought periods was almost prohibitive. But now, when sheep are worth from 20s. to 30s. per head, it is a good business proposition to take steps to save them, as even with feed at abnormal prices such a course is usually cheaper in the end than the cost of re-stocking later. Most graziers recognise this fact, and have made every endeavour to carry their stock through by paying high prices for agistment or the purchase of feed. To cope successfully with droughts, however, it is necessary that provision be made during good years, as unless this is done the amount of stored fodder in the country when dry conditions prevail will be totally inadequate. During droughts the few who have reserves of fodder are handsomely rewarded for their foresight; but if farmers could be certain of receiving for forage each year a return which would ensure them a reasonable profit, they would be well satisfied to grow forage for sale purposes.

A very sound policy for the large sheepowners to adopt would be an arrangement on their part with neighbouring farmers to grow and store for them fodder in normal years, with delivery to be made when the necessity

* A. H. E. McDonald, Chief Inspector of Agriculture.

arises. Farmers are often in a better position than many of the large graziers to undertake the work of conserving fodder, as they have the necessary equipment and suitable land. A great area is occupied by graziers on which it is impossible to grow crops, and relief must perforce be obtained from more favourably situated country.

It is only by some such organisation and co-operation between farmers and graziers that sufficient reserves of forage will be created and appalling loss of stock from time to time prevented. One of the most satisfactory methods of conserving forage in connection with such a scheme is to ensile it.

A System of Ensilage Benefits the Farmer.

It might be stated at once that under normal conditions it is neither difficult to raise crops suitable for silage, nor is silage difficult or inconvenient to make. The crops can be raised easily because the seed can be sown much earlier than wheat is ever sown for hay or grain, and thus grows during the most favourable season. It is not inconvenient to make, because the crop can be cut and all the work of making completed well before the usual routine of haycutting commences. There is a further advantage that the work can be done when the weather is cool; it is therefore not nearly so trying as the operation of haymaking.

A wheat farmer to be successful must carry sheep on his land as well as grow grain; and a good reserve of silage will not only prevent loss during droughts, but it will enable him to increase the numbers because of the reserve of feed on which he can draw should the necessity arise. Where the size and character of the farm is such that the owner finds it impossible to carry sheep permanently, except a few ration sheep, the adoption of the system of silage-making may place him in the position of being able to make use of sheep to a greater extent, and thus augment his returns.

Under present conditions it is hardly possible for a great many wheat-farmers to carry many sheep profitably, as the nature of their holdings is such that the natural grasses, even when helped by the wheat stubble, are not sufficient to provide feed for any length of time. There is no great inducement for a farmer to grow crops specially for sheep feed when he knows that he will have to wait until the crops are ready before he can buy, and at that time, owing to the abundance of grass, sheep will be so high in price that the margin will not recompense him for the cost of growing the crop.

It is undeniable that a better system of rotation is required in the wheat areas than the almost universal wheat and bare fallow, because such a practice will within a very few years so reduce the supply of humus in the soil that the yields of wheat will no longer enable a profit to be made. Such a condition is already arising in many soils, and will become more pronounced as time passes. In this country where the rainfall is so uncertain, one of the most important constituents of the soil is humus, because it is one of the prime factors in helping the soil to retain moisture for a long period, and even the best fallowing will not yield good results in its absence.

The only practicable means of restoring or maintaining a good supply of this constituent, except by allowing the land to lie out in grass for a long period, is to grow upon it, in rotation with wheat, a crop which can be fed down by sheep. The remains of the plants left after the sheep, and their excrement, become humus, which gives to the soil the desirable moisture-retaining character.

The conservation of silage will enable the farmer to adopt such a system with greater certainty of making a good profit directly from his green crops, as well as indirectly by improving the present yield, because it will place him in the position of being able to stock the land to its full capacity. Unless such a reserve is held it is unsafe to do so, as the green crops may fail to grow at the expected time owing to the absence of rain.

Further, it enables him to lamb his ewes with certainty. Should a dry season threaten at the mating time he need not be afraid to join in the usual way.

Another consideration which should weigh heavily with anyone who has to deal with stock, is the enormous load of anxiety which is lifted from the mind of the fortunate possessor of silage. The man who has a good reserve can carry his sheep along on the grass up to what may be called the last moment; and then when in the ordinary course some of the weaker ones would be dying through lack of food, he can turn to his silage with the satisfactory feeling that although things have got pretty bad he is still right for a further few months, and that it is very unlikely that it will not run before his feed supply runs out.

Choice of the Site.

The main consideration is that the place selected should have a non-porous soil. To make sure of this it would be advisable to sink a trial shaft to a depth of 12 feet. The place should be above flood-level if convenient, but, provided it is not in a swamp, any place with the requisite subsoil will answer, as part of the earth taken from the pit can, in country liable to inundation, be deposited in a bank around the pit, say 40 feet to 50 feet distant, so as to prevent flood-water entering, and at the same time leave plenty of room to work drays between the bank and the edge of the pit.

Two instances have come under notice where a white pipeclay underlay a stiff red-clay subsoil. The excavation was continued into the underlying shale for some feet, but the soakage from the white clay bands needed constant attention. This trouble continued after the pits were bricked and cemented, but was overcome in one instance by placing joists in the bottom and covering them with flooring boards, and excavating a small well on one side to hold the accumulated drippings. A pump was permanently fixed for the purpose of occasionally pumping the pit out. In the instance where this was not done, the silage was spoiled.

It might be suggested that farmers who find, after sinking some distance, that the pit is leaking from any stratum of soil, should cease deepening, or get the desired depth in the silo by erecting above ground, or else should make some provision to remove the water when it accumulates. The risk of water soaking into shallow pits is not so great.

A dairy-farmer should select a site handy to the milking and feeding yards. It would be better for this class of farmer to grow crops for silage as near as possible to the feeding place. Where it is a matter of feeding silage to stock other than milking cows, the area under forage crops may be anywhere on the run, and pits may be excavated convenient to the crop.

Making the Pits.

The best practice is to make pits to hold about 100 tons each. It is better, where up to about 1,000 sheep are to be provided for, to make the pits this size rather than larger, as such a pit will feed that number for about two months, and it might happen that it will not be necessary to feed longer.

If the pit were larger, only a portion may be required, and the pit then remains open. This does not lead to a great amount of loss, but at the same time it is more satisfactory to use the pit right out.

Preferably the pits should be made in pairs, as each can be filled alternately, and opportunities allowed for the settling of the material. A pit about 60 feet x 21 feet x 9 feet deep will hold about 100 tons. The whole of the excavation is done with the plough and scoop. A careful man can make the sides almost perpendicular. The ends are left with the batter, and the steeper the batter the better.

Filling.

Cutting with the reaper and binder is the most economical method, as the sheaves are easier to handle than loose stuff. This makes up for the cost of the twine. A team of about six men is required, one to drive the binder (this man can help with the waggons when he has cut enough crop for the day's work), four men with two waggons, and one man in the pit. If waggons are not available, slides can be used for bringing in the material. These are very handy, as one man can load a slide and bring in a lot of stuff in a day. In filling the pit the sheaves are laid lengthways. Cutting the twine on the sheaves allows the material to settle evenly. It is preferable to remove the twine, as it may cause trouble amongst the stock when the silage is being fed. The pit is filled up practically to the ground level, and the waggons are then drawn into the pit and over the material when unloading. This helps to compress it. Some men, when making silage, take the waggons or drays in from the commencement and tip the loads or pull them off with ropes.

When the pit has been filled up to the ground level, or a little above, the material must be allowed to settle for a couple of days. The advantage of working two pits comes in here, as one may be settling whilst the other is being filled. In a couple of days the material will settle considerably. Work should then be resumed and the material built up until it is about 4 feet above the surface, keeping the stack fairly square. A further period of settling should be allowed, and when this has taken place the filling may be continued. Careful note should be taken of how the pit settles, as this gives a good indication as to when it will be safe to stop. When it is considered that the bottom has settled thoroughly it should be again built to a height of about 4 feet. Allowing periods for settling, and spreading the work over about a fortnight, the pit is so filled that when covered it will not settle below the land surface level. Even when allowing for plenty of settling, and leaving a stack of about 4 feet, the material will, after a few months, sink down until only a slight mound is left. It is very important to get the pit well filled, otherwise after a few weeks the site of the pit will be marked by a deep depression. Thus, not only is the use of some of the storage capacity of the pit lost, but water will run into it. This is unwise, although rain does not injure the silage, and even very heavy falls during the process of making causes no damage. A well-filled pit, a few weeks after filling, will show just as a small mound. It must be remembered that even when pressed in as tightly as possible the material is, comparatively speaking, very loosely packed. The heat generated softens the stems, and the enormous pressure of the greenstuff above and the covering of earth presses it together until finally it becomes almost as solid as a plug of tobacco.

Covering.

After the final filling it is advisable to allow the material to settle for two or three days. This reduces the height and renders covering easier. If the rate of settling is very slow, it may be taken for granted that the pit has been well filled. If there is any doubt the work of covering may be left for a week. The delay will not result in any appreciable loss, and will show whether further filling is required.

The work of covering is done with a scoop. At Coonamble Experiment Farm earth is scooped straight on to the top of the greenstuff and practically no loss of material occurs. Pits which have been emptied have only shown about 2 inches of loss at the surface. A covering of about 9 inches or a foot of earth is required. It is quite unnecessary to use a deeper layer, as it does not protect the silage any better and means a greater expense in covering and in removing the soil later.

It will be noted that nothing has been said in regard to noting the temperature of the material as the pit is being filled. It has not been mentioned because we do not find it necessary. It can be taken as a certainty that if the crop is cut at the stage indicated and put straight into the pit the result will be satisfactory, and there is no more need to take the temperature than there would be when building a haystack.

At the same time a man who is making silage for the first time is naturally anxious to know how things are going in the pit, and for his own satisfaction he may like to be able to take the temperature. It can easily be done by placing a gas or water pipe upright in the centre of the pit to project above the surface, and whenever it is desired to take the temperature the thermometer may be lowered into the pipe.

Cost of Excavation.

In all, four pits, with an aggregate capacity of about 550 tons, have been made on the Coonamble Experiment Farm. Two were excavated in 1913, and during the following year.

Accurate records of the time taken and wages paid were kept. One man was paid 10s. and one 8s. per day of eight hours, four horses were used, each valued at 2s. per day. In estimating the present-day cost of excavating a pit the necessary adjustments in connection with the increase of wages can be made.

In 1913, two pits, with a total capacity of about 500 cubic yards, giving holding capacity of 250 tons, were excavated.

The cost was—Wages, £24 6s. 1d.; horses, £10 16s.; a total of £35 2s. 1d. The cost per cubic yard was 1s. 5d., equal to 2s. 10d. per ton of silage.

In 1914, two more pits, totalling 600 cubic yards, were excavated at a cost of—Wages, £19 7s. 2d.; horses, £7 13s. 6d.; a total of £27 0s. 2d. The cost per yard in this case was 10 $\frac{3}{4}$ d., equal to 1s. 9 $\frac{1}{2}$ d. per ton. The great reduction as compared with the first two pits was due to the previous experience and to the better implements which were available.

The pits, if well looked after, will last several years, so that the cost to be debited against each ton of material is practically nothing—it would amount to about 3d. per ton.

The 550 tons made at Coonamble were cut from 110 acres of land bearing heavy crops, the average yield being 5 tons per acre; but it must be considered that the silage is not required every year, and it will be found in practice that if a good supply is put by in the years when the crops are heavy none need be put up when they are light.

The practice in raising a crop for silage is to plough or disc up stubble land as soon as the wheat is off, and sow early. The only operations are ploughing, harrowing, and drilling.



A Pit Silo.

Feeding the Silage to Sheep.

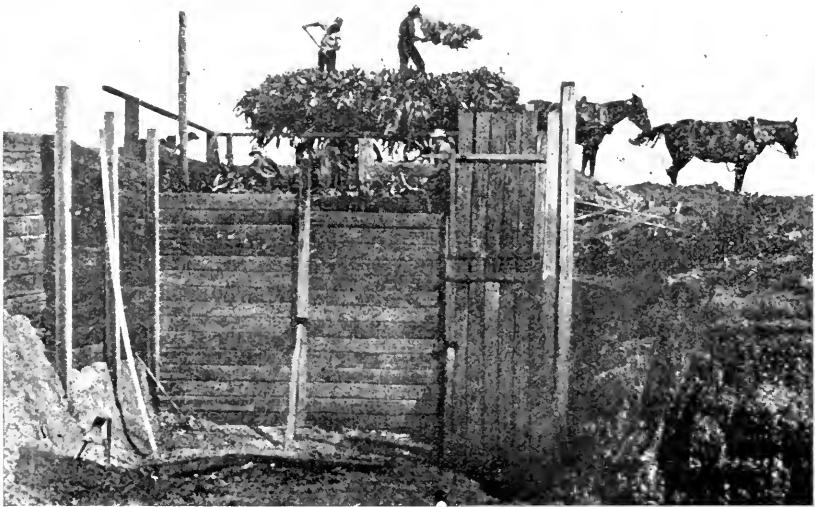
The pits are uncovered by simply removing the earth with a scoop. If any earth happens to get mixed with the silage, it shakes out when the silage is thrown to the stock. It is preferable to open up a section at a time—say 16 feet of the length of the pit. The silage will be found to have a coating of, perhaps, 2 or 3 inches of rotten material. This can easily be forked out of the way. The silage is densely packed and almost as solid as wood, and is cut out in benches of about 4 feet the full width of the pit with an axe or an adze. When a clear face is obtained and a block is cut, the silage can be lifted quite easily. One man can feed 800 to 1,000 sheep daily, giving them a liberal allowance. The silage need only be thrown out over a clean piece of ground, and well spread. It is better to get a good deal out every day before the sheep are allowed to feed, as they not only surround the waggon and are likely to be injured, but the strong ones run ahead picking the choice bits and trampling the remainder. Sheep should be drafted into lots according to their strength for feeding; if this is not done, the strong ones take all the best of the silage and leave only coarse straw for the weaker ones. This is likely to cause compaction in the stomachs of those sheep which continually get the worst of the feed. If the sheep are about all of the same strength they get the feed equally and no trouble will be experienced.

No other foodstuff need be given with the silage, and the sheep do well. It is necessary, however, to give an ample supply of common salt, in which about 6 per cent. of Epsom salts has been mixed.

In the pit method practically no waste occurs. After feeding out one pit of about 90 tons at one of the experiment farms only a few straws could be seen lying about the pit and paddock. The total waste in the pit and whilst feeding did not amount to more than 1 per cent. of the material originally put in.

HILLSIDE SILOS.

When the conformation of the land allows it, the hillside silo possesses many advantages. Amongst these are the ease with which it can be filled, the silage being thrown downwards from the carts, and the less labour required in the removal of the silage than from the ordinary pit, it being removed from the lower side. As the silage is below or level with the surface, weighting materials, such as earth, stones, &c., are economically applied, and the silage is protected from the sun and winds.



Filling a Hillside Silo, Bathurst Experiment Farm.

To take the place of the tub silo at Bathurst Experiment Farm a hillside one was excavated. Most of the excavating was done with plough and scoops, as in tank-sinking. The sides were trimmed with the pick, and the bottom also squared where the plough could not work. After sinking several feet, the decomposed granite became very hard, but exposure to the air and rains for a month or so softened it and allowed of its being ploughed, and intermittent work thus assisted in reducing the cost.

The excavation was carried 12 feet below the surface, and the earth taken out was placed 4 feet above, leaving the silo 16 feet deep. Upon this earth the teams were drawn when filling the silo.

Old railway sleepers were used to timber the sides, to keep the soil and loose earth in position. The slope of the hillside is such as to allow of any water running off by means of a drain from the lowest portion.

The dimensions of the silo are 36 by 20 feet by 16 feet deep, but a temporary end made of sleepers can be placed so as to enclose but half this capacity, or remove back according to the amount of fodder available. A fall of 1 foot in the 36 was allowed for drainage.

No arrangements have been made for any roofing, as in dry climates 1 foot or 18 inches of earth would be sufficient to absorb all excepting the very heavy rainfalls.

Over 80 tons of maize silage have been placed in a section of this silo with very satisfactory results as regards costs and waste.

OVERGROUND SILOS.

In the dairying districts of the State the overground silo, in one form or another, has come to be regarded as a necessary adjunct to the most economical conduct of the industry. Several classes of material can be used for the construction of overground silos; they are principally stone, brick, wood, or concrete. Each of these has its own recommendations, and the choice depends in a considerable degree on which is the nearest to the farm, and its cost compared with the others. In the opinion of a good many farmers the wood silo turns out the best silage, and concrete the next best, but the point is not one about which there is entire unanimity. Both stone and brick—unless plastered with cement mortar—absorb a good deal of the moisture in the vegetable material ensiled, and the "cure" is, therefore, not so satisfactory nor the fodder so palatable when ultimately fed to stock.

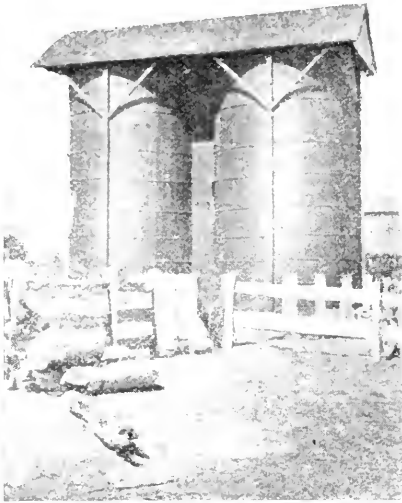
The cost of an overground silo will vary considerably according to the nature of the material used in construction, locality, &c. The size also affects the proportionate cost, the large silo costing considerably less per ton capacity than the small one. Generally speaking, however, it may be said that the 100-ton silo is fair value for the outlay. It may be mentioned here that it is a serious mistake to make the silo too small, for small quantities of material do not ensile well, and are apt to produce such a proportion of waste as to make the enterprise disappointing.

The silo should be as handy to the bails as circumstances will allow, so that feeding may be carried on with the least possible amount of labour. Should the dairy-farmer be building both bails and silos, and can find a steep bank in a convenient position, he may place the lower part of the silo into the face of the rising ground, and have bails running out from it

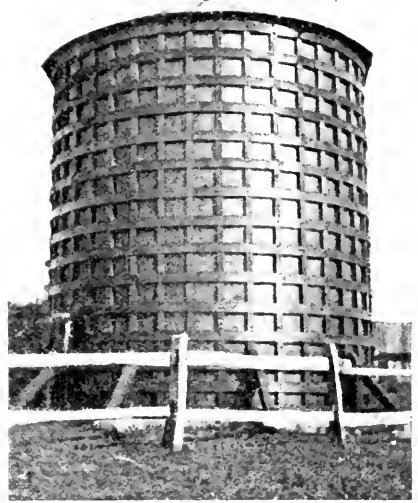
Shape of the Silo.

The silo should be circular in shape, or as nearly so as practicable. The stave, or tub silo, is circular; but frame silos may be octagonal, or have more than eight sides, all equal. The more sides they have the better, as they then approach to the circular form. A circular silo will contain more cubic feet than any other form built with the same quantity of timber, which is a great advantage from the point of cost; and moreover, a circular silo of 100 tons capacity has less wall surface, consequently less risk of "spoiling" the silage, than any other form of the same capacity. Sharp corners are objectionable, as the pressure tends to be uneven and this adds to the percentage of waste.

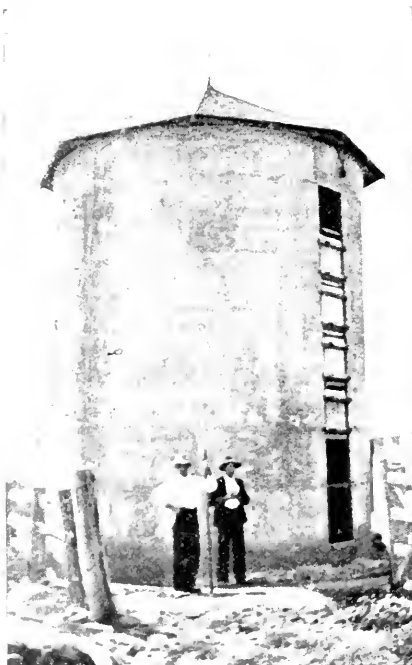
The silo, if it is to be a good one, must not have too much surface area: it cannot be too deep; it must be perfectly jointed together, so that it will exclude the air from all sides; it must be strong; and last, but not least, it must be convenient.



Twin Tub Silos.



Wood and Iron Silo.

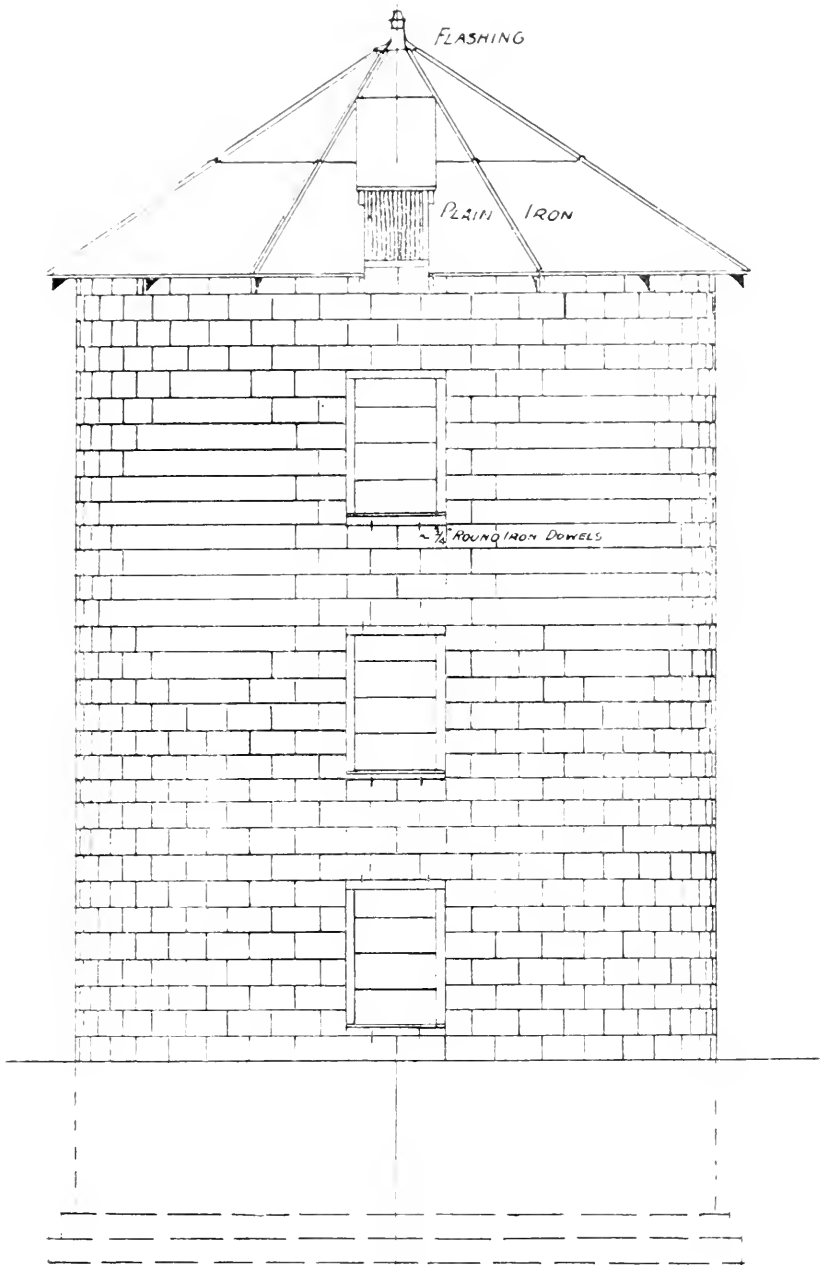


Ferro-cement

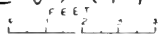


Brick Silo.

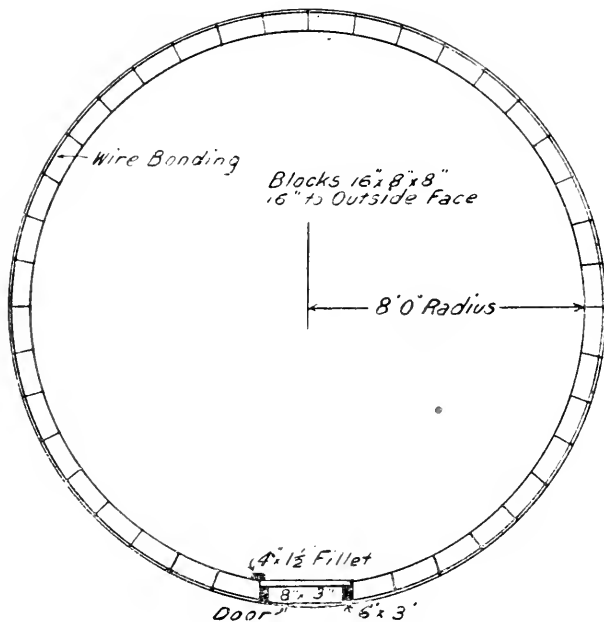
TYPES OF OVERGROUND SILOS.



ELEVATION

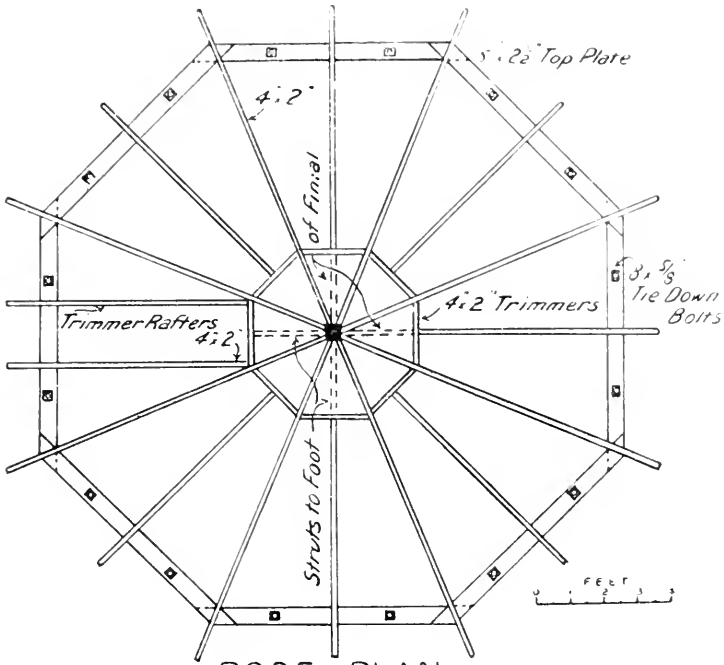


Concrete Block Silo

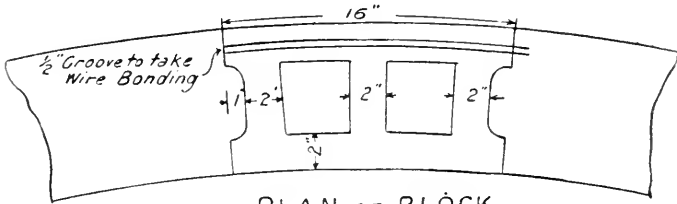


PLAN OF SILO

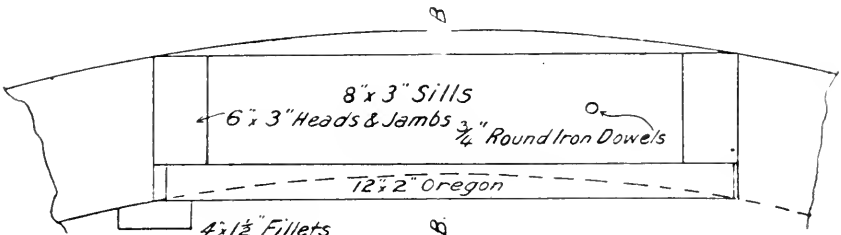
Concrete Block Silo,



ROOF PLAN

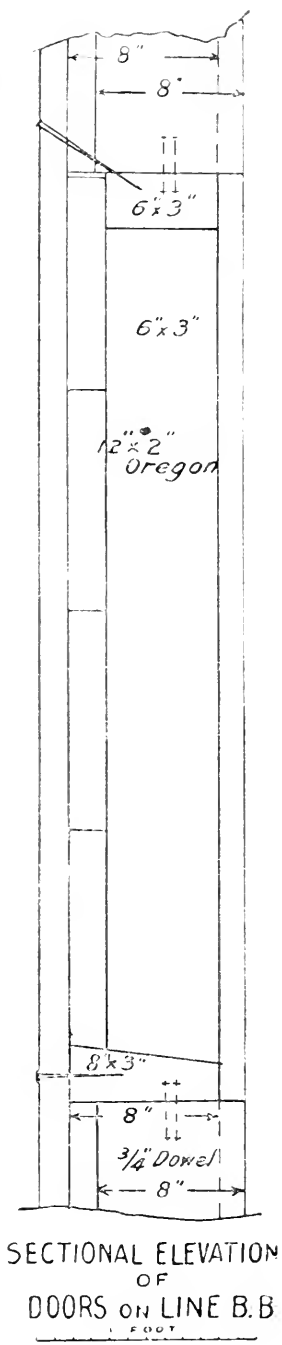
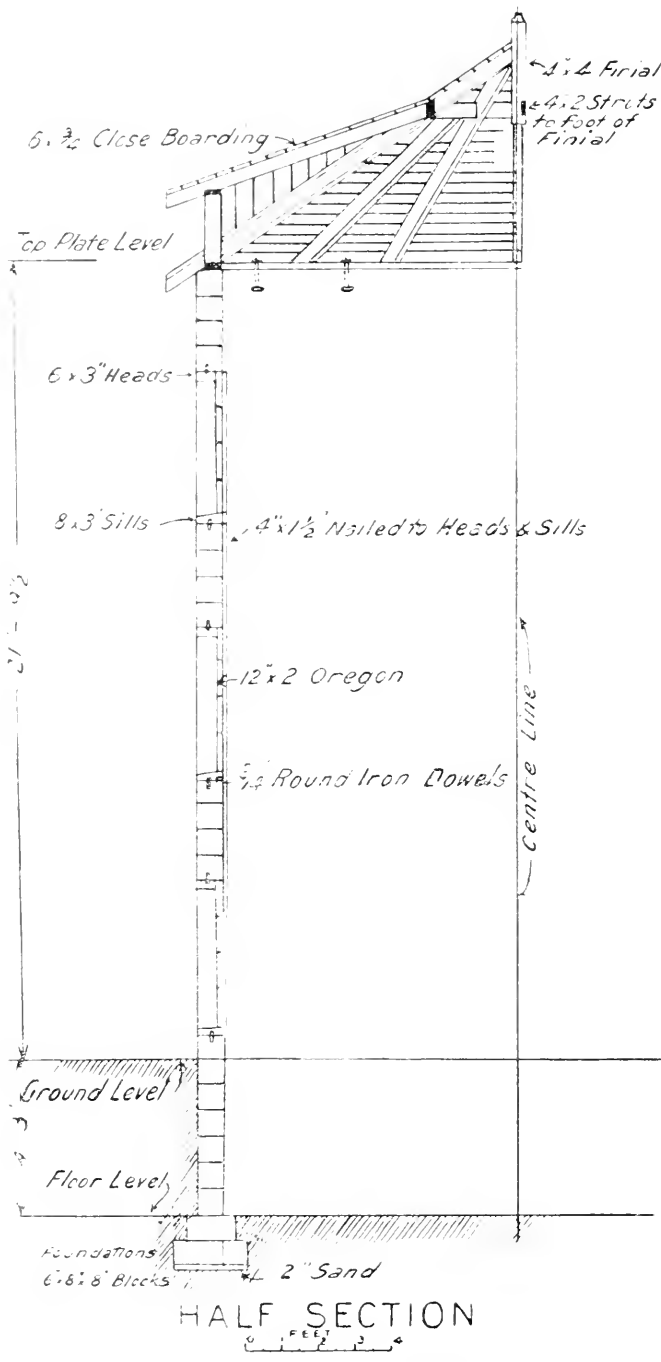


PLAN OF BLOCK



PLAN OF DOORS

Concrete Block Silo.



Concrete Block Silo.

Size to Build.

With regard to the capacity of the circular silo, it is said that the quantity to be taken out varies very much according to the amount of succulence, moisture, or water there is in the crop when it is put in.

The weight of a cubic foot of good silage in the silo is about 35 lb., and undoubtedly this will be the case with the exception of, say, 4 feet from the top, if it is properly trampled down when filling, but if this be neglected the amount per cubic foot will be considerably less.

The following table of approximate capacity will afford a good idea of what size to build:—

Height—feet.	Diameter—feet.	Capacity—tons.
28	14	78
30	14	83
24	16	86
26	16	95
30	16	108
30	18	138
36	18	166

The capacity given represents the number of tons of silage that will be in the silo after all shrinkage has occurred.

The Concrete Block Silo.

The cheapest form of concrete silo is that built of concrete blocks or large concrete bricks. These are most expeditiously made with a block-making machine, but a home-made mould may be constructed with wood and plain iron, which, though slower in turning out the blocks or bricks, will be found quite satisfactory, especially to the farmer who makes up his mind to make the blocks a few at a time on otherwise slack days. Working quietly on these lines it is possible for a farmer to collect, at a minimum of expense, the necessary material for a structure that will be a valuable asset on his farm, and a cheap insurance against periods of scarcity.

The machine for making the blocks at present costs £60 at least, but with a man and a boy a hundred blocks can be turned out in a day. The best type of machine is that which turns out the block face downwards; this allows for a better class of material being used on the face for weathering purposes. With a home made mould not more than twenty blocks per day can be finished.

The shape of the block referred to is shown on the third page of plans, and the mould may be simply a four-sided box, with the necessary cores to form the two holes. These holes in the blocks not only economise in concrete material, but form a cavity in the walls, which acts as an insulation.

SPECIFICATION.

Concrete Block Silo. Height 25 feet, diameter 16 feet.

Material.—The mixture used may be sand and cement for the face (3 of sand to 1 of cement) tamped into a mould about $\frac{3}{4}$ inch thick; for the remainder, 5 of gravel and sand to 1 of cement. About sixty to sixty-seven blocks are made from a cubic yard, and 1,676 blocks, including eighteen halves, are required to build a silo.

This allows for footings, which may be of blocks laid as shown in section ; or the lower course may be of concrete, laid in the trench 24 inches by 8 inches deep, in which case 1,553 blocks will be sufficient.

Excavation.—The lower 4 feet 3 inches of the silo is set into the ground ; this reduces the labour of elevating when filling and strengthens the silo. If the ground is firm, such as hard clay, no other floor requires to be provided, but if it is soft, a concrete floor about 6 inches thick should be put in. No drainage from the floor is necessary.

Walls.—On the footings, set the blocks in cement mortar, gauged 3 to 1, and with $\frac{3}{4}$ inch thick joists.

At 3 feet from the floor and to each course upwards, bed at 1 inch from the outer face either a $\frac{3}{4}$ inch round iron rod or two strands of No. 8 fencing wire twisted together.

A groove should be made in the top bed of the blocks to receive this, but if wire is used and it is carefully set, it may be laid in the bed-joint mortar. The outer face joints are struck jointed, and the inner face pointed up, and the whole of the inner face of the silo is bagged over with cement wash.

Doors.—The first door frame is set on at 9 inches over the ground line, and spaced as shown. Frames are made of sawn hardwood, the sills 8 inches by 3 inches weathered, and the remainder 6 inches by 3 inches, square, and each fitted with two $\frac{3}{4}$ inch iron dowels top and bottom. The dowels are set about 4 inches into the cement blocks, which are made solid for the purpose of receiving them. Over the inner face of the frames, and on one side of the openings, is fixed a vertical hardwood batten to form a groove to take the ends of the door planks. This serves to hold the latter in position when the silo is empty. The door planks are of dressed 12 inches by 2 inches oregon, jointed at the edges, and when set into the frames they are covered over at the inner face with 2-ply roofing material, extending about 6 inches beyond the frame to better exclude the air.

Roof.—The top plates are formed into an octagon and secured at the top course of blocks by means of $\frac{1}{2}$ inch bolts, bedded into the blocks, and a roof is built as indicated on the plan, boarded and covered with either plain galvanized iron or flexible roofing material, with $1\frac{1}{2}$ inch rolls in the angles. Guttering is unnecessary on the eaves, unless the water is required. A dormer opening is formed, as shown, for entrance of the head of the elevator or blower. No door is required on this.

A cheaper roof of open gable ends may be substituted for that on the plan ; it serves equally well, but does not look so well.

SECTION XII.

The Feeding of Farm Stock.

THE study of dietetics is only in its infancy in this country, and has not yet assumed its true position of importance, but it will come more and more to the front as the country becomes more closely settled. Scientific feeding is economic feeding with all classes of animals; its neglect here is due to the fact that the vast majority of our stock has been, and still is, entirely paddock fed. This state of affairs is steadily passing away; and with the continued cutting up of large estates, the extension of mixed farming and irrigation, and more intense working of the land, it will become more and more necessary to hand-feed stock of all descriptions, except, of course, in those areas of the State which will for very many years, and probably for all time, remain in large holdings.

This change of conditions does not only apply to large stock but also to sheep, which, if not hand-fed, will in the future be grazed by methods very different from those at present employed. These methods will approximate more and more to those existing in Europe and will involve greater subdivision of farms, the growth of crops solely to be fed-off by sheep, and the feeding-off of several small paddocks in rotation in place of one or two large ones.

THE GENERAL PRINCIPLES.*

The question of the economic feeding of farm animals depends as much on scientific principles as does the economic feeding of farm crops.

Farmers all the world over have come to realise that in order to apply manure without waste, it is necessary to apply it with some regard to the nature of the crop and to the nature of the soil. It is safe to say that when the farmer nowadays applies farmyard manure the object of supplying plant-food is only a secondary consideration. It is added to improve the nature of the soil, to supply vegetable matter, to loosen the texture and so forth; but if the farmer wishes to supply plant-food, he does so with a less bulky and more rapid acting, and consequently more economical fertiliser. The indiscriminate use of manures like guanos and bonedust has given way to a more careful selection of the kinds of fertilisers suitable to the requirements of different crops, and a consideration of the readiness with which the various ingredients are availed of by the plant.

In the same way the feeding of farm animals is quietly undergoing a revolution, and it behoves the farmer who does not wish to see himself at a disadvantage to learn something concerning the nature of the substances which comprise the food of his stock, and of the idiosyncrasies of the individual animals.

For animals, just as much as plants, require certain definite ingredients in their food, and require these to be present in definite proportions. There is, however, this difference, that with plants the supply of a large amount of unnecessary food simply means a waste of money, but in the case of

* F. B. Guthrie.

animals it may have injurious effects on the health. The selection of food by the plant takes place, for the most part, by means of the roots, and before it enters the plant itself; whereas, with animals, the assimilation of the nutritive material takes place after the food has been swallowed, and the indigestible material has to be got rid of, and if this is excessive in amount, discomfort and even disease result. Indigestion, the "blowing" of cattle, the formation of fibre balls in the stomach, are all instances in point.

Nature of Food Required.

It is also quite clear that not only do different animals require different foods, but that the same animal must be fed differently according to the object in view in feeding. The simplest problem, and the one that forms the basis of all dietaries, is what is called the maintenance diet, that is to say, the amount of food necessary to keep the animal in good health, and to meet daily requirements and repair the waste of tissue. And without going too much into technicalities, it may be laid down that a food must contain the following ingredients:—

- (1) Water;
- (2) Mineral matter;
- (3) Fat or oil;
- (4) Carbohydrates (substances such as starch and sugar);
- (5) Flesh-forming material, or albuminoids (substances such as gluten) which contain nitrogen.

Just as the crop requires all the nourishing constituents to be present for its proper growth, and fails if one be absent, so the animal will starve on a diet composed exclusively of, say, carbohydrates (starchy and sugary foods) if the nitrogenous materials are absent.

The amount of albuminoid material especially is of the highest importance in the feeding of stock, as it is the only source of supply of the nitrogenous material which is essential to the animal, and it has been found that the amounts of albuminoid and non-nitrogenous material in the food must bear a definite ratio to one another, and that if a food contain too large a proportion of carbohydrates or of albuminoids the result is equally disastrous. This ratio differs with different animals, and even with the same animal when used for different purposes. For example, a horse doing heavy draught work requires a relatively larger proportion of albuminoids in its food than one doing light work.

How the Food is Supplied by Plants and Fodders.

Let us briefly discuss the ingredients present in plants and fodders, and see what part they play in providing food for animals. All plants and fodders contain the following ingredients:—

Water.—The presence of water makes the food more succulent and palatable. It also renders it more easy of digestion. It takes the place of drinking water to some extent, and animals fed on watery food will require less to drink.

Mineral matter comprises the salts, such as common salt, lime compounds, phosphates, and other mineral saline substances which are essential for the food of animals. It is from this part of its food that the animal derives the material to build up its bones, which are largely composed of phosphate and carbonate of lime. All parts of the animal body contain a certain proportion of mineral ingredients, and the amounts of these in the

food depend upon the amount of ash. Some of the salts—like common salt—have a definite physiological action, and, though not properly foodstuffs, are essential to a proper digestion of foodstuffs. The amount of this mineral, or saline matter, is not taken into account in estimating the feeding value of a plant, for though small in amount it is always present in sufficient quantity to supply the requirements of the animal.

Fibre is that part of the plant which is unattacked by acids or alkalis. It is practically cellulose. It cannot be regarded as digestible, for although it disappears to some extent in the body of the animal, especially with grass and herb-eating animals, it is not broken down in the way that the digestible carbohydrates are attacked (see these), but is decomposed in such a way as not to produce heat, and its assimilation is probably unattended by much benefit to the animal. It has no feeding-value. Its presence is, however, essential, as it gives bulk to the food, and mechanically stimulates the walls of the alimentary canal, promoting healthy digestion. Too much fibre, however, makes the food too bulky, so that the animal cannot eat sufficient of it to get the necessary amount of nourishment. It also makes the food unpalatable. Of these constituents the only one possessing direct feeding-value is the mineral matter or saline matter, and this, though always small in amount, is present in sufficient quantity in all fodders, and in estimating the feeding-value of a plant as food we do not usually take it into account. Water and fibre, it will be seen, are not direct foods, but give succulence and bulk, and exercise a physiological action.

The ingredients of direct feeding-value are the following:—

Albuminoids.—These are distinguished from the others by the fact that they are the substances which contain nitrogen. They are composed of carbon, hydrogen, oxygen, and nitrogen. The flesh and blood of animals is made up of nitrogenous material, dry blood or meat containing about 16 per cent. nitrogen as do also substances like hair, wool, horns, hoofs, &c. It will thus be seen that the amount of albuminoids in the food is a point of the highest importance since these are the only source of nitrogen available to the animal. The albuminoids are, therefore, often called “flesh formers” or “muscle formers.” Their chief function is to produce the nitrogenous material of the body, and to some extent the fat, and to maintain it, replacing the daily waste of the tissues. By their combustion within the body, heat and mechanical force are also developed.

Carbohydrates.—This is the name given to a large class of organic compounds found in plants, the principal of which are the starches and sugars. The carbohydrates are composed of carbon, hydrogen, and oxygen only, without nitrogen. Their consumption, therefore, does not add to the nitrogenous substances of the body nor repair the waste. Their function is the production of heat and mechanical energy by their combustion within the body. They are often called “heat-producers,” because they maintain the temperature of the animal. The process of their combustion consists in combining with oxygen, and being split up into carbonic acid and water, a process identical with that of the burning of fuel. They also partially assist in the production of fat, especially when consumed in excess of immediate requirements.

Fats and Oils.—The function of these substances is much the same as that of carbohydrates. They also are composed of carbon, hydrogen, and oxygen, but contain proportionately much less oxygen, and consequently much more carbon and hydrogen, than the carbohydrates. They are on

this account a much more concentrated form of fuel, and their combustion produces a greater amount of heat and energy than does that of starch or sugar.

The following summarises roughly the part played by each of these ingredients in the nourishment of the animal:—

Mineral matter supplies bone-material and inorganic salts.

Albuminoids supply flesh and all nitrogenous material, replace waste of tissue, supply to a lesser degree heat and energy and fat.

Soluble Carbohydrates and Fat supply heat and muscular energy; also fat when taken in excess. The heat-producing power of fat is very much greater than that of carbohydrates, being about $2\frac{1}{4}$ times that of starch.

Cellulose, even when assimilated, is of little value as a heat-producer, as it is not split up into carbonic acid and water like starch, sugar, fat, &c.

Nutrient Value of Foods.

In calculating, for the sake of comparison, the nutrient values of different fodders, the percentages of albuminoids, soluble carbohydrates and fat are simply added together, the fat being multiplied by $2\frac{1}{4}$ to reduce it to its "starch equivalent."

Albuminoid Ratio.—This is a matter of the first importance in the compounding of a properly balanced ration, and is obtained by taking the percentage of carbohydrates, adding to it $2\frac{1}{4}$ times the percentage of fat, and dividing the sum by the percentage of albuminoids. This ratio of albuminoid or nitrogenous substance to the non-nitrogenous constituents in the food differs considerably in different classes of food.

Thus lucerne hay contains one part of nitrogenous material to about three and a half of non-nitrogenous. This is an example of a relatively nitrogenous food, and the ratio is said to be a "narrow" one. In the case of straw on the other hand there are twelve to thirteen parts of non-nitrogenous material to every one part of nitrogenous material. This is an example of what is known as a "wide" ratio, and represents a food poor in nitrogenous constituents. Foods such as oil cakes, &c., have a still higher nitrogen content (a much narrower albuminoid ratio) than lucerne hay. Thus decorticated cotton cake contains about one part of nitrogenous matter to one and a half non-nitrogenous, or has an albuminoid ratio of one to one and a half.

This albuminoid ratio is of the greatest importance in the choice of rations for different animals, for the ratio which gives the best results varies considerably with different animals, and also with the same animal at different stages of its growth and according to the purpose for which it is fed. Thus, for dairy-cattle a more nitrogenous food is required than for cattle fed for fattening purposes, a narrow ratio being found to increase the yield of milk, though feeding appears to have little influence on the nature of the milk.

Horses doing heavy work also require a greater proportion of nitrogenous material than those doing only light work.

Growing animals require, as a rule, a larger proportion of nitrogenous material and a larger total quantity of nutritive material than do mature animals, though they require less bulk in their food.

It is, therefore, evident that the selection of a properly balanced food, a food containing the correct proportions of nitrogenous to non-nitrogenous constituents, is a matter of the first importance, and depends upon the nature and age of the animal and the work which it is to do.

Digestibility.

A question of even greater importance than the selection of a properly balanced food, is the question of its digestibility. The digestibility of a food depends upon three principal factors—(a) the nature of the food itself; (b) the kind of food with which it is mixed; and (c) the nature of the animal. The variability of all these factors, and the difficulty of determining accurately the digestibility of different foods, makes this a rather intricate problem.

An enormous amount of experimental work has been done in Europe and the United States in determining the digestibility of the different constituents in mixed foods fed to different animals. Some idea of the differences shown may be judged from the fact that, for example, when bullocks and sheep are fed on clover-hay, only about half the total amount of nitrogenous matter present is digested by the animal, whereas 80 per cent. is digested from brewer's grains.

Again only about 20 per cent. of the fatty matter in hay is digested by the animals, whereas practically the whole of the fatty matter in brewer's grains is digestible.

Ruminants, again, are able to digest and make use of quite half the woody fibre contained in their food, owing to the more complete preparation the food undergoes in their system, whereas animals such as the horse and the sheep are only able to digest a very small proportion of cellulose. Then, again, the degree of maturity of plants affects their digestibility. According to European experiments, when clover-hay is fed to oxen before flowering, 71 per cent. of the nitrogenous matter was found to be digestible, when fed in full bloom the amount digested diminished to 65 per cent., and when the blooming was over the percentage of nitrogenous matter digested by oxen was only 59 per cent.

It will be seen from these examples that the important question of the digestibility of foods becomes a very intricate one. The process of digestion varies considerably with different animals, rendering necessary a difference in their food. Briefly, it is as follows:—In all animals the food during mastication is mixed thoroughly with saliva before being swallowed. The flow of saliva is pretty considerable in most farm stock; the horse and the ox secrete about 100 lb. in the course of the day.

Besides mixing the food mechanically into a bolus suitable for swallowing, the saliva contains a ferment which changes the starch into sugar, this action continuing in the stomach. Passing into the stomach the food receives the gastric juice, which is poured upon it. The gastric juice is an acid liquid containing hydrochloric acid, rennet, and pepsin, and other soluble ferments. The special function of the pepsin in this acid solution is to convert the albuminoids into soluble substances easy of digestion.

The stomachs of different animals vary considerably in size and function. Ruminants have four distinct stomachs or compartments, the stomach of the ox holding about 230 to 260 quarts, whilst the single stomach of the pig holds only about 7 to 9 quarts, and that of the horse 17 to 19 quarts.

In ruminants the action of the first three stomachs is preparatory to the fourth, in which digestion occurs. The single stomach of non-ruminants corresponds with the fourth stomach of ruminants.

Passing into the small intestines, the food now receives three other fluid secretions, the bile, which is secreted by the liver; the pancreatic juice, secreted by the pancreas or sweetbread; and the so-called intestinal secretion.

The bile is an alkaline fluid, and its principal function is to render the fats and oils soluble, converting them into glycerine and soaps.

The pancreatic juice contains a number of ferments which continue the conversion of starch into sugar, and of fats and albuminoids into digestible substances. It also contains rennet, the substance which curdles milk.

In the larger intestine, the process of digestion is continued and completed; fermentation takes place, producing a partial digestion of the woody fibre of the food.

Digestion is a very slow process in animals and takes from three to four days at least. In the case of sheep it has been found that digestion was not completed till seven or eight days after the food has been taken.

Bulk and Flavour.

The bulk of the food supplied is also a matter of considerable importance in selecting a ration. All animals require a certain bulk in their ration, and feeding with concentrated foods alone does not give satisfactory results. This is especially the case with ruminants, which require in their food a large proportion of ingredients that are innutritious and that have only a mechanical action.

The ingredients which give bulk to the food are water and woody-fibre. Natural herbage, hay, straw, &c., provide these in the proper proportion, but when cake and more concentrated foods are resorted to, it is necessary to avoid the extremes of over-bulkiness or coarseness on the one hand, and of over-concentration on the other. If the food is too bulky the animal is unable to eat enough to provide itself with the proper nourishment; thus, rations containing an excessive amount of fibre are unpalatable, and those containing excessive quantities of water are laxative.

If, on the other hand, the ration given is too concentrated, it does not exert the necessary mechanical action upon the stomach, and the digestive juices do not act properly.

Palatability of the food supplied is another point which has to be considered in devising a ration.

An animal fed on the same ration continually loses appetite, and does not derive the full benefit from its food. A highly nutritious ration persisted in without change may be of less economic value than a succession of less nutritious foods properly alternated.

Palatability is largely influenced by variety, and by the amount of water, which gives succulence.

The value of the excreta as manure is also a point that has to be taken into consideration in selecting the most economical kind of food.

The actual manurial value of the different foods varies enormously, ranging from 4s. per ton in the case of turnips to £5 13s. per ton in the case of cotton-seed cake.

In the selection of an economical food, this point requires careful consideration, since the value of the excreted matter varies, not only in the foods themselves, but according to the proportions digested by different animals.

Classification of Feeding Stuffs.

It will be convenient to classify the different fodders that are on the market according to the particular ingredient in which they are especially rich, or which gives them their character as a food.

None of them are suitable for feeding without admixture for any length of time, and the feeder's art consists in so combining them as to provide a cheap and palatable food approaching in composition one or other of the rations which experience has shown to be the most suitable for the particular animal and the particular object in view. Feeding-stuffs can be divided into six classes, according to their richness in the different ingredients.

Class I, Foods rich in Albuminoids.—First in order of nitrogen-content come the different oil-cakes, decorticated cotton-seed cake being the richest, with over 40 per cent. albuminoids, followed by linseed and coco-nut cake, with about 30 and 20 per cent. respectively. The leguminous seeds come next, peas and beans containing from 20 to 22 per cent. albuminoids. Another fairly nitrogenous feed is dried brewers' grains, the dried malt residues after the sugar has been extracted by the brewer; both these and malt sprouts (the dried shootlets of the germinating barley) are used extensively for feeding cattle in other countries.

Dried brewers' grains contain about the same amount of nitrogenous matter as beans and peas. Bran comes next with about 12 per cent., and then the cereals, oats, rice, wheat, barley, maize, with from 10 to 12 per cent. albuminoids. The best clover hay contains about the same quantity, hay from the grasses being somewhat lower in nitrogen. Good lucerne hay contains as much as 14 per cent. nitrogenous matter.

Class II, Foods rich in Fat or Oil.—Amongst the fatty foods, some of the oily seeds, such as linseed, sunflower seed, &c., come easily first, linseed itself containing over 34 per cent. of oil. Such seeds in the shape of ground meal may be occasionally fed, but both on account of their cost and their extreme richness in oil need not be considered as ordinary stock foods, except under special circumstances. The crushed cakes of these seeds from which the oil has been pressed are waste-products of the highest economical value as a food. They are extremely rich, as we have already seen, in nitrogenous material, and contain a considerable proportion of oil, varying according to the nature of the original substance and the process by which the oil has been extracted. Of these, linseed, cotton seed, rape seed, and coco-nut cake are the richest in oil, running from 8 per cent. in the case of rape cake up to 11 or 12 in the case of linseed or coco-nut.

Dried brewers' grains are also fairly rich in oil, containing as much as 3 per cent. Of the cereals, oats and maize are the richest in oils, with 5 to 6 per cent., whilst bran contains about 4 per cent.

Class III, Foods rich in Carbohydrates.—In this class are found the cereal grains, wheat and maize heading the list with over 70 per cent. carbohydrates (principally starch), bran containing about 50 per cent., and the pulses, peas and beans, about the same quantity. Brewers' grains and meadow-hay come next with from 40 to 45 per cent., and these are followed by the straws of the different cereals, with an average content of 35 to 37 per cent., and the oil-cakes, which contain from 30 to 35 per cent. carbohydrates.

Class IV, Foods rich in Mineral Matter.—Of the foods rich in mineral matter, the oil-cakes are all fairly high, with an average of 6 to 8 per cent., bran and hay (clover and grass) being a little lower. The cereal straws are also fairly rich in mineral matter, containing between 4 and 5 per cent. The cereal grains are not particularly rich in salts, except rice, rice-meal being sometimes exceptionally high, and containing as much as 8 per cent., of which phosphates form a considerable part. Phosphates are also well represented in the ash of the oil-cakes and of bran, the ash of the cereal straws, on the other hand, being low in phosphates.

The above comprise the foods in which one or other of the nutritive ingredients predominate, grouped into classes according to their richness in these essentials. A few of them, such as the oil-cakes, brewers' grains, &c., we see are rich in more than one such constituent.

These are all concentrated foods, the percentage of water present in any of them never rising above 16 per cent., and the amount of fibre, or indigestible matter, never exceeding 10 to 11 per cent., except in the case of the hays and straws.

We have already seen that both succulence and bulk of food are factors of the first importance in the making up of rations; it is, therefore, necessary, in order to complete the list, to add the classes of bulky food characterised by succulence and by the amount of indigestible matter.

Class V, Succulent Foods.—The most watery of the ordinary farm foods is the turnip, which contains over 92 per cent. of water; the swede, mangel, carrot, and similar roots follow next, with cabbage and the green tops of roots and vegetables, their water content ranging from 89 to 85 per cent. Clover (growing) contains about 83 per cent., and pasture-grass and potatoes about 75. Green fodder—that is, cereal crops cut for green feed—vary from 70 to 79 per cent. water. Of these foods, several of the roots may be characterised as sugar-crops, notably turnip, swede, mangel, and beet, whereas the potato contains 16 per cent. or so of starch.

Class VI, Foods rich in Fibre.—The cereal straws and hay, both of clover and pasture-grass, are included in this class; the straws containing from 68 to 75 per cent. indigestible fibre, clover and meadow hay, on the other hand, 25 to 26 per cent.

The Proportions Digested.

All the above figures require to be considered in the light of the different digestibility of the various ingredients. This varies, as we have seen, not only in the different kinds of food, but with different animals. Thus ruminants are able to digest 81 per cent. of the nitrogenous matter in lucerne hay, as against 73 per cent. digested by horses; 72 per cent. of the carbohydrates in lucerne hay and 45 per cent. of the fat are digestible by ruminants, whereas horses digest only 70 per cent. of the carbohydrates and not more than 14 per cent. of the fat. Pigs, again, are able to utilise 84 per cent. of the protein and 98 per cent. of the starch in potatoes, whereas ruminants can only assimilate 45 and 90½ per cent. respectively of these ingredients. Ruminants, again, can always digest a larger proportion of the fibrous material than can horses or pigs. They digest, for example, about one-half of the fibre in wheaten straw, whereas horses only assimilate about 18 per cent.

The digestibility of any one food also varies very considerably, according to the nature of the other feeds with which it is mixed. On account of the great difficulty of accurately carrying out digestion experiments, the science of the economical feeding of farm stock can only be said to be in its infancy. At the same time, we have sufficient data to enable any stock-feeder to compound for his stock rations which shall be not only suitable for the purpose, but economical, as opposed to the wasteful rule-of-thumb methods at present too largely adopted.

Dietary Standards.

The composition of the ration will vary according to the animal to which it is fed, its age, and the purpose to which it is put.

We have to distinguish between a maintenance diet—the diet required for the animal when kept at rest or doing very light work—and that required by an animal doing more severe work.

Special rations are required for fattening animals, for dairy cows, for young growing animals, and so forth, and the requirements of animals under these different circumstances vary very considerably.

It will readily be seen that the subject is a very wide one. It is one that will amply repay a little careful study on the part of the farmer. In dairy-farming, more particularly, feeding on rational lines is an essential to the attainment of the best results.

These few notes are not intended to do anything more than to draw attention to the general principles of the subject, and to the different points which have to be considered in devising a suitable ration for different classes of farm stock.

These points may be summed up as follows:—

- Kind of animal.
- Age.
- Purpose of feeding.
- Composition of fodders of which the ration is composed.
- Proportions of digestible nutriment in the ration.
- Cost of the different fodders of which the ration is composed.
- Manurial value of excreta.
- Palatability, variety, bulk, &c.

Vitamines.

In devising a ration, whether for men or animals, we have nowadays to take into account an additional factor hitherto unknown and about which little is understood at the present time, namely, the vitamine content. The literature on this subject is voluminous and for the most part so highly technical and specialised that it is difficult to extract matter that can be reproduced in a form suitable to the general reader. Furthermore, the experimental work has hitherto been carried out principally in substances used as food for human beings, and very little beyond generalisation is possible in the discussion of stock foods. The following few notes may serve to indicate the facts already established and the chief points to be considered.

Interest was first aroused in the subject when a disease known as beri-beri was found to occur amongst people who subsisted on a diet of milled rice. Eijkman reproduced this disease in pigeons by feeding them on milled rice, and Fraser and Stanton were able to show that the disease (poly-neuritis), could be cured by feeding of rice-millings. Funk, in 1911, thought that he had isolated the active ingredient present in the rice-millings, and called it "vitamine." This was a specific for beri-beri, and was called anti-beri-beri or anti-neuritic vitamine.

The term vitamine is perhaps unfortunate and misleading. It was given by Funk, who thought that he had isolated a definite chemical compound having a composition analogous to that possessed by a group of organic substances known as amines, the prefix "vita" being added on account of their supposed importance to life.

The compound was not, however, isolated by Funk, and has not so far been prepared by anybody in a pure state. On this account, no doubt, many chemists are dubious as to the existence of any such body or bodies, and the misleading designation does not help to allay the doubts.

The nomenclature of the vitamins is rather confusing, as English and American authorities adopt somewhat different designations. There are at present three principal substances recognised as vitamins (though the number is generally regarded as being increased to five by the subdivision of the functions of two of them), to which the following names have been given:—

1. *Anti-beri-beri, Anti-neuritic, or Water-soluble B.*—This was the first vitamine to be recognised, as has been explained. It is found in all natural food-stuffs, that is, in raw foods. It is comparatively plentiful in seeds of plants, and in eggs, and it is also plentiful in cellular organs, such as liver and

brain. In the case of cereals it is contained in the outer skin, which is removed in milling, and yeast and yeast extracts are particularly rich in it. It is relatively low in flesh.

2. *Anti-rachitic, or Fat-soluble A*—This vitamine is abundantly present in animal fats, such as cream, butter, beef-fat; in fish oils, as cod-liver and whale oil; in the yolk of eggs and in green-leaved vegetables, but not in roots.

3. *Anti-scorbutic or Water-soluble C*.—This vitamine is abundant in fresh vegetables, as cabbages; roots such as swedes and turnips; very abundant in lime, lemon and orange juice. It is found only in small quantities in animal tissues and is very easily destroyed by heating or drying.

These three are the principal recognised vitamins, but the existence of at least two others is suspected, and they must be taken into account. Thus, in the case of the Water-soluble B vitamine which is present abundantly in yeast, it is considered by more recent investigators that the vitamine which is an essential to the proper development of the yeast-cell, differs from the Water-soluble B, and they have proposed to designate it as Water-soluble vitamine D. It is also now considered not unlikely that the Water-soluble B may itself be composed of two vitamins—the anti-neuritic and the growth-producing vitamins. Similarly, the Fat-soluble A may possibly consist of two vitamins, the one having anti-rachitic and the other anti-ophthalmic properties.

The distribution of the three principal vitamins and the relative proportions in which they exist in various substances are given in the following tables:—

• TABLE A. Showing Relative Proportions of all three Vitamins in Substances.

Vitamins appreciably present in—				Vitamins practically absent in—			
Fat-soluble A type (anti-rachitic).							
Cod-liver oil	...	...	++++	Yeast	..	...	-
Butter-fat	...	...	+++	Vegetable oils	...	...	-
Cream	...	...	++	Seeds	...	...	+ ?
Egg-fat	...	...	++	Lard	...	...	+ ?
Green leaves	..	...	++	Nuts	..	...	-
Water-soluble B type (anti-neuritic).							
Yeast	...	...	+++	Cod-liver oil	...	...	-
Germ of seeds	...	...	+++	Vegetable oils	...	...	-
Rice millings	...	...	+++	Lard	...	...	-
Natural grains	...	...	++	Butter-fat	...	...	-
Nuts	...	...	++	Milled products, as	...	...	-
Some vegetables	...	...	++	rice,	...	...	-
Orange juice	...	...	++	flour, &c.	...	...	-
Skimmed milk	...	...	+	Cooked foods	...	...	+ ?
Water-soluble C type (anti-scorbutic).							
Lime and lemon juice	..	...	+ - +	Yeast	...	...	-
Orange juice	...	...	+ - +	Cod-liver oil	...	...	-
Tomato	...	...	++	Nuts	...	...	-
Some fresh vegetables	..	...	++	Grain and seeds	..	...	-
Sprouted seeds	...	...	++	Canned foods	...	...	+ ?
Fresh unpasteurised milk	..	...	-	Cured meats	...	...	-
				Cooked foods	...	...	+ ?

* From "Vitamins," by A. D. Emmett.

* TABLE B. Comparative Anti-scorbutic (Water-soluble C) Value of equivalent weights of Substances.

Fresh Lemon or Orange juice (raw)	100.0
„ Cabbage leaves or juice (raw)	100.0
„ „ „ (cooked 100°C. for 20 minutes) ...	30.0
„ „ „ (cooked 70-80°C. for 70 minutes) ...	10.0
„ Swede or turnip (raw)	60.0
„ Tomatoes (raw)	60.0
„ Green beans (raw)	30.0
Potatoes (cooked at 100°C. for 30 minutes) ...	7.5
Fresh Carrot juice (raw)	7.5
„ Beet-root juice (raw)	Less than 7.5
„ Beet juice (raw)	7.5
Dry beans, peas, &c. (raw)	7.5
Fresh cow's milk (raw)	1.0 to 1.5
Germinated beans, peas, &c. (raw)	3.0

* Quoted by Emmett, from Chick and Daryell, Brit. Med. Journal, Vol. 2, 1920.

* TABLE C.—Distribution of the three principal Vitamines among Cereals, Pulses, &c.

	Fat soluble A	Water soluble B.	Anti-scorbutic.
Wheat, maize, rice (whole grain) ...	+	+	0
Wheat-germ	++	+++	0
Wheat and maize (bran)	0	---	0
White wheaten flour, pure cornflour, polished rice, custard powder, egg substitutes	0	0	0
Linseed, millet	++	+	0
Dried peas, lentils, &c.	-	+	0
Pea flour	0	0	0
Soja beans, haricot beans	+	++	0
Germinated pulses and cereals ...	+	++	++

From "Milling" 24th December, 1921, by F. W. O.

From these tables it will be seen that the references to specific stock foods are rather scanty. There are, however, a few general observations which may be made use of in devising rations for stock. Heating as a general rule appears to reduce slightly vitamine content. The Water-soluble C vitamine is more stable towards heat than the fat-soluble. Milk, if properly pasteurised does not appear to lose its vitamines, but if not properly pasteurised and cooled quickly is almost devoid of this substance. Storing also tends to lower the vitamine content of foods. For these reasons (combined heating and storing) silage is less rich in these substances than the original material from which it is prepared. Similarly, bleached and burned hay is lower in vitamines than is hay that has been properly cured.

The fertility of the soil would appear to influence the vitamine content of the crops grown on it. Lucerne grown on rich land is generally rich in the vitamine A, but on poor soils both the lucerne and the milk and butter may be affected detrimentally in this respect. It is generally accepted that vitamines are not synthesized by animals which are dependent for them upon plants—that is to say, animal flesh and other products, such as milk or eggs or fats, are rich or poor in these bodies according to the richness or poverty of the animals' food in this respect.

The importance of milk as part of the ration, particularly for young stock and for animals suffering from disease due to diet-deficiency, has been studied by F. E. Place, of Roseworthy College, South Australia. He urges* that it is most profitable to keep young stock thriving, and that milk is an essential for them: that stoppage of growth may be rectified by the addition of milk to the diet, and that the stinting of milk in early life results in increased susceptibility to diet-deficiency diseases later on. Properly pasteurised milk is efficient. White-eye or opacity of the cornea in calves and young sheep is a symptom of vitamine deficiency, and disappears if milk is fed in the case of calves or fresh pasture in the case of sheep. In the case of diseases the dosage of milk may be large. Whole milk is rich in vitamine A fairly rich in B, and contains C in variable quantities. Skimmed milk has lost some of its vitamine A.

It has already been mentioned that storing and heating are inimical to the vitamine content, and it may generally be said that fresh fodder, such as the grasses and particularly leafy vegetables (see tables on pages 774-5) are specially rich in the Fat-soluble A type—more so than roots and tubers. Such foods are richest in this vitamine at an early stage of growth, as, for example, lucerne and carrots: bright green lucerne, properly cured, is a superior food, owing to its vitamine content, to light, bleached lucerne.

On germination, seeds have a higher content of both the anti-scorbutic and the anti-neuritic type. The nutritive value of eggs may be increased by feeding sprouted grain to poultry, especially in the winter.

The seasons and the climatic conditions also affect the vitamine content of fodder. In periods of drought the grasses are deficient in vitamins, a deficiency which is reflected in the milk.

If dairy-cattle are fed on stover without any grain, the milk produced will be deficient in these substances.

In the feeding of dairy-cattle the presence of vitamins in the ration is of great importance, much more so than in the case of beef-cattle. Milk, as stated above, is rich in vitamine A, fairly rich in B, and contains C in variable quantities. Meat (muscle), on the other hand, contains only small quantities of vitamine A, whilst the presence of B and C is somewhat doubtful. The vitamins present in the foods fed to cattle are stored only to a limited extent in the meat, but abundantly in the milk.†

Of the ordinary stock foods, the valuable oil cakes, coco-nut cake and cotton-seed cake have been investigated for their vitamine-content. They are fairly rich in B, contain A, but no C. The oils themselves, such as coco-nut oil, linseed oil, and cotton-seed oil, contain none. The only oils and fats containing vitamins in any quantity are such as are not fed to stock, such as cod-liver oil and butter (which are rich in Fat-soluble A) and whale-oil, some animal fats, orange-peel oil, and a few others, in which A is present, though not so abundantly. Similarly, sugar and starch contain no vitamins, so that the high feeding value of rations rich in fats or oils and carbohydrates is due solely to their calorific value. Lucerne is rich in vitamins A and B, fresh lucerne being as rich in this vitamine as in butter, and when fed to dairy-cattle increase the proportion of these vitamins in the butter produced.

Of seeds and grain used in stock and poultry feeding, maize (both yellow and white) is fairly rich in B, yellow maize containing in addition vitamine A.

* A paper read before the Australian Association for the Advancement of Science, and published in the *Journal of Agriculture*, South Australia, May, 1921.

† "The Vitamines." H. C. Sherman and S. L. Smith.

Sprouted grains and malt are rich in C, fairly rich (?) in B and contain A. Whole wheat, oats and rye, like yellow maize, are fairly rich in B, and contain A.

Bran is fairly rich (?) in B, and contains A.

Millet seed is fairly rich in both A and B.

The choice of poultry foods is influenced by the fact that eggs are fairly rich in A, contain B, and (doubtfully) C. Egg-yolk is very rich in Fat-soluble A.

It will be seen that there still remains a large amount of research work to be done in the direction of stock-feeding with reference to the vitaminic content of the various foods and their relation to growth. As experiments of this nature are intricate and laborious, necessitating the study of diseases induced in animals under close observation (albino rats, pigeons, chicks, and tadpoles are the victims most favoured), and the cure of these diseased conditions by proper feeding, some considerable time must elapse before the influence of vitamins in stock rations can be established satisfactorily.

FEEDING IN RELATION TO DISEASE.*

The correct methods of feeding and the use of suitable feeding materials have a very important bearing on the health of stock.

In this article the principles which should govern the feeding of each class of stock are briefly referred to, but no attempt is made to go deeply into the chemical composition of feed or to adjust too nicely the balance of the different food constituents required. The various diseases which are commonly associated with errors in feeding are the main issue, together with the measures to be adopted to prevent these conditions.

The Value of Foodstuffs.

It may be well to point out that undue reliance must not be placed on chemical analysis only in estimating the value of a food, and that the nutritive values ascribed to various foodstuffs solely on that basis are liable to be very misleading. A most important modification in assessing these values is introduced by the question of digestibility, and in estimating this quality actual experience is of the greatest value, although much good work has been done by direct experimentation.

The difference in the requirements of the various classes of animals introduces a further modification, since the power of digesting many kinds of food varies greatly, as would be expected if the anatomical structure of the animals and the physiological processes of digestion were considered. Thus, rough, coarse material which can be well utilised by cattle will simply pass through horses in an undigested condition; and again, the amount of concentrated food which they can utilise is greater than that assimilable by horses. From the point of view of health, the composition of the food is, in practice, of more importance than its quality; and while improper methods (either avoidable or otherwise) are responsible for very heavy losses yearly, bad food—that is, food affected with rusts, moulds, &c.—or of such very poor quality as to be directly harmful, is only occasionally responsible for ill-health and death. This fact emphasises the responsibility of the stockowner himself; in not a few cases, however, the improper methods are almost unavoidable, either because suitable feeding stuff is not available or financial conditions prevent its purchase.

* Max Henry, M.R.C.V.S., B.V.Sc.

THE HORSE.

To attain the maximum of efficiency a horse requires food in which the concentrates (grain, &c.) and the roughage (chaff, hay, straw, &c.) are more or less correctly proportioned. For resting horses, or those doing little and slow work, all concentrates may be cut out, but the harder or faster the work to be performed, the greater the proportion of concentrated food required. This principle must not, however, be pushed too far, since on a diet of concentrates alone the horse fails properly to utilise the food given him, and a certain quantity of roughage is essential to digestion and comfort.

If the ration of the army horse, which is called upon to do regular and hard work, is taken as a basis, it will be seen that one of equal parts (roughly) of grain and hay or chaff, varying from 10 to 15 lb. of each for light and heavy horses respectively, the medium coming in between on 12 lb., was found to be the most satisfactory. The undoubted success which attended the use of this ration inclines us to accept it as a standard. Whenever a reduction has to be made it is always preferable to make it in the chaff or hay. With horses in this country it is often difficult to estimate just what they are getting, owing to the custom of cutting oats and wheat in the unripened state for chaff; some of the best samples of chaff are very nearly equal to a half grain ration, while other samples are hardly above straw value. This must be taken into consideration in estimating the amount of grain to be added to produce a good ration.

Broadly speaking, there is a decided tendency to over-estimate the value of the average chaff ration and to undervalue the use of grain in conjunction with it. Instances have occurred during the recent dry period when it was cheaper to buy oats than chaff, taking into consideration their respective food values and the quantity required as a maintenance ration. One of the objections to a ration composed solely of chaff, especially if of inferior quality, is the large quantity required and the consequent amount of labour imposed on the digestive organs of the horse in extracting sufficient nutritive material to supply his wants. A smaller quantity of grain will give more nutritive material at the cost of less energy to the horse and less money in freight and trouble in handling to the owner.

Where horses are partly grass-fed and partly hand-fed, the value of grain as against chaff is very high because the horse is getting his roughage himself. When the grass is on the dry side, sufficient roughage is obtained in this way to supply his needs in that direction. To balance his ration, however, grain is required, and the comparative prices and food values should be considered when deciding which to purchase. Too often advice to improve a ration is interpreted to mean give more chaff, and so the animal is still further overloaded. A ration containing too great a proportion of concentrates will, if maintained for long, lead to impairment of digestion and waste, owing to improper assimilation, while a diet containing too much roughage will not permit of constant heavy work and is liable to lead to impaction.

Methods of Feeding.

Whatever the feed given it should be well divided. The horse does best if fed little and often, but conditions of work reduce the maximum number of feeds practicable to three or four, all of which should preferably contain both grain and chaff. Probably the best system, if it can be managed, consists of three roughly equal feeds of mixed grain and chaff and

a feed of hay the last thing at night. But conditions differ so greatly in the town and the country, and the amount the horse gets from the paddocks varies so widely that each case has to be dealt with on its merits. Feeding should be as regular as possible if the best results are desired, and no sudden changes of food should be given if they can be avoided. New foods should be introduced gradually. Watering should precede feeding, and the horse should always have water available even when eating.

When arrangements to such an end are practicable, each horse should be fed separately: the custom of feeding many horses from long troughs is wasteful and leads to the bolting of the feed on the part of greedy animals and the underfeeding of those weaker or of more slow-eating habit. Bolting of the food and consequent imperfect mastication, prevents the animal deriving the full benefit of its ration, as much is passed through improperly digested—often with serious results. With teams continually on the move, long trough feeding may be unavoidable; but in standing camps and on farms the extra labour and cost involved in providing partition rails should be more than recouped by feed economy and lessened risk. The use of nose bags is worthy of greater consideration than it receives, for they provide a method of accurate feeding, ensuring extra feed to those animals which require it. The idiosyncrasies of various animals with regard to diet are worth some study, as a ration which will keep in condition an animal with good digestive and assimilative powers, and one which eats slowly, may not be sufficient for other horses. Peculiarities of this nature can only be known and dealt with by the man in charge of the horses.

Salt is usually supplied to horses, and is much relished by them, but it is not taken in quantities large enough to have as much influence on parasitic or other disease as is usually supposed. It probably acts more as an aid to digestion and in rendering the food more appetising, and so improves the general health. Thus, as with everything which improves the general health, it increases the animal's power of resistance to the effects of parasites.

Horse Foodstuffs.

The preceding remarks on the general principles of horse-feeding may be usefully considered in conjunction with the following brief notes on the chief materials used as food in this State.

Oats.—The best of all grains for use in feeding horses, and not sufficiently appreciated in this country—a very safe grain to feed, as the amount of hull on the grain prevents overgorging and massing in the stomach. Especially useful for horses on hard and fast work. The various food constituents are very well balanced in oats.

Maize (corn).—A very valuable horse-feed, but the food constituents are not so well balanced as in oats, and better results are obtained if maize is fed with the addition of some bran, linseed meal, or hay, or chaff made from legumes such as clover or lucerne to supply the deficiencies. Providing the ration is otherwise satisfactory, maize is as good as oats for the average working horse, but not so good as oats for young growing animals.

Wheat.—An unsatisfactory grain to feed to horses on account of the danger of engorgement and its tendency to form a pasty mass. Unlike oats, it should always be fed mixed up in chaff to prevent trouble, and horses which have not been accustomed to wheat should be brought on to it carefully. Its nutritive value is high, but it is not so well balanced as oats.

Barley.—Not much used in this State, but a good horse-feed, especially if lightly crushed and fed with bran and chaff. It can replace oats or maize if the ration is otherwise balanced.

Chaff.—Oaten or wheaten chaff is the bulk food most used in this country, and is likely to remain so. Its value varies very greatly (as before mentioned), but when of good quality it is doubtful if any bulk food is superior to it in food value, handiness, economy and suitability for average working horses. Feeding exclusively on chaff of low quality has its drawbacks.

Bran.—A very excellent food for working horses in moderate quantities. Its value is not solely to be judged by its chemical analysis, which does not do it full justice. It has a mild laxative effect, supplies various salts much needed by growing animals, is very useful for sick animals, and can be utilised to balance rations poor in protein and mineral salts.

Lucerne (hay and chaff).—Not considered a very satisfactory sole bulk food for horses, but very nitrogenous; it will greatly increase the food value of a ration which is poor in such constituents, and will improve a diet which is principally of oaten or wheaten chaff, if added in moderate quantities.

Hay (grass or clover).—Both forms are valuable foods, clover being of most use in conjunction with a diet low in nitrogenous matter. Good grass hay and oats give a nearly perfectly balanced ration.

Linseed Meal.—Both this and other similar meals can be fed to horses in quantities of up to 2lb. daily, and can replace about twice the quantity of bran so far as ordinary food material goes. If too much is fed it is simply wasted, being passed through unassimilated.

Straw.—For horses which are not being worked, straw can be quite usefully employed as feed, especially if made palatable with molasses, which will also increase its food value. A judicious admixture of chaff and chaffed straw may also be utilised for horses doing easy work, and it is in fact widely used. It must be remembered that the mastication and digestion of straw requires a good deal of energy on the part of the animal. Oaten and barley straw are the best.

Molasses.—Of much value in making such feeds as straw, &c., palatable to horses, in increasing the carbohydrates contained in the food, and in acting as a mild laxative.

Many other materials can be utilised as horse-feed, and the adaptability of the horse to different fodders is remarkable, particularly if he is brought on to them gradually and fed on them regularly. Whatever the feed selected, care must be taken that the quality is good. Musty and mouldy food, new grain, dusty hay and chaff, and inferior food of all kinds are liable to lead to trouble.

Diseases Associated with Feeding.

Of the diseases associated with feeding in the horse, the most important is of course, colic in one or other of its numerous forms; and among others may be noted azoturia, forage poisoning, laminitis and lymphangitis.

Colic.—The commonest causes of this complaint are errors in the quantities of food given and the size of the feeds. Sudden changes of food (particularly that from grass to grain), heavy feeding immediately before hard work, the bolting of quantities of indigestible grain, such as wheat, and the ingestion

of large quantities of fibrous matter, such as the running stems of the paddy-melon (*Cucumis myriocarpus*)—all these are liable to cause colic in strong, well-conditioned horses, and there are also other causes likely to operate in animals debilitated through a continuous low ration or temporarily exhausted from excessive strain. The administration of even an ordinary grain food will at times cause trouble in these cases, and the giving of an extra large feed to a tired or exhausted animal may lead to serious results.

In cases of debility the tone of the digestive organs is so low that large quantities of concentrated food cannot be dealt with, and indigestion and colic result. Debilitated animals are also peculiarly prone to flatulent colic if food of a highly succulent and fermentative nature is given. Weak and exhausted animals should, above all others, receive small feeds at comparatively short intervals. They should also be worked with care, as it is in animals in that condition that colic is especially apt to be associated with watering. On the other hand, the danger of giving water to a warm horse has been much overestimated.

In many cases where improper feeding may not lead to attacks of colic it will induce a more or less serious indigestion—at times acute, and at others chronic—which is shown in a failure on the part of the animal properly to digest his food, and a consequent unthriftiness. In such cases the first step should be to investigate the methods and materials used in feeding and to correct any errors noted. This should always be done before resort is made to medicine, which will in many cases be then found unnecessary.

Azoturia.—The ill effects of maintaining a resting horse on the same high ration on which he has recently been working are seen in those cases of azoturia which occur frequently in cities and which seem to be due to the overloading of the resting system with a rich diet, and the sudden disturbance of metabolism involved in the change from work to leisure. An appropriate reduction of the diet and the provision of a laxative food such as a bran mash on the day before a holiday, will to a fair extent prevent such cases.

Forage Poisoning.—Mortality from this cause is nearly always associated with a supply of mouldy or dirty food, and can be largely prevented by assuring that such material is not used.

Laminitis.—Overgorging with wheat is often followed by this disease, but it is not likely to occur if the wheat is properly fed and the horses are not put on to it too suddenly.

Lymphangitis.—A complaint frequently seen in horses kept on full feed during rest days immediately following days of hard work. Under such circumstances the richness of the diet should be lowered before the rest.

CATTLE.

Owing to the natural conditions under which the majority of cattle are kept in this country, the diseases associated with feeding are intimately connected with seasonal variations, such as the frequent dry periods and the almost equally frequent, though much shorter, periods of heavy rain and floods, with the consequent rapid growth of succulent green herbage and grass. Forms of disease in which food deficiency, in some form or other, and sudden changes from dry to green feed, play an important part, are very prevalent. This is

not the case in countries having an equable climate; digestive troubles there are principally found in cattle which are stall-fed, and though the number of cattle so treated in this country is only a very small proportion of the whole, it will tend to increase, and some attention must be given to methods of artificial feeding and the digestive troubles incidental to it.

The great influence of proper feeding on productivity, either of beef or milk, and the methods best calculated to maintain and increase this qualification, do not come within the scope of these articles, but before passing to the diseases connected with paddock-fed cattle, some reference will be made to the principles governing stall feeding. Naturally the methods of feeding an animal with a simple stomach of limited capacity, such as the horse, cannot be applied to cattle which have a compound stomach of large size. While the best results are obtained from frequent small feeds to the horse they are obtained by large feeds at longer intervals with cattle. The proportions of concentrated food to bulky food are also quite different, as cattle can deal with far more bulky material, and can usefully ingest food of a fibrous nature, which would be of very little value to the horse. In other respects, however, the same principles apply when the animals are stall-fed.

Regularity of feeding is of great importance, sudden changes of food should be avoided, musty or mouldy food is dangerous, and some care is required to balance the ration from the point of view of disease. Certain deficiencies in many of the natural pastures can well be supplied by some modified form of stall feeding, and disease incidental to such deficiency avoided in that way. Better results will usually be obtained from feeding cattle on a mixed ration than from using one composed entirely of the products of one particular plant.

Foodstuffs used for Cattle.

The commoner materials used in feeding cattle may be briefly described, although diseases of the digestive tract in cattle which are stall-fed are not so intimately connected with any particular food or foods as is the case with horses. The descriptions are merely examples of the different types of food used, and an approximate idea only is given of the best method of utilising them.

Lucerne (hay or chaff).—A most valuable food, which, on account of its high nitrogenous content can be largely utilised in place of more expensive concentrated food, and when mixed with corn or other silage and bran furnishes a very useful ration. A very safe food.

Silage (corn or sorghum).—A very useful bulk food, but care should be taken that no mouldy silage is fed. Owing to its succulence it is of great value to dairy cattle, and being slightly laxative the digestive tract is kept in good condition by its use.

Chaff (oaten and wheaten).—A useful bulk food, but requires more concentrates to balance the ration than does lucerne chaff.

Bran.—One of the best forms of concentrated food for cows, and of great value in maintaining health by its action on the digestive organs, its mineral content, and its power of protecting stock from some disease conditions associated with food deficiency.

Hay (grass and clover).—Although not much utilised in this country, hay furnishes excellent roughage for cattle, and if made from a mixture of grass and clover is especially valuable. It forms an excellent medium for supplying the long rough feed which is so beneficial to all ruminants, and which

enables them more perfectly to digest the chaff, bran, and meal which form the larger portion of their food. By improving rumination and digestion this food aids in preventing colic, tympany, and indigestion.

Corn and Corn Meal.—Valuable concentrated foods but lack protein; they are best given with lucerne or clover hay.

Oats.—Good concentrated food but does not possess the same high value for cattle as for horses. If the ration is well balanced it can replace corn.

Linseed Meal.—A concentrated food rich in protein and mineral salts. Can be used to balance much of the lack of protein in chaff. Slightly laxative.

Pumpkins.—Useful as part of the bulk food but requires the addition of a considerable amount of concentrates to make a balanced ration. The same thing applies to melons, &c., and roots.

Diseases Associated with Feeding in Cattle.

Tympanites—Hoven.—This is due to the formation of gases in the rumen or paunch, and very frequently follows the feeding of cattle on luxuriant and succulent green food. It is more often observed, even in well-fed stock, when they are first turned on to clover, trefoil, lucerne, and other leguminous plants, but it is more likely to occur if the animals are hungry and are put on to the pasture in the early morning. Even a small amount of dry food given previously will tend to counteract the likelihood of tympanites occurring, and cattle may safely be put on to growing crops after the sun has been on them for a few hours, even though the same crops might have caused trouble before such exposure to the sun. It should also be remembered that cattle become accustomed to a food, and that the first occasion on which they are put on to these crops is likely to be the most dangerous. Consequently, the first day they should be allowed to feed for a few minutes only, and well watched, the time being increased gradually each day. Should rain occur, however, and a fresh, quick shoot result, care will again be required.

The same conditions may result when stock which have been for long on dry food are first given a quantity of green food of any description; this may occur among travelling stock coming empty on to green, succulent food. The reputation of some plants, such as pigweed (*Portulaca oleracea*), as poisonous, has not improbably resulted from mortality from this cause.

As each case must be dealt with according to local circumstances, the only advice possible is that care should be taken when animals come on to succulent food after a long spell on dry innutritious feed, or after a railway journey during which they have been deprived of food and water.

Impaction of the Rumen.—Many cases described under this heading would be more correctly described as atony of the rumen, as the impacted condition not infrequently results from a weakened state of the organ itself. It occurs under two rather different sets of conditions. Cattle which have been for long on a diet of innutritious food of a bulky nature may become so lowered in health, although maintaining fair condition, that what is known as the "tone" of the animal is not up to the standard required for dealing with the food. The digestive tract appears to be one of the first portions of the body to suffer from this lack of tone—the

rumen consequently fails to deal properly with the mass of ingesta and it accumulates. Naturally the more the weakened rumen is overloaded the less capable it becomes, and the result is a stoppage of its movements and action. Correction of the diet in the direction of replacing portion of the bulky food with nutritious concentrates, such as grain, meal, and bran, represents the best method of relieving the condition, but it must be done in the early stages. Once a weak rumen is heavily overloaded the provision of good food is of small value, as it will not be properly digested.

Scrub-fed cattle are particularly likely to suffer from a general impaction of the digestive system, including the rumen, partly because of the very low feeding value of any scrub—and this is so no matter how valuable such scrub may be in keeping animals alive through time of drought—and partly on account of the astringent character of many of the plants used in scrub feeding. Scrub alone can only provide sufficient nutriment to keep stock alive, and, as a rule, they steadily lose tone while fed on it. This condition may eventually lead to impaction, which, however, may not show until the stock are put to some strain, such as travelling, when it may very quickly become evident.

Atony of the rumen, leading to impaction, may also occur among well kept cows which are entirely fed on concentrates and chaff without any admixture of hay or long food, and are, at the same time, deprived of grazing. There is no doubt that ruminants, to maintain themselves in a really fit condition, require a certain amount of rough fibrous material. Lacking the stimulus of this type of food, the digestive organs are apt to become deranged, and impaction results.

Impaction of the Omasum.—Generally, this complaint is found following other diseases, but it often occurs as a result of lowered vitality in cattle on dry, innutritious food, when water is scarce, and, in spring and autumn, when fresh grass is shooting among a lot of dry, dead stuff. In all such cases, the condition of this organ is probably due to chronic indigestion and derangement of the functions of the system from prolonged dry feeding, and from the change on to green food. Where animals are kept in good tone with regular nutritious feeding, and no other disease is present, the condition is not common.

Depraved Appetite.—This is a common occurrence among cattle on coastal areas. The animals devour bones, sticks, stones, dead rabbits, and all kinds of indigestible rubbish. The causes are many and various, the most important, probably, being an insufficiency of certain mineral matters in the soil (dealt with below under the heading *Osteomalacia*), but other cases occur which may generally be ascribed to indigestion from some obscure cause. In all cases the essential line of treatment consists in alteration and enrichment of the food supply, change of paddocks, provision of some artificial feeding, and a supply of salt.

Osteomalacia.—This disease is very generally associated with certain poor types of soils, and is usually shown by the bone-chewing habit of the animal. It can best be combated by supplying food fairly rich in mineral salts, such as bran, lucerne chaff, clover-hay, or other suitable artificial foodstuff. In addition, sterilised bone meal should be added to the food, as much as 2 oz. per day being given at times. Salt is not very often required by such cattle to any great extent, though with all dairy cattle a supply of rock salt is necessary if they show any desire for it.

It will be noted that the great majority of the diseases of cattle which are associated with feeding—a few of which are mentioned above—are really deficiency troubles in some form or other, and this is the main point it is desired to urge in connection with cattle. It is not necessarily bulk weight which is deficient—it may be nutritive constituents. The scrub-fed cattle, which cannot travel without breaking up, the bone-chewing dairy cow of the coast, and the unthrifty pot-bellied youngsters, are all affected in different ways by some variety of the same thing, and these conditions—and the many other diseases which come more or less directly as sequels to these—can all be prevented by attention to feeding. If grazed continuously and never manured, the natural pastures cannot provide the necessary food material in sufficient quantities during the whole year—certainly not in time of drought. A gradual impoverishment of many of the grazing lands is thus taking place, and with that impoverishment will come an increase in disease.

The addition of artificially-grown food to the natural pastures must be made if this is to be prevented, and will be required sooner in some parts of the State than others, according to the natural fertility of the country, and the length of time it has been grazed. Those food constituents which are most likely to be wanting are the proteins and mineral salts, and in supplying the former the very great value of the legumes—lucerne, clover, trefoil, and peas—should always be borne in mind. The mineral salts most lacking will be lime salts and phosphates. For the former the leguminous plants are again of high value, and for the latter bran and the oilcakes and meals are useful.

It will be remarked that these diseases are really in contrast to the diseases in horses, which are nearly all due to errors in methods of feeding.

Poisoning.—Although often reported, poisoning in cattle is seldom proved, but a few of our native and introduced plants must be held responsible for mortality at times. As instances, sorghum, blue couch, rosewood, and possibly others at times kill by the formation of prussic acid: certain types of Darling pea cause the well known symptom of a pea-stricken animal; burrawang leads to a peculiar nervous condition commonly, but erroneously, called rickets; the cape tulip will at times kill cattle unaccustomed to it, and there are many plants which require further investigation before definite pronouncement can be made as to their toxic properties.

Prevention in all such cases is the obvious course, but this is at times impossible, or nearly so. Only with regard to the prussic acid forming plants can effective measures be taken. If cut and dried they are practically harmless, whereas they are most dangerous in young, quick growth, and when stunted and growing up after once being eaten off.

Indigestion in Calves.—Owing to the artificial manner in which most calves in dairying districts are reared, indigestion and its consequences, general unthriftiness, diarrhoea, and stunted growth are very common; these troubles may be due to any one or combination of the following causes:—Overloading the very young animal's stomach through endeavouring to give sufficient nourishment to cause it to thrive in too few feeds; replacing full milk with skim milk or milk substitutes too early or too suddenly; giving the feed cold or only slightly warmed instead of at the normal temperature of milk fresh from the cow; sudden changes of food, as from skim milk to substitutes, and

back again ; so feeding a bunch of calves that the little animals gulp it down as quickly as possible to prevent others from getting it ; and giving such a small ration that the calves are driven to eating rough forage, and hay, &c., at too early an age.

In order to prevent disease in calves from improper feeding the following points require attention :—Cleanliness in feeding, which should preferably be from metal receptacles which can be scalded out ; separate feeding of the calves to insure that each one gets a fair feed and is not unduly hurried ; feeding the milk and other material at blood heat ; the gradual substitution of skim milk for whole milk, and the replacing of the nutritive material thus lost by meal obtained from cereals or other concentrated food ; regularity in times of feeding and of quantity of material used ; gradual change of food when necessary, and gradual weaning. The skim milk which is used should be as fresh as possible, since the longer it is kept the more likely it is to be contaminated and so cause diarrhoea. The skim milk, buttermilk, and whey obtained from creameries and factories is particularly dangerous, since the feeder has no control over the possible contamination of the material ; it should be pasteurised before being used.

Tuberculosis.—Contracted by cattle when young by feeding on the milk and milk products of tuberculous cows, and by grazing over badly contaminated paddocks at a later stage. To prevent infection, stockowners should do everything in their power to get rid of tuberculous cattle, and if using the milk or milk products from mixed herds for the purpose of feeding their calves should pasteurise or boil it.

Actinomycosis.—This disease is contracted from the feed, and very little can be done to prevent it except to destroy animals affected, and so prevent reinfection of pastures.

Grass Seed Abscesses.—Due to grass seeds penetrating the soft tissues of the mouth. It is difficult to prevent ; but overstocking the pastures on which dangerous grasses such as barley grass grow, might effect something.

SHEEP.

The principles affecting the feeding of sheep are studied still less than those affecting the feeding of other animals, but in drought periods their consideration is often a matter of very great importance, demanding attention in relation both to cost and to prevention of mortality.

Sheep grazing in paddocks are subject to the diseased conditions associated with the same method of feeding in cattle—that is, tympanites when brought on to succulent feed suddenly, impaction of various organs of digestion after a long course of dry feeding, acute poisoning from prussic acid developing plants, and slow poisoning from Darling pea, &c. Tympanites or hoven usually occurs in mobs of travelling sheep, sheep just off trucks, and those recently brought from a dry area to more favoured spots. The losses are at times exceedingly heavy, and those measures of prevention which can be utilised with animals on a farm or holding—methods such as only allowing the animals to remain a short time on such succulent grazing or supplying them with some dry food before allowing them on it—are often not practicable. Any such steps as are possible, however, should be taken.

The second common cause of mortality—impaction of various organs—is not so readily recognised or dealt with, since it is apt to be of slow onset and to follow a long period of dry feeding. The tendency is to regard the fact that sheep have lived for some considerable period on scrub or very dry unnutritious food as evidence that the food is sufficient for them, but as a matter of fact a continuous lowering in tone is taking place, varying in degree according to the quantity and quality of the food. This lowering in tone may be so slight that no ill-effects are observed, and when good feed comes again the sheep recover their tone; on the other hand, it may be so marked that the digestive system becomes unable to deal with the food, impaction results, and heavy mortality may follow. This is particularly liable to occur in pregnant ewes towards lambing time, and in sheep that are travelled or put to some other strain. In between these manifestations are all gradations of the trouble, and in many cases only small numbers of the weaker sheep die. What the animals suffer from is actually slow starvation. The impaction is certainly increased by the astringent nature of so many scrub fodders. It is impossible to lay down any hard and fast rules as to when and under what particular conditions mortality will occur, but it is obvious that the longer the period of nutritious feeding the more likely it is to have unfavourable results. Experience with the particular fodders used and the conditions existent on each holding must serve as the owner's guide.

It is plain that prevention of such mortality as is under consideration depends on the supply of food which will counterbalance both the lack of nutritive quality and the astringent nature of the scrubs and rough, dry fodders. Although to prevent all ill-effects this must be undertaken throughout the period of dry feeding, it is remarkable how rapidly sheep will recover from very severe loss of tone and impaction—even after deaths have occurred in the flock from these causes—if food is changed. Loss of lambs through deficiency of milk in the ewes (an indirect effect of the trouble discussed) may also be guarded against at the same time by use of the same measures.

The most useful way of considering the question of measures likely to prevent losses will be to take in turn the various feeding materials used in carrying sheep through a dry time and to note their value, and the most satisfactory method of utilising them. In doing so it must be borne in mind that financial considerations and the number of sheep to be dealt with must modify the decision on these points to a degree varying with any particular case.

Oats.—While this is a very good grain food for sheep, it does not appear to equal maize: as a sole food, owing to its larger husk content, it is superior to wheat. It is usually fed either by scattering or in troughs, but (as with all grains) scattering has considerable drawbacks, as a certain quantity is wasted, and in picking it off the ground the sheep are bound to become sanded to a certain extent. In some instances sanding has increased the ill-effects of impaction, if it has not directly caused mortality. It may be said here that no grain alone can be a satisfactory feed for a ruminant animal over long periods, and the fact that sheep have been brought through certain periods of drought on a grain ration does not invalidate this fact. Owing to their comparatively high nitrogen content oats form a useful adjunct to silage, straw, and chaff feeding.

Maize.—This appears to be about the most suitable grain to feed to sheep, and owing to its larger size there is probably less lost in scattering it than is the case with oats and wheat. It does not alone provide such a

balanced feed as oats, however. It will give better results if fed with lucerne chaff than with oaten or wheaten, or a small ration of meal may be combined with wheaten chaff to create the balance.

Wheat.—Much used in feeding sheep by both methods. Pretty well equal in value to maize. Best if fed with lucerne chaff. General remarks on oats as feed apply to maize and wheat also.

Bran.—A most valuable feed for breeding ewes. Keeps the digestive tract in good order, and, being fairly rich in nitrogenous matter, can be used with wheaten or oaten chaff without the addition of grain. A small chaff and bran ration of roughly equal parts, trough-fed, is very useful when sheep are on scrub or dry innutritious fodder.

Chaff (oaten and wheaten).—Has not the same value as lucerne, but is a good bulk food. Really good chaff, as produced in this country, can be fed alone, and will provide good sustenance without additional food, though it is better to add bran for breeding ewes. Poor chaff is not very much better than straw.

Straw.—Can be very largely utilised in the feeding of sheep; and while barley straw is probably the best, oat and wheat straw can both be made use of. Its palatability is greatly increased and its nutritive value raised if given with molasses. If a lucerne ration is being fed, straw can be used to replace portion of this ration without lowering the value of the ration to a serious extent.

Silage.—Silage is always of value. To obtain the best results some portion of the feed should be dry roughage, such as lucerne hay or straw.

Linseed and other Meals.—Supplied in small quantities to sheep being trough-fed on chaff or straw, these can entirely replace bran and grain, as they are rich in nitrogenous material and in mineral salts.

Improved Feeding Methods Necessary.

These notes apply to the feeding of sheep in dry periods with a view to preventing mortality apart from actual starvation—although, as already indicated, nearly all such mortality is really at basis slow starvation. It is not intended here to discuss feeding from the point of view of fattening, but it may advisedly be pointed out that so long as our sheep are exposed to the extremes of feeding which exist in New South Wales, so long must heavy mortality be expected. The maintenance of food supplies on a more even basis would prevent a very great deal of this mortality, and though such ideas are impracticable to a great extent in the case of the large sheep-run, they are not so on many sheep farms. The most obvious methods of ensuring it are the conservation of hay and silage, the subdivision and spelling of paddocks, and the growing of crops for grazing. The future must inevitably see a great increase in the application of such methods of reducing mortality.

As already pointed out, much loss occurs from continued dry feeding, and yet further loss is involved in the sudden change to extremely succulent food. Surprise is often expressed that mortality in sheep is so heavy after the appearance of what is referred to as good food, but as a matter of fact such rapid-growing, succulent food as appears after copious rains following drought possess very little body, and in the already weakened

condition of the animal will not sustain life, particularly as at such times the animal requires the production of a good deal of bodily heat. The question then arises of the possibility of supplying some dry roughage in addition to the green food.

Apart from these direct effects of feeding on mortality, it has, it may be reiterated, a somewhat indirect influence in leading to many deaths among ewes prior to lambing. It is not suggested that every such case is dietetic in origin, but it is desired to stress the intimate connection between feeding and many such cases of heavy loss. These deaths are in all probability due to a complexity of causes, beginning with lack of digestible and nutritive food, leading to a slowly developing atonic condition of the digestive tract, which becomes less and less capable of dealing with what food is available. The strain of advancing pregnancy is added to these difficulties, a tendency to constipation is induced by the fibrous astringent food, and as a result of these multiple causes the weakened animals succumb. If at the first sign of such mortality food of the nature of bran, lucerne, linseed meal, &c., can be provided, it may be almost entirely checked.

Poisoning.

At times heavy losses occur in sheep as a result of plant-poisoning. Blue couch and rosewood have been responsible for many deaths as a result of the formation of prussic acid, and variegated thistle has killed many, probably from the same cause. Very little can be done to prevent this, as there is no indication when the plants are likely to be poisonous, but warnings issued with regard to particular patches of country have at times been disregarded, with disastrous results.

The commonest form of chronic poisoning is that due to Darling pea, which can only be dealt with by getting rid of the plant. There are, in addition, many other plants concerning which our information is very vague and unsatisfactory, and concerning which there is urgent need for investigation.

PIGS.

Feeding and disease are not so intimately connected in the pig as in other animals—largely because in the majority of cases the feeding is more controlled, and because, whereas with other stock most of the trouble is due to the nature of the food, with pigs the most serious disease (that is, tuberculosis) is due to infected food. It may safely be said that the great majority of cases of tuberculosis of the pig in this country are due to infection by tubercular milk and milk products, and the only satisfactory method to safeguard the animals is to boil such food before feeding it.

The amount of mineral salts (particularly lime and phosphates) in the food of pigs is of considerable importance, and the disease commonly known as rickets is largely due to deficiency of these ingredients. In cases where the pigs are affected a change of diet is advisable, and food fairly rich in these salts, such as bran, pollard, lucerne-hay, clover-hay, &c., should be tried.

One of the common forms of poisoning in the pig occurs from the administration of brine with the food, either through ignorance or carelessness. Otherwise, poisoning is generally due to the careless handling of rabbit poison.

ANALYSES OF FODDERS.*

The following table has been prepared in order to provide a handy reference to the composition of the more common fodders obtainable on the local markets, and of a number of plants that furnish fodder in times of scarcity, especially in pastoral districts.

It must be understood, however, that the inclusion of any plant or substance in this list does not necessarily mean a recommendation for its use as a fodder. The figures given represent as nearly as possible the compositions of the various substances, but it must be remembered that in some cases, particularly in green fodders, hay, grass, straw, &c., the composition is liable to variation, because differences due to the treatment or making are added to differences induced by the soil and the season.

The variations in composition between oat straw from different fields or different varieties is greater than the differences between oat straw and barley or wheat straw, and the same would apply to other products.

The analyses were made in the Chemical Laboratory, Department of Agriculture.

	Water.	Ash.	Albuminoids.	Crude Fibre.	Nitrogen-free extract.	Ether Extract.	Albuminoid Ratio.	Nutritive Value.
Green Fodders.								
Lucerne... ..	73.5	2.3	6.6	6.2	11.0	0.4	1 : 1.8	18.5
Barley (Cape)	65.4	1.6	3.9	7.4	21.4	0.3	1 : 5.7	26.0
" (skinless)	70.9	2.2	4.1	7.8	14.6	0.4	1 : 3.8	19.6
Wheat (Bunyip)	68.1	1.9	4.4	10.3	14.5	0.5	1 : 3.6	20.0
" (Cleveland)	63.0	2.2	4.8	11.6	17.8	0.6	1 : 4.0	24.0
" all varieties	72.0	2.0	2.6	9.5	13.2	0.7	1 : 5.7	17.4
Oats (Algerian)	69.1	1.8	3.9	8.6	16.3	0.3	1 : 4.4	20.9
Sorghum (<i>Sorghum vulgare</i> , Pers., var. <i>sacharatum</i>)	74.9	1.2	2.2	5.4	15.7	0.6	1 : 7.5	18.7
Black line Kafir corn (<i>Sorghum vulgare</i> , Pers.)	75.0	1.2	1.9	6.6	14.8	0.5	1 : 8.4	17.8
Indian cane (<i>Saccharum officinarum</i>) ...	69.6	11.0	2.3	6.8	10.1	0.2	1 : 4.8	13.3
Broom millet	75.0	1.6	3.1	9.8	10.2	0.3	1 : 3.5	14.0
Millet China white	75.0	1.0	2.2	5.8	15.5	0.5	1 : 7.8	18.8
" " yellow	75.0	0.8	3.3	6.9	13.3	0.7	1 : 4.5	15.2
Rice (dry land Paddy)	75.0	2.2	5.1	6.2	11.0	0.5	1 : 2.4	17.2
Rape fodder	79.1	1.9	2.0	4.0	12.3	0.7	1 : 6.9	15.9
Mangold fodder	86.2	0.9	1.9	1.1	9.5	0.4	1 : 5.5	12.3
Cabbage "	86.3	1.1	1.2	1.8	9.1	0.5	1 : 8.5	11.4
Pea "	81.8	1.2	3.1	7.9	5.2	0.8	1 : 2.3	10.1
Oat "	80.1	1.7	2.6	6.7	7.7	1.2	1 : 4.0	13.0
Rye "	75.0	1.7	2.2	9.1	11.5	0.5	1 : 5.7	14.8
Tares	86.9	1.2	3.2	3.2	5.0	0.5	1 : 1.9	9.3
White lupins	81.9	1.8	3.8	3.6	8.4	0.5	1 : 2.5	13.3
Clover (crimson, <i>Trifolium incarnatum</i>) ...	78.7	2.9	4.6	3.9	9.3	0.6	1 : 2.3	15.3
" (ball, <i>Trifolium</i> sp.)	75.0	1.6	4.0	8.1	11.1	0.2	1 : 2.9	15.6
Teosinte (<i>Euchlena luxurians</i>)	75.0	1.2	2.5	6.9	14.0	0.4	1 : 6.0	17.4
Medic (burr) (<i>Medicago denticulata</i>) ...	70.0	1.0	2.1	1.5	24.9	0.5	1 : 12.4	28.1
" (cut-leaved) (<i>Medicago laciniata</i>) ...	70.0	1.2	2.7	2.5	22.9	0.7	1 : 9.0	27.2

* Compiled by A. A. Ramsay, Principal Assistant Chemist.

Analyses of Fodders—continued.

	Water.	Ash.	Albuminoids.	Crude Fibre.	Nitrogen-free extract.	Ether Extract.	Albuminoid Ratio.	Nutritive Value
Green Fodders—continued.								
Medic (black) (<i>Medicago lupulina</i>) ...	70.0	3.1	7.7	4.7	13.7	0.8	1: 2.0	23.2
Tagosaste (Tree lucerne) (<i>Cytisus proliferus</i>)..	75.0	2.4	7.4	6.0	9.2	0.1	1: 1.3	17.0
Guinea grass	70.0	2.5	3.1	10.3	13.3	0.3	1: 4.7	17.6
Mallow, small flowered (<i>Malva parviflora</i>) ...	70.0	0.8	3.3	1.2	24.4	0.3	1: 7.6	23.4
Barley grass (<i>Hordeum murinum</i>)	70.0	2.6	3.6	10.0	13.5	0.3	1: 3.9	17.3
Cut grass	70.0	1.4	2.2	13.1	13.0	0.3	1: 0.2	15.9
<i>Paspalum stoloniferum</i>	74.2	3.6	4.4	7.3	9.4	1.1	1: 2.7	16.3
„ <i>virgatum</i>	70.0	1.7	2.5	11.0	14.3	0.5	1: 6.2	17.9
„ <i>dilatatum</i>	70.0	2.2	2.6	11.1	13.6	0.5	1: 5.7	17.3
Rhodes grass (<i>Chloris gayana</i>)	70.0	2.2	3.0	8.1	16.1	0.6	1: 5.9	20.5
Italian rye (<i>Lolium italicum</i>)... ..	70.0	2.1	2.7	8.3	16.2	0.7	1: 6.6	20.5
Sheep's Barnet (<i>Poterium sanguisorba</i>) ...	70.0	2.6	3.3	6.8	15.8	1.5	1: 5.8	22.5
Cocksfoot (<i>Dactylis glomerata</i>)	70.0	2.1	2.7	9.3	15.2	0.7	1: 6.2	19.5
Perennial rye (<i>Lolium perenne</i>)	70.0	2.1	2.3	7.6	17.4	0.6	1: 3.2	21.1
Rib grass (<i>Plantago varia</i>)	70.0	2.9	4.0	5.1	17.4	0.6	1: 4.7	22.3
Texas blue grass (<i>Poa arachnifera</i>)	70.0	2.2	2.9	10.1	14.2	0.6	1: 5.4	18.5
Fat-hen (<i>Chenopodium album</i>)	81.6	3.1	6.5	2.2	5.9	0.7	1: 1.2	14.0
Broad bean (stalks)	84.3	1.7	4.2	4.3	5.3	0.2	1: 1.4	10.0
<i>Phalaris bulbosa</i> (<i>P. commutata</i>)	70.0	2.6	2.5	8.6	15.4	0.9	1: 7.0	19.9
Hooker's fescue grass (<i>Schedonorus hookerianus</i>)..	70.0	1.9	2.2	9.3	15.5	0.6	1: 7.7	19.1
<i>Danthonia penicillata</i>	70.0	3.1	2.0	8.6	15.7	0.6	1: 8.5	19.1
Coolah grass (<i>Panicum prolatum</i>)	70.0	2.0	2.4	7.6	17.3	0.7	1: 7.9	21.3
<i>Festuca bromoides</i>	70.8	7.3	1.1	5.7	10.9	1.2	1: 3.3	17.7
Cape weed (<i>Cryptostemma calendulaceum</i>) ...	91.0	1.3	1.0	1.7	4.1	0.4	1: 5.0	6.0
Pig face (<i>Mesembryanthemum squillaterale</i>)...	90.2	2.1	1.3	1.3	4.5	0.1	1: 2.6	6.5
Elephant grass or Napier's fodder grass (<i>Pennisetum purpureum</i>)..	65.8	2.7	3.6	13.2	14.2	0.5	1: 4.3	18.9

Dry Fodders.

Hay, wheaten (Typical)	11.0	7.1	9.4	23.1	46.7	2.7	1: 5.6	62.2
„ „	10.8	5.5	6.6	22.4	53.0	1.7	1: 8.6	63.4
„ „ (Bobs)	10.1	5.3	8.8	33.2	41.7	0.9	1: 5.0	52.5
„ „ (Firbank)	10.7	5.1	8.3	29.7	45.0	0.7	1: 5.3	55.4
„ „ (Huguenot)	10.3	4.9	5.6	31.5	46.8	0.9	1: 8.7	54.4
„ „ (Zealand)	10.8	5.7	7.6	31.7	43.0	1.2	1: 6.0	53.3
„ „ (Bayah)	10.4	5.8	6.8	32.5	44.0	0.5	1: 6.6	51.9
„ „ (Marshall's No. 3)	14.5	4.3	6.3	26.6	46.8	1.0	1: 7.8	55.4
„ „ (Federation)	11.8	5.2	6.3	23.1	47.8	0.8	1: 7.9	55.9

Analyses of Fodders—*continued.*

	Water.	Ash.	Albuminoids.	Crude Fibre.	Nitrogen-free extract.	Ether Extract.	Albuminoid Ratio.	Nutritive Value.
Dry Fodders—<i>continued.</i>								
Hay, oaten	11.8	6.2	8.4	32.4	39.6	1.6	1: 5.1	51.6
Chaff, wheaten (average)	13.1	5.8	4.8	31.0	44.0	1.3	1: 9.8	51.3
„ oaten	12.5	3.1	4.3	33.2	46.0	0.9	1: 11.2	52.3
„ rye	10.1	4.6	6.6	42.7	33.9	2.1	1: 5.9	45.2
„ " Cocky "	10.8	6.2	7.2	24.3	49.9	1.6	1: 7.4	60.7
Straw, wheaten	11.5	5.6	3.8	29.2	49.0	0.9	1: 13.4	54.8
„ barley	10.1	5.0	4.0	33.1	46.7	1.1	1: 12.3	53.2
Hay (<i>Paspalum dilatatum</i>)	10.6	6.4	10.3	28.0	43.4	1.3	1: 4.5	56.6
„ Hungarian millet	12.9	6.7	10.7	31.4	36.6	1.7	1: 3.8	51.1
Pith of maize cob	13.6	1.6	4.5	35.3	44.4	0.6	1: 10.2	50.3
Pigeon-pea hulls	11.8	3.7	8.8	31.7	43.3	0.7	1: 5.1	53.7
Brewers' combings or malt combings	12.3	5.9	23.5	13.6	44.1	0.6	1: 1.1	69.0
Corn chaff (maize)	15.6	4.2	10.3	17.6	51.3	1.0	1: 5.2	63.9
Lucerne hay	10.0	8.9	16.0	24.6	37.7	2.8	1: 2.8	60.0
Lucerne dust	8.6	15.1	19.1	11.2	42.0	4.0	1: 2.7	70.1

Ensilage.

Mixture, composition unknown	60.9	4.7	4.2	13.7	15.3	1.2	1: 4.3	22.2
„ „ „	60.2	1.9	4.8	11.7	20.7	0.7	1: 4.6	31.1
„ „ „	68.3	3.1	6.7	12.8	6.6	2.5	1: 1.8	18.8
„ „ „	55.0	5.1	8.4	8.9	21.2	1.4	1: 2.9	32.8
„ „ „	52.8	3.4	8.4	13.7	20.0	1.7	1: 2.8	32.2
Self-sown malting barley and other plants	60.5	5.3	4.1	8.6	19.4	2.1	1: 10.3	46.5
Wheat and wild oats	35.2	4.8	5.0	15.4	37.7	1.9	1: 8.4	47.0
Maize stalk and leaf	64.0	2.2	3.1	11.0	19.3	0.4	1: 6.5	23.3
Dry maize stalks with lucerne and molasses added.	68.4	1.1	5.1	6.6	18.2	0.6	1: 3.8	24.7
Prickly-pear ensilage	85.1	2.3	1.8	1.9	8.7	0.2	1: 5.1	11.0

Roots, Tubers, Bulbs.

Canna bulbs	77.1	0.9	2.1	0.6	19.1	0.2	1: 9.3	21.7
Chufa or earth almond	39.2	1.8	4.0	6.8	39.7	8.5	1: 14.7	62.8
Giant lily bulb	75.1	0.8	4.6	2.0	17.4	0.1	1: 3.8	22.2
Potato	78.3	1.1	2.1	0.4	18.0	0.1	1: 8.7	20.3
<i>Rumex rosea</i> leaves (dangerous weed)	51.5	2.3	2.7	3.1	39.1	1.3	1: 15.6	44.7
Taro	62.7	1.2	3.5	0.5	31.5	0.6	1: 9.4	36.4

Analyses of Fodders—*continued*.

	Water.	Ash.	Albuminoids.	Fibre.	Nitrogen-free extract.	Ether Extract.	Albuminoid Ratio.	Nutritive Value.
Grains and other Seeds.								
Barley	12.3	2.4	11.6	4.1	67.7	1.9	1 : 6.2	83.6
Beans	13.3	2.2	26.5	5.5	51.2	1.3	1 : 2.1	39.6
Bean, sword	12.3	2.9	28.9	6.9	46.3	2.7	1 : 1.8	81.3
" French	13.1	3.4	26.3	3.6	52.0	1.6	1 : 2.1	81.9
" Lima	12.4	3.7	22.4	3.4	56.8	1.3	1 : 2.7	82.1
Cowpea, black-eyed	11.9	2.8	21.3	3.2	59.3	1.5	1 : 2.9	84.0
Dhourra meal	12.3	1.2	10.9	3.9	69.1	2.6	1 : 6.9	85.9
Lentils	12.0	2.1	23.1	2.7	59.5	0.6	1 : 2.6	84.0
Millet (seed)	12.8	2.0	14.2	3.6	65.4	2.0	1 : 4.9	84.1
Maize, white	12.7	1.4	11.0	1.6	69.8	3.5	1 : 7.1	83.7
" yellow	12.8	1.3	11.4	1.5	68.4	4.6	1 : 6.9	90.2
" Northern River, yellow	11.4	1.3	10.1	1.5	71.1	4.6	1 : 8.1	91.6
" black	12.0	1.1	7.7	1.2	73.9	4.1	1 : 10.8	90.3
Oats (Algerian)	10.9	3.3	8.5	11.8	60.6	4.9	1 : 3.4	80.1
Pea, marrowfat	11.9	2.5	25.0	5.5	53.4	1.7	1 : 2.3	82.2
" blue	12.5	2.1	18.4	4.5	61.3	1.2	1 : 3.5	82.4
" grey	14.1	2.0	19.3	4.8	58.3	1.5	1 : 3.7	81.0
Wheat (average quality)	13.7	1.5	8.7	2.4	72.8	0.9	1 : 8.6	83.5
Mill Products.								
Bran, wheaten, from hard wheat	13.4	6.8	18.6	7.9	59.8	2.5	1 : 3.0	75.0
" " " medium wheat	15.2	3.9	20.4	6.6	52.1	1.8	1 : 2.7	76.3
" " " soft wheat	14.7	4.5	13.4	7.5	58.0	1.9	1 : 4.6	75.7
" " " macaroni wheat	13.1	4.0	16.9	5.9	56.1	4.0	1 : 3.9	82.0
" " " (average quality)	12.5	3.8	16.9	6.8	57.8	2.2	1 : 3.7	79.7
" oaten	7.7	4.3	14.0	21.8	46.3	5.9	1 : 4.3	73.6
Pollard from hard wheat	11.7	4.3	19.5	3.7	56.7	4.1	1 : 3.4	85.4
" " " medium wheat	13.6	2.4	19.4	3.5	58.8	2.3	1 : 3.3	83.4
" " " soft wheat	11.3	2.5	13.7	3.6	66.3	2.6	1 : 5.5	85.9
" " " macaroni wheat	11.6	3.7	17.4	4.5	59.1	3.7	1 : 3.9	84.5
" " " (average quality)	12.3	2.5	17.2	3.0	61.2	3.8	1 : 4.1	87.0
Whole meal (wheaten)	12.1	0.8	14.3	0.8	70.7	1.3	1 : 5.1	87.9
Oat hulls	8.4	4.4	4.3	27.8	53.5	1.6	1 : 11.0	69.4
" bran	7.7	4.3	14.0	21.8	46.3	5.9	1 : 4.3	73.6
" pollard	8.1	2.4	15.8	2.1	66.7	4.9	1 : 4.9	93.5
" screenings	9.2	3.3	9.2	13.7	57.3	7.3	1 : 8.0	82.0
Rice meal or rice bran	10.9	8.3	14.4	5.3	45.1	16.0	1 : 5.6	95.5
Maize meal	13.3	1.7	12.7	1.4	67.4	3.5	1 : 5.9	88.0

Analyses of Fodders—*continued*.

	Water.	Ash.	Albuminoids.	Fibre.	Nitrogen-free extract.	Ether Extract.	Albuminoid Ratio.	Nutritive Value.
Oil Cakes, &c.								
Brab cake	14.5	5.2	42.3	4.0	25.3	8.7	1 : 1.1	87.2
Castor cake	18.8	7.1	26.9	20.6	13.7	12.9	1 : 1.6	69.6
Coconut-oil cake (type)	10.0	5.5	20.0	8.5	47.0	9.0	1 : 3.4	87.3
Linseed	11.3	5.1	30.8	8.3	40.7	3.8	1 : 1.6	80.1
Pea cake	16.1	4.6	45.3	4.4	17.2	12.4	1 : 1.0	90.4
Miscellaneous.								
Biscuit sweepings	9.2	1.1	6.4	0.1	60.8	22.4	1 : 17.4	117.6
„ meal	6.6	1.0	8.0	0.1	72.4	11.9	1 : 12.4	107.2
Rabbit meal	10.7	13.6	62.3	0.3	10.2	2.9	1 : 0.3	79.0
Blood	13	6.0	78.4	..	1.7	0.3	1 : 0.03	80.8
Green bone	6.2	63.4	18.7	2.0	8.5	1.2	1 : 0.6	29.9
Cattle food (Munn's)	10.2	0.8	15.1	4.3	62.7	6.9	1 : 5.0	93.3
Marshmallow, seeds	9.0	5.2	18.1	34.7	32.8	0.2	1 : 1.8	51.4
„ fresh leaves, &c.	78.4	4.7	6.1	3.1	7.1	0.6	1 : 1.4	14.6
Molasses and megass	26.0	6.6	4.9	5.3	56.8	0.4	1 : 11.8	62.6
Molascuit (molasses and hay)	17.7	8.0	2.9	4.1	66.6	0.1	1 : 23.0	69.7
Dry molasses feeder	18.4	8.8	8.4	9.3	54.7	0.4	1 : 6.6	64.0
Molasses	24.0	10.5	4.6	..	60.9	..	1 : 13.2	65.5
Milk	87.3	0.7	3.5	..	4.6	3.9	1 : 3.8	16.9
Saltbush.								
<i>Atriplex nummularia</i> (cultivated)	75.0	5.9	4.6	3.3	10.6	0.6	1 : 2.6	16.6
„ „ (uncultivated)	75.0	9.4	4.3	2.3	8.6	0.4	1 : 2.2	13.8
„ <i>halimoides</i>	75.0	7.7	3.9	3.4	9.5	0.5	1 : 2.7	14.5
„ <i>angulata</i>	75.0	12.2	2.9	5.5	3.6	0.8	1 : 1.9	8.2
<i>Rhynchosia parvifolia</i>	75.0	7.6	4.1	4.7	8.1	0.5	1 : 2.2	13.3
„ <i>billardieri</i>	75.0	8.6	5.7	2.8	7.4	0.5	1 : 1.5	14.2
„ <i>hastata</i>	75.0	4.2	9.1	2.4	8.3	1.0	1 : 1.2	19.6
Unidentified	75.0	8.4	3.1	3.1	9.9	0.5	1 : 3.6	14.1
Prickly-pear.								
<i>Opuntia ficus-indica</i> *	93.8	1.2	0.5	0.6	3.5	0.4	1 : 8.8	4.9
„ <i>clatior</i>	89.8	1.9	0.7	1.4	5.8	0.4	1 : 9.6	7.4
„ <i>brasiliensis</i>	86.2	2.4	0.9	1.5	8.5	0.5	1 : 10.7	10.5
„ <i>coccinellifera</i>	87.9	1.7	0.8	1.0	8.3	0.3	1 : 11.2	9.8
Leaves of Common Scrub Plants.								
Booigal (<i>Eucalyptus largiflorens</i> , F.V.M.)	16.1	4.1	6.8	9.1	56.7	7.2	1 : 10.7	79.7
Apple-tree (<i>Eucalyptus stuartiana</i> , F.V.M.)	34.6	3.2	6.4	9.7	42.8	3.2	1 : 7.7	55.4
Stringybark (<i>Eucalyptus macrorrhyncha</i> , F.V.M.)	39.5	2.6	5.6	6.4	40.8	5.1	1 : 9.3	57.9

Analyses of Fodders—*continued*.

	Water	Ash.	Albuminoid ^s .	Fibre.	Nitrogen-free extract.	Ether Extract.	Albuminoid Ratio.	Nutritive ^a Value
Leaves of Common Scrub Plants—<i>continued</i>								
River oak (<i>Casuarina cunninghamiana</i> , Miq.)	42.3	3.0	6.8	20.9	25.3	1.7	1: 4.3	35.9
Cattle gum (<i>Eucalyptus coriacea</i> , A. Cunn.)...	36.8	2.9	8.8	8.6	36.9	6.0	1: 5.7	59.2
Currajong (<i>Sterculia diversifolia</i> , G. Don) ...	35.6	5.0	10.4	14.5	32.8	1.7	1: 3.5	47.0
Rosewood or blue or apple bush (<i>Heterodendron oleæfolium</i> , Desf.)	23.7	4.0	12.8	16.5	40.2	2.8	1: 3.6	59.3
Belar (<i>Casuarina</i> sp.)	15.6	4.8	9.4	37.0	30.1	3.1	1: 8.9	46.5
Dogwood (<i>Myoporum</i> sp.)	28.6	3.5	9.3	10.9	45.4	2.3	1: 5.4	59.9
Warriah	11.3	5.1	11.9	35.9	32.0	3.8	1: 3.4	52.5
Wilga (<i>Geijera parviflora</i> , Lindl.)	49.3	5.2	13.3	7.8	22.0	2.4	1: 2.1	40.7
Whitewood (<i>Atalaya hemiglauca</i> , F.v.M.) ...	36.7	6.3	13.1	20.8	21.6	1.5	1: 1.9	38.1
Currawong (<i>Acacia</i> sp.)	13.5	2.9	12.9	30.6	38.1	2.0	1: 3.3	55.5
Bunbutt	23.6	7.7	13.5	16.7	34.5	4.0	1: 3.2	57.0
Needle bush (<i>Hakea leucoptera</i> , R.Br.) ...	12.6	4.8	6.4	39.1	36.4	.7	1: 5.9	44.4
Beefwood (<i>Grevillea striata</i> , R.Br.)	37.1	2.9	5.6	26.6	26.9	.9	1: 5.2	34.5
Mulga (<i>Acacia aneura</i> , F.v.M.)	39.1	3.6	9.1	29.9	15.7	2.6	1: 2.4	30.7
Emu bush (<i>Eremophila longifolia</i> , F.v.M.) ...	51.6	3.7	8.9	5.4	29.6	.8	1: 3.5	41.3
Supple Jack	33.2	6.6	11.0	15.0	33.0	1.2	1: 3.2	46.7
Leopard wood (<i>Flindersia maculosa</i> , F.v.M.)	41.7	3.4	9.3	11.4	30.3	3.9	1: 4.2	48.4
Gidgea (<i>Acacia homalophylla</i> , Cunn.)	41.0	8.7	7.3	22.6	18.3	2.1	1: 3.2	30.3
Sandalwood (<i>Eremophila</i> sp.)	41.8	5.6	8.6	8.8	33.5	1.7	1: 4.3	45.9
Quinine (<i>Alstonia constricta</i> , F.v.M.)	51.7	3.7	9.0	9.2	24.5	1.9	1: 3.2	37.3
Broom bush (<i>Apophyllum anomalum</i> , R.Br.)	19.8	13.2	9.9	44.8	0.7	1.6	1: 1.4	24.2
Currant bush (?) (<i>Leptomeria aphylla</i> , R.B.)	18.0	5.0	5.6	33.1	33.8	4.5	1: 7.8	49.5
Wild fuchsia (<i>Myoporum acuminatum</i> , R.Br.)	33.3	3.9	9.1	5.1	47.1	1.5	1: 5.5	59.6
Colone (<i>Owenia acidula</i> , F.v.M.)	49.0	6.9	9.2	12.5	21.3	1.1	1: 2.6	33.0
Myall (<i>Acacia pendula</i> , Cunn.)	48.5	4.5	9.6	19.6	16.6	1.2	1: 2.0	23.9
Bramble or wild orange (<i>Capparis mitchelli</i> , Lindl.)	28.0	8.1	13.1	19.0	30.5	1.3	1: 2.6	46.5
Bastard myall (<i>Acacia cunninghamii</i>)	26.5	4.3	11.2	25.7	29.5	2.8	1: 3.2	47.0
Tea-tree (<i>Leptospermum attenuatum</i>)	10.3	2.7	7.9	12.5	63.0	3.6	1: 9.0	79.0
Coral-tree (<i>Erythrina</i> sp.)	74.8	1.7	3.5	1.9	17.8	.3	1: 5.3	22.0
<i>Lyonsia eucalyptifolia</i>	31.5	5.8	10.4	16.2	29.0	7.1	1: 4.3	55.4
"Napunyah" or Yellow Jacket (<i>Eucalyptus ochrophloia</i> , F.v.M.)	7.0	.8	7.6	9.7	66.2	8.7	1: 11.3	93.4
Wattle (<i>Acacia decurrens</i>)	10.4	3.3	13.1	20.5	40.2	3.5	1: 4.4	70.2
Zamia Palm (<i>Macrozamia spiralis</i>), Kernel...	81.3	1.1	...	4.7	12.2	.2	.....	12.7
" " " leaves...	76.7	1.0	2.6	6.2	13.3	.2	1: 5.3	16.3

HAND-FEEDING SHEEP IN TIMES OF DROUGHT*

In considering a problem of such magnitude, the different conditions under which stock are kept in the various districts, the facilities for making or obtaining fodders at a reasonable cost, and the methods of feeding, are all of importance. In addition, the possibilities of successfully weathering a season of drought depend upon the individual grazier, and the care and attention he is able or willing to devote to his flock. The methods will depend largely on local conditions, and no one method of feeding nor any single class of fodder can receive universal recommendation, though the number of fodders available for hand-feeding is limited to the crops commonly used in the State. The deciding factors, when it comes to the point of actually feeding the flock are—

1. The fodder available.
2. The cost, including transport and labour.

Anticipatory Measures.

It is possible to reduce the risks connected with the business of sheep-farming in a very material degree by the adoption of methods which are anticipatory of periods of drought, and among these may be mentioned the avoidance of overstocking, the improvement of pastures, the conservation of fodder in the form of ensilage, and the preservation of trees and shrubs suitable for feeding in periods of scarcity.

Avoid Overstocking.—In a good season the growth of herbage is so profuse that stock cannot possibly keep it down: it is trampled underfoot and lies in a tangled mass on the ground. It is not to be wondered at, perhaps, that with a profuse supply of natural fodder the sheep-owner is tempted to purchase more sheep, with the idea of fattening them and sending them to market. Actually he should aim at keeping that number of stock which will enable him at the threat of a dry season to dispose of his wethers and surplus ewes, so that he may have sufficient feed left to carry on with his breeding stock. This must be done before the sheep show signs of loss of condition, and the owner must calculate at the time what sheep he can afford to keep and what will be the probable cost of hand-feeding them. Even if he is unable to obtain what he considers their market value, it is better to lose a little on their value at once than be put to the worry and expense of finding agistment and feed at famine prices, with the probability that in addition a great number will eventually be lost.

The most valuable stock—those that should be saved—are the young breeding ewes, these being the foundation of the future flock. Hence, if it is decided to dispose of any of the stock, the wethers and broken-mouthed ewes should be sold first. Young ewes of fair quality will be valuable after the drought has broken, and will repay the cost of being kept through the bad season.

Permanent Improvement of the Pastures.—Much of the natural herbage has been replaced by weeds that are largely useless for grazing purposes. In some cases the spread of these pests has been alarming, and the question of their eradication and replacement with good, edible herbage is worthy of very serious consideration. This aspect of the question is rarely faced by

* Compiled from an article by W. L. Hindmarsh, B.V.Sc., D.V.H.

the grazier, in spite of the work of the scientific officers of the Department of Agriculture, who constantly urge the trial of various grasses and plants which have been proved to be of exceptional value when planted in many parts of the State.

Ensilage.—The necessity of conserving the natural fodder which makes such abundant growth in the pastures in good seasons has constantly been emphasised by the Department. While most stockowners will agree as to the wisdom of this course, few attempt to put the principle into practice, and forage that would help to carry stock over a dry season is still allowed to go to waste. It is well understood that in some parts, owing to the nature of the ground and herbage, and the presence of fallen timber and stones, it is not possible to use farm machinery to get the crop off. Where it is practicable, however, the farmer should never fail to turn the surplus growth into ensilage, and thus insure himself in the most economical way possible against drought. According to the district and season, prolific growth of trefoil, marshmallow, variegated thistle, crowfoot, and other herbage might well be utilised for the making of silage. Where the sheepowner is in a position to do it, silage can, of course, be made from most of the green crops usually cultivated. Maize, sorghum, lucerne, wheat, oats, and various grasses have all given successful results.

Edible Trees and Shrubs.—Belts of edible shade trees which could be lopped when necessary are not only of importance as emergency fodder, but also act as shelter from the weather both in summer and winter. The sheepowner should do all in his power to encourage the growth of such valuable trees, instead of carelessly cutting them out, as has so frequently been the case in the past.

Some Points in Hand-feeding.

Commence Early.—It is important when a dry spell occurs not to wait until the sheep have lost condition and strength before starting to hand-feed. The weakness of a sheep that has been starved is reflected in all the internal organs, and such an animal is unable to assimilate the nourishment in the food which it ingests. It can easily be understood that there is far more chance of keeping up the condition of a healthy sheep than of one with a constitution already weakened by lack of nourishment. The hand-feeding might be commenced with small amounts while there is yet a little natural food.

Bulk Necessary when Grain is Fed.—Edible scrub, hay, dried grass, leaves, etc., all help to keep active the voluminous digestive organs of ruminants. These organs are accustomed to dealing with large masses of food, and they will not efficiently do their work with small amounts of concentrated fodder. The feeding of grain alone without the addition of some roughage will be attended with disaster. In this connection, the straw, which is held of little account in many wheat districts, would be of inestimable value in drought time for making up the bulk of fodder so necessary to the digestive system of the sheep. The cost of saving it would be amply repaid by the number of sheep kept in health.

Maintain the Health of the Flock.—Where food of a coarse, harsh nature is used—and this applies very particularly to edible scrub—it is necessary to give some laxative in order to prevent impaction of the bowels. The large amount of fibrous matter in these foods, together with lack of water, tends to

the formation of matted masses and balls of indigestible matter in the stomach and intestines. To combat this, molasses, Epsom salts, salt, etc., may be used in solution or as a lick. In purchasing a proprietary lick make certain that it contains no astringent salt, such as sulphate of iron.

When to stop Hand-feeding.—After the first rains have fallen and grass and herbage make their first shoot, hand-feeding should not at once be discontinued. The young green stuff does not contain much nutriment, and it is very laxative in action. The sudden change of diet is liable to cause severe scouring, so that hand-feeding should be continued until the natural food available is able to supply the necessary nutriment. Another reason for continued feeding is that the change of weather often has a detrimental effect on the sheep, and they are liable to be lost if not kept in good heart. Often it will be noted that in spite of their hunger sheep do not take to the young herbage at once. Losses are often heavier after the rain than during the drought, and much of the loss is due to the sudden discontinuance of hand-feeding. These losses are, of course, quite apart from those due to flood waters, or to sheep being cut off from assistance, and are most often noted in lambing ewes.

Mixed Feeds are Advisable.—In hand-feeding no one food is sufficient to keep up the animal's strength. Under normal grazing conditions stock on the selection of a variety of herbage, and in artificial feeding variety should still be provided. To do this a balanced ration—that is, a ration combining all the constituents necessary for the health and natural growth of the body—should be adopted. This is best obtained by the use of grain, combined with some leguminous fodder. Of course, it is understood that these are not always available, or the prices may be prohibitive, and the grazier may be compelled to make what arrangements he can, according to local circumstances. It is also advisable, where it can be carried out, to vary the food so that the sheep may have a change of diet. This is of considerable advantage to the natural economy of the animal's body, and the sheep relish the change and will keep in better strength because of it.

Feeding should be Regular.—Even if the amounts given are only small, feed should be supplied regularly. At first the sheep will need to be mustered, but with regular feeding this soon becomes unnecessary. A little food given daily will produce better results than larger amounts at irregular intervals.

Give Special Attention to Weak Animals.—Arrangements must be made to feed the weaker sheep apart from the remainder of the flock. Under ordinary conditions the stronger and more pugnacious sheep get more feed than the weak. This is especially the case where troughing is used. There should be at least nine inches of troughing to each sheep. If the food is fed from the ground it should be trailed or scattered in such a way as to give all the sheep an equal chance. If necessary, the poorer sheep should be drafted off into a different paddock and fed separately; otherwise they will be robbed of their ration and death will result. Similarly, lambing ewes as they drop their lambs should be placed in a separate paddock, where they will not be hindered by the lambs from obtaining their food. If this is not done the ewes either lose their rations or forsake their lambs in order to get their own food.

The Care of Lambing Ewes.—Lambing ewes should be fed before the time of parturition approaches. In many cases it is not until a week before lambing that it is decided to feed the ewes, but there is just as much

drain on the vitality of the ewe while the foetus is "in utero" as when it is born, and just as much dependence on the mother for nutriment. The ewes should be fed, if it is necessary to feed at all, during the whole period of gestation—not just at the latter end, as is usually the case.

Should the ewes forsake the lambs, special feeding is necessary. If the lambs are allowed to take their chance with the remainder of the flock heavy losses will result. Grain should be boiled or soaked before being fed to such young stock, and care must be taken that it has not soured.

Feed in Small Mobs.—It is recommended that feeding be undertaken in small mobs. There should be never more than 1,000 in each case, while better results will be obtained where the mobs are only 500.

The Water Supply.

The water that sheep receive during a drought depends on the local conditions. It is known to all sheepowners that sheep are fastidious about their water supply; be it tank, river, or bore, they take a liking to it, and will often refuse water from other sources. As the river or tank begins to dry the percentage of vegetation and mineral matter in it increases, and the sheep continue to drink it. If droved to another tank or supply they may refuse to drink for some days, especially if it is clear and free from rubbish.

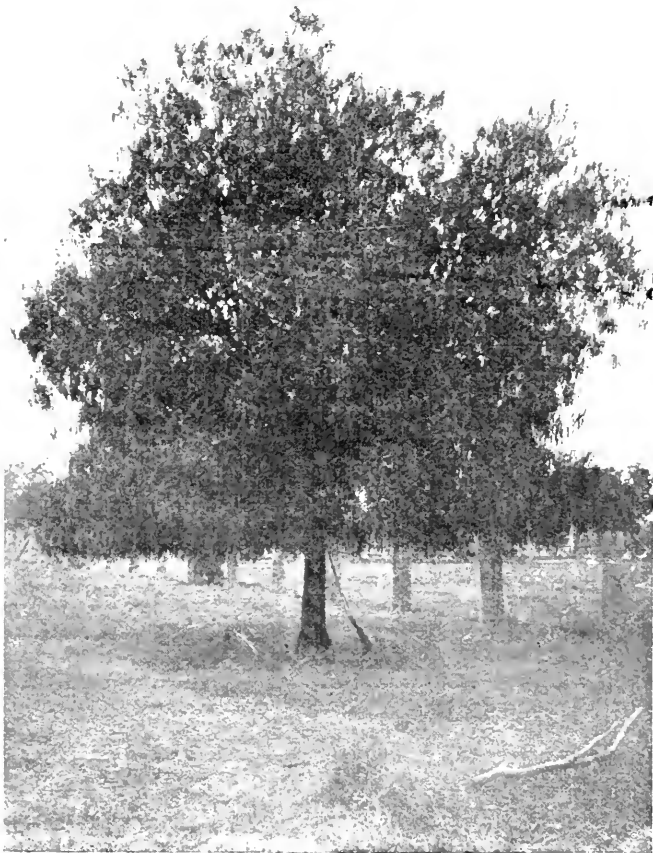
These facts, however, do not affect the general principle that water for stock should be as fresh and pure as possible. Because sheep have taken a liking to a pool of muddy water, full of decaying weeds and vegetation, is no reason why they should be permitted to use it if another and better supply can be obtained. Such water not only contains the impurities referred to, but also enormous numbers of putrefactive bacteria. Owing to shortage of food, the animal's system is already weakened, and these foreign matters irritate the digestive organs and have a far more dangerous effect than in normal seasons.

Watering, at all times and seasons, is far better carried out by troughs. Even in the western districts, it is often possible to sink wells and raise the water with windmills. The water so obtained is in every way preferable to that saved in tanks. It is clean, fresh, and cool, and has not the sediment of mud and dung which is usually present at the open end of a tank where many animals water. In addition, the supply is far more likely to be permanent. The necessity for troughs in sheep paddocks watered by bore drains is not so great, since the sheep have a great length of drain at which to water, and the water is not stagnant. A further advantage of watering from troughs lies in the fact that sheep are less liable to infection from parasitic worms, which danger always exists about open tanks.

Where, however, these tanks are the only supply available, steps should be taken to purify the water which has become foul and heavily charged with decaying vegetation and mineral matter. Water containing much mud may be clarified with lime or alum. If it contains much decaying organic material, it contains as well numerous putrefactive bacteria. At all times this is unsuitable for stock, but in drought times the sheep are more liable to gastro-intestinal derangements, and this at the very time when the water is more heavily charged with harmful bacteria. The purification of such water can be accomplished by the addition of chloride of lime, one part to one million parts of water.

The watering of sheep should be carried out regularly. When fodder is being provided by lopping trees, those within the vicinity of the water supply are certain to be cut out first, and the sheep may presently need to be shepherded from the fodder to the water and *vice versa*. Similarly, it may not be possible to feed artificially on other forage near the water, and in such cases also it may be necessary to shepherd the sheep to and fro. This travelling, provided it is not excessive, is an advantage, as it ensures that the sheep have exercise. Otherwise, the sheep have a tendency to wait about the feeding-ground until the waggons arrive with the daily ration, thus losing the exercise usually obtained when grazing. Travelling the sheep should, of course, be limited to the cooler hours of morning and evening.

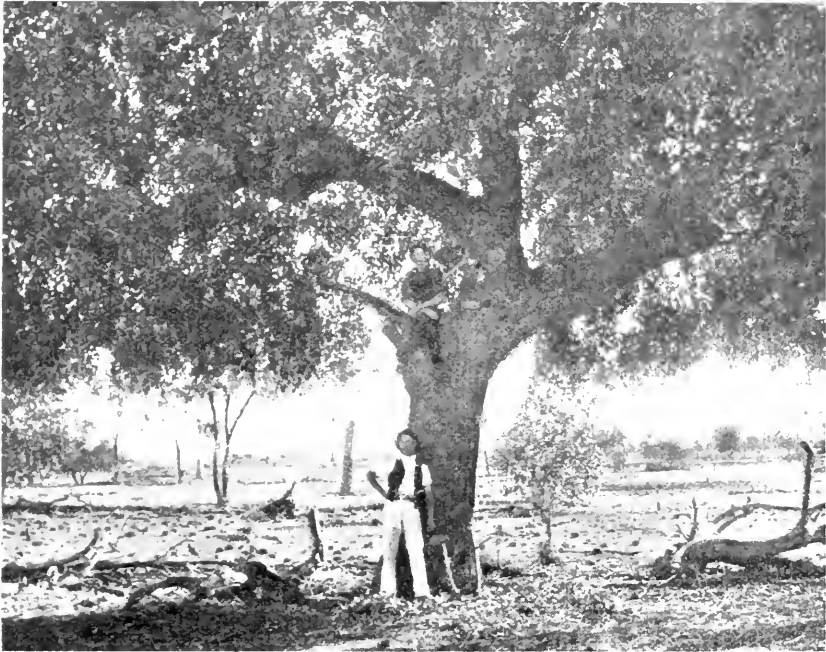
The need for water during the hot months, especially when the sheep are fed on dry feed, is very great, and it should be seen that the sheep have access to water at least twice daily.



Wilga (*Gilgou parvifolia*, Lindl.).

Various Foodstuffs.

Scrub Feeding.—The varieties of native scrub and trees available for feeding stock in drought depend on the districts affected. Probably the best known are kurrajong, wilga, mulga, myall and willow; others not so palatable, but extensively used are apple, box, rosewood, boree, pine, &c. Certain drought-resistant plants, such as saltbush, &c., are not included in this category, since they are the natural sheep food of the western districts. It is a matter of regret, as some stockowners are beginning to realise, that these natural fodders should have been so ruthlessly cut out. Even when being cut for sheep it is noticed that in some cases, instead of being lopped, the trees are felled, thus destroying their future usefulness, not only as food but as shade and shelter.



An old Kurrajong tree before lopping.

It must be borne in mind that these are only emergency fodders. They do not provide a balanced ration, and while alone they may keep up the health of stock for a limited period, eventually condition will be lost and signs of digestive disturbance be noted. In any case they are entirely unsuited to lambing ewes. Their value is much increased by—

- (a) The addition of small amounts of grain daily, say, 4 to 8 oz. per sheep.
- (b) The addition of salt, Epsom salts, and molasses in the form of a lick.

This acts as a corrective, and lessens the liability to impaction of the digestive organs. The proportions might be 1 part Epsom salts, 3 parts Liverpool salt, 4 parts molasses. The amount of Epsom salts might be increased if deemed necessary. Sulphate of iron, although it is recommended as a good tonic in normal seasons, should not be used, as it is an astringent, and increases the liability to constipation.

- (c) Adding a little hay to the above ration. If hay is added even only once or twice a week the stock would resist the adverse conditions more successfully.

It will be noted that in some cases sheep do not relish the scrub when freshly cut, but later, when it is drier, they eat it readily.

Ensilage—Feeding should commence while there is still a little dry feed about, and about 1 lb. should be given daily. This quantity can be increased as required up to 3 lb. per sheep per day, which is sufficient to keep the sheep in condition. Where practicable, the addition of a little grain twice a week is an advantage.

Hay, Chaff, and Straw.—On the whole these do not appear to be favourable as fodders for sheep when used alone. Hay feeding is not economical, as the hay is scattered and trampled into the dust when fed; moreover the initial expense is very great if it is purchased at drought prices. Chaff may be fed from troughs, but it is liable to be blown about and to get into the sheep's eyes unless damped. These fodders are of course preferable to scrub, but on lucerne, oaten or wheaten hay, ewes (even if they keep fair condition) do not secrete sufficient milk to rear their lambs. With the addition of some grain, and damped with brine or molasses and water, better results have been obtained, as in this case the ration contains more nutriment material and the salt and molasses help to correct the constipating effect of a continuous ration of dry food.

Bush hay may be cut and stored from the natural pastures. It is common to see fine crops of native grasses allowed to go to seed and dry up, when with a little labour they could be saved and stored. While such hay is not so satisfactory as ensilage (which contains much of the original moisture), it would nevertheless be the means of saving stock during a dry season.

Straw is a food that is much neglected in our wheat-growing districts; while its nutritive qualities cannot be compared with those of hay, its value is very great as an emergency fodder. Even though straw that is not stored performs a useful service if it is returned to the soil, it must be urged that if some of it were saved it would be of incalculable value to the sheep in time of drought. Soaked in or sprinkled with molasses and water, straw will readily be taken by sheep. Where possible the straw should be steamed immediately before using to make it more palatable. Grain is a necessity with any hay or straw if the sheep are to be kept in condition.

Grain.—Grain food has many advantages, possibly the most important being that it is concentrated and is easy of transport; but as already pointed out, grain alone is not a good fodder unless the stock can pick up some roughage to make up the bulk of the food. Generally speaking, maize has given the best results; as a drought food it is superior to other grain. Four ounces daily appears to be a usual ration per sheep, but this is rather small, and 8 oz. daily is much to be preferred.

The question of crushing or soaking the maize is also worthy of attention. A healthy adult sheep should be quite capable of masticating the grain without treatment, but where the sheep are young or poor it is advisable to soak the grain so that it may be more easily assimilated. The disadvantage of soaking is that if fed from the ground the dust and dirt adheres to the grain and is ingested. To some extent this may be overcome by soaking in a limited amount of water, so that all the moisture is absorbed. Soaked grain should be fed at once, as it will become sour if kept for any length of time. If it is desired to break the maize it should only be cracked—not ground.

With wheat, as with maize, some roughage is required. The results are by no means so good as with maize, and there is always the danger of the sheep picking up earth and sand with the grain. Soaking the wheat beforehand is not an advantage, unless some medicament (salt, molasses, &c.) is added to the water. It is not so nutritive for sheep as maize and is less economical.

Experience with oats and barley is somewhat similar to that with wheat. Barley, however, is hard to masticate, and should be crushed before using.

Other Foods.—Various other foods that may be obtainable locally can be used during drought. Pumpkins and melons contain a large percentage of water, and, of the two, pumpkins are to be preferred. About $2\frac{1}{2}$ tons of pumpkins are reported to be equal in nutritive value to 1 ton of maize ensilage. The vines when green are good food, but when dry they are very



The same tree after lopping.

liable to cause death from impaction of the bowels. Pickling onions, cabbages, and potatoes (they should not constitute more than one-half of the ration), and mangolds and turnips, can also be used. Bran and pollard are usually too expensive to use for sheep, and (owing to the improvements in milling machinery) they do not contain much nourishment. They are, however, useful when mixed with other foods, since they both contain a large percentage of crude protein matter. Linseed has always been recognised as a splendid stock food when used judiciously, and cake broken up to pieces about the size of an almond (known as "nuts") and supplied to sheep at the rate of about 3 ounces of these per sheep per day, fed by broadcasting as an additional ration, is useful in keeping sheep in good condition.

SECTION XIII.

Weeds on the Farm.*

IMMEDIATELY a plant gets out of control it becomes a weed, even though under different circumstances it may be an harmless or even a useful species. The uncertainty of the conditions that may develop a plant of comparatively harmless characteristics or occasional occurrence into a pest that it is almost impossible to control, makes it necessary for the farmer to be in a position to recognise the more common of those species of plants usually termed weeds.

Not only is this necessary, but it is also important for him to have a knowledge in a general way of the means by which his property may become infested, and in the event of it becoming so, of the most likely methods of effecting extermination or control.

In this country of wide, imperfectly occupied areas, with special liability to attack by new weeds from the four quarters of the world, a moral obligation attaches to every citizen to do what he can to check the weed menace, and he should bear in mind that the expenditure of a shilling in tackling a weed when first observed, may perhaps be more efficacious than one hundred pounds the following year. Every plant that makes its appearance in a district should be viewed with suspicion, and unless the finder knows what it is, he should pull up one by the roots and address it to The Director, Botanic Gardens, Sydney. Whether the weed be harmless or not, it is desirable that the local Town Clerk or Shire Clerk be informed, in order that the proper municipal or shire officer may keep an eye on the intruder, and, if necessary, approach the local body with the view of suitable action being taken under the authority of the Local Government Department.

The Harmful Effects of Weeds.

As a pest of farm crops it may be briefly stated that weeds rob the crop of soil moisture and of plant-food, harbour insect pests and diseases, and when harvested with the crop detract from its market value.

From a stock-raising aspect, the poisonous properties of certain species, the effect of the seeds of other sorts on the mouths and even the skins and wool of animals, and the indigestible nature of the foliage of yet other species, make their control, and, if possible, their extermination, a necessary part of farm practice.

How Weeds are Distributed.

Many species of weeds seem to be fitted with devices specially designed to enable the distribution and reproduction of the type in the face of much opposition. Some (such as the thistles) have parachute arrangements on the seeds, others hairs, others again wing-like structures, all of which enable the seed to be distributed over a very large area by the wind. Some seeds are so small that they are carried by the wind without any of these helps, and yet others have seeds that are rolled along the ground for considerable distances by the wind.

Floods, adhesion to the coats and feet of animals, manure, unclean seed, and birds, are some of the many means by which seeds of weeds can be taken from an infested to a clean area.

* Condensed from various sources, especially "The Weeds of New South Wales," by J. H. Maiden, I.S.O., F.R.S., F.L.S., Government Botanist, Sydney, from which also are taken the illustrations in this section.

Weed seeds, too, are remarkable for their hardness and vitality, being capable of germination under conditions that would not suit more useful species of plants, and in many cases they are capable of remaining dormant in the soil for long periods—to germinate when more favourable conditions result from cultural or other action.

Prevention and Control.

When a weed has become firmly established, it may be a very difficult—almost an impossible—task to eradicate it, and thus methods of preventing the introduction, or in any case of eradicating the pest in the very early stages of development, are most important considerations.

Cheap seed is often very dirty; there is no economy in buying seed that can be sold cheaply because it has been hurriedly collected or taken from paddocks infested with weeds. All seed, without exception, should be screened.

As means of control the following suggestions are made, and farmers can adapt them to their needs in accordance with the severity of the infestation and the means at their disposal.

1. *Preventing the Weeds from Seeding.*—Many weeds are of an annual character, and the systematic removal or destruction of the flower head before the seed is formed prevents the survival of the weed till next season. A number of species, however, are perennials possessed of bulbous rootstocks, or fleshy or woody roots that could not be effectively handled in this way; but the continuous removal of the top growth during the growing season has a wearing down effect on even the hardiest plant. Without leaf growth the root must die, and by an aggressive policy of persistent cutting, control of these types may sometimes be effected.

In some very obstinate cases (as for example, Johnson grass) it is advisable to worry, not only the top-growth, but the roots also, and to call in the assistance of the hot sun and drying winds by continuous exposure of the roots.

2. *Killing the Seedlings.*—In the life of all plants, the seedling stage is the most delicate, and though some species of weeds are exceedingly hard to destroy even in that stage, more success can be achieved in the control if they are attacked early than if they are allowed to mature.

3. *Enforced Germination.*—The practice of inducing weed seeds to germinate by cultivation before the sowing of the main crop, has proved a useful means of controlling certain species of weeds that are commonly found associated with particular crops. Such a weed as the wild oat can be handled in this manner as described in the Wheat Section of this Handbook (see page 248).

4. *Grazing-off.*—The depasturing of sheep on the crop of herbage that is produced on the stubbles is recognised as sound practice on sheep and wheat farms. It not only turns into wool and mutton the young and succulent weed growth, but it prevents the undue reproduction of the weeds and is a useful method of maintaining the humus content of the soil.

5. *Rotation of Crops.*—Certain species of weeds are continuously associated with a particular crop, mainly by reason of the fact that the cultural operations in regard to that crop are such as to allow an amount of leniency to the weed. A rotation of crops, besides being good practice from other points of view, can be made to control these weeds if a crop is introduced which, by its cultural requirements, results in conditions unfavourable to the growth of the weed.

6. *Smothering Crops*.—The growth of a crop that by reason of its dense foliage excludes light and air from the surrounding soil, either in rotation with or in combination with the main crop, is a measure often adopted for the control of weeds. Green manure crops can sometimes be put to this use in addition to their normal function.

The application of artificial nitrogenous fertilisers to a weed infested stand of a fodder crop such as lucerne often results in such a vigorous growth as to smother and crowd out the weeds.

7. *Drainage*.—Species of weeds that are common to low-lying areas are found to disappear when an infested area is drained and put to more profitable use by being sown to a useful crop.

8. *Chemical Exterminators*.—There are a number of chemical substances which are injurious to plant growth and which may under some circumstances be applied to the destruction of weeds, but under general conditions the cost of their purchase and application is too great for their use on large areas.

Proclaimed Weeds in New South Wales.

The following is a list of plants declared to be noxious in various Shires and Municipalities in New South Wales, up to 31st July, 1922:—

Plants declared to be noxious.		No. of Municipalities.	No. of Shires.
Scientific name.	Common name.		
<i>Ailanthus glandulosa</i> ...	Tree of Heaven	3	.....
<i>Alternanthera achryantha</i> ...	Khaki Weed	9	9
<i>Amaranthus paniculatus</i> ...	Wild Amaranth or Prince of Wales' Feather.	6	.....
<i>Amaranthus viridis</i> ...	Fat Hen or Pigweed	4	.....
<i>Ambrosia artemisiifolia</i> ...	Roman Wormwood or Dunbible Weed.	1	2
<i>Amsinckia intermedia</i> ...	Yellow Burr Weed	3	6
<i>Anthemis cotula</i> ...	Wild Chamomile	2	.....
<i>Arymona mexicana</i> ...	Mexican Poppy or Binneguy Thistle	19	32
<i>Asclepias physiocarpa</i> ...	Wild Cotton	3	2
<i>Bassia quinquecupis</i> ...	Roly Poly	4	.....
<i>Boussingaultia basseloides</i> ...	Lambs' Tails	2	.....
<i>Bursaria spinosa</i> ...	Blackthorn or Native Boxthorn ...	8	1
<i>Carduus lanceolatus</i> ...	Black Thistle, Scotch Thistle (so-called), or Spear Thistle.	60	9
<i>Carduus marianus</i> ...	Variiegated Thistle or Milk Thistle ...	11	1
<i>Carduus pycnocephalus</i> ...	Slender Thistle	7	2
<i>Carthamus lanatus</i> ...	Saffron Thistle	23	33
<i>Carthamus tinctorius</i> ...	Saffron Thistle	12	14
<i>Cassia Sophia</i> ...	Yellow Pea	3	4
<i>Cenchrus tribuloides</i> ...	Burr Grass ... ..	.....	1
<i>Centaurea calcitrapa</i> ...	Star Thistle	55	56
<i>Centaurea melitensis</i> ...	Cocksbur	7	12
<i>Centaurea solstitialis</i> ...	St. Barnaby's Thistle	4	2
<i>Chenopodium album</i> ...	Fat Hen or Goose Foot	12	1
<i>Chrysanthemum segetum</i> ...	Wild Marigold	4	.....
<i>Conium maculatum</i> ...	Hemlock	5	4
<i>Cryptostemma calendulaceum</i> ...	Cape Weed	30	17
<i>Cucumis pepriocarpus</i> ...	Musk Melon or Paddy Melon ...	5	5
<i>Cuscuta</i> spp. ...	Dodder	1	1
<i>Cytisus scoparius</i> ...	English Broom	3	1
<i>Datura Stramonium</i> ...	False Castor Oil Plant, Thorn Apple, Green Stem or Purple Stem Thorn Apple.	50	17
<i>Echium plantaginicum</i> ...	Paterson's Curse or Blue Weed ...	32	64

LIST OF PLANTS DECLARED TO BE NOXIOUS, &c.—*continued*.

Plants declared to be noxious.		No. of Municipalities.	No. of Shires.
Scientific name.	Common name.		
<i>Eichhornia speciosa</i>	Water Hyacinth	11	19
<i>Emic australis</i>	Cat's Head	12	10
<i>Erigeron canadensis</i>	Fleabane	7	.....
<i>Erigeron tinifolius</i>	Cobbler's Pegs	11	.....
<i>Gilia squarrosa</i>	Californian Stink Weed or Sheep Weed	4	2
<i>Hemizonia pungens</i>	Chinese Burr	1	.....
<i>Honoria collina</i>	Cape Tulip	9	11
<i>Hypericum perforatum</i>	St. John's Wort	17	34
<i>Isola granulata</i>	Stinkwort	30	56
<i>Kunzea corifolia</i>	Tea Tree	1	.....
<i>Lantana camara</i>	Lantana	33	28
<i>Lepidium draba</i>	Hoary Cress	1	.....
<i>Lepidium ruderale</i>	Wild Cress	2	.....
<i>Linaria latina</i>	Blanket Weed	3	4
<i>Lithospermum arvense</i>	Corn Gromwell	1	1
<i>Lycium barbarum</i>	Barbary Box Thorn	5	10
<i>Lycium chinense</i>	Chinese Box Thorn	5	.....
<i>Macrozamia spiralis</i>	Burrawang or Wild Pine Apple	2	1
<i>Marrubium vulgare</i>	Horehound	12	3
<i>Martynia proboscidea</i>	Devil's Claw	2	9
<i>Myriophyllum</i>	Thread of Life	4	7
<i>Nicotiana glauca</i>	Tree Tobacco	5	17
<i>Oenothera oderata</i>	Evening Primrose ... ..	.....	1
<i>Olearia ciscidula</i>	Viscid Aster	2	2
<i>Onopordon acanthium</i>	Scotch Thistle, or Heraldic or Common Thistle.	23	4
<i>Ostrospermum moniliferum</i>	(None)	2	.....
<i>Paspalum</i>	Paspalum	1	.....
<i>Phytolacca octandra</i>	Red Ink Plant or Dye Berry	22	5
<i>Pinelea paniciflora</i>	Serub Kurrajong ... ..	.....	2
<i>Polygonum hydropiper</i>	Smart Weed	4	1
<i>Reseda luteola</i>	"Weld" or Dyer's Weed	2	3
<i>Ricinus communis</i>	Castor Oil Plant	19	8
<i>Rosa rubiginosa</i>	Sweet Briar	40	54
<i>Rubus fruticosus</i>	Blackberry	65	66
<i>Rumex spp.</i>	Docks	11	1
<i>Rumex crispus</i>	Curled Dock	19	.....
<i>Salsola kali</i>	Saltwort	3	.....
<i>Scolymus maculata</i>	Spotted, Golden or Californian Thistle	5	1
<i>Sida rhombifolia</i>	Sida retusa, Paddy's Lucerne or Queensland Hemp.	21	2
<i>Solanum cinereum</i>	Narrawa Burr	12	14
<i>Solanum nigrum</i>	Wild Black Currant	4	.....
<i>Solanum rostratum</i>	Buffalo Burr ... ..	.....	1
<i>Solanum sodomianum</i>	Apple of Sodom	3	.....
<i>Solanum verbascifolium</i>	Wild Tobacco Tree	4	6
<i>Spartium junceum</i>	Yellow Broom	2	.....
<i>Swainsona galioifolia</i>	Indigo	1	5
<i>Taraxacum glandulifera</i>	Stinking Roger	1	.....
<i>Tribulus terrestris</i>	Caltrops	4	1
<i>Ulex europaeus</i>	Gorse or Furze	6	3
<i>Verbascum thapsus</i>	Great Mullein or Shepherd's Blanket	1	1
<i>Verbena bonariensis</i>	Purple Top	11	6
<i>Verbena venosa</i>	Wild Verbena	4	6
<i>Watsonia angusta</i>	Watsonia	1	1
<i>Xanthium spinosum</i>	Bathurst Burr	*	*
<i>Xanthium strumarium</i>	Neogoora Burr	*	*

*Declared noxious throughout the whole State.

SOME OF THE WORST WEEDS.

The best guide to the relative importance of the weed pests of the State is the number of shires and municipalities in which each weed is declared noxious. The following descriptions and illustrations deal with a number of those which are proclaimed by a large number of local bodies.

Bathurst Burr (*Xanthium spinosum* Linn.).

The Bathurst burr is a much-branched annual shrub, 1 to 3 feet high, and very spinous. The fruit is nearly egg-shaped and covered with hooked prickles, which readily attach it to the hides and fleeces of animals and the clothes of man. The presence of burr greatly detracts from the value of wool.

Eradication is almost impossible, but by preventing the plants from maturing seed by cutting in spring and summer, and by burning to destroy seeds as soon as the plants are dry enough, a measure of control can be effected.

The Bathurst burr is a proclaimed weed throughout the whole State of New South Wales.

True Star Thistle (*Centaurea calcitropa* Linn.).

A weak-stemmed, crawling, scrambling plant with small pink or purple thistle-like flowers. It forms masses 2 or 3 feet high and more than that in diameter. The prickly leaves and flowers are sufficiently formidable to cause it to be handled very carefully. Its spreading habit protects the main stem, so that it is not easy to get at the root for the purpose of destroying the plant.

Being an annual, the star thistle should be destroyed when just coming into flower; it can be ploughed in if abundant. It bears an enormous quantity of seeds, which are wafted about by the wind.

The list of shires and municipalities in which this pest has been proclaimed is as follows:—

SHIRES.

Abercrombie	Dalgety	Macintyre	Talbragar
Adjungbilly	Sumaresq	Macquarie	Tallaganda
Amaroo	Gadara	Mandawa	Tamarang
Bannockburn	Gilgandra	Marthaguy	Teaterfield
Barraba	Goobang	Mitchell	Terania
Berrigan	Goodradigbee	Mulwaree	Tindrebongie
Bibbenluke	Gostwyck	Mumbulla	Tumbarumba
Bland	Gundurimba	Murray	Tweed
Blaxland	Gunning	Murrumbidgee	Wakool
Canobolas	Gwydir	Murrungal	Wallarobba
Carrathool	Hume	Narraburra	Waradgery
Cobbora	Jindalee	Nepean	Waugoola
Cockburn	Kyogle	Oberon	Wingadee
Coolamon	Lachlan	Patrick Plains	Wollondilly
Cooten	Liverpool Plains	Peel	Woodburn
Crookwell	Lockhart	Rylstone	Yarrowlumla
Culcairn	Lyndhurst		



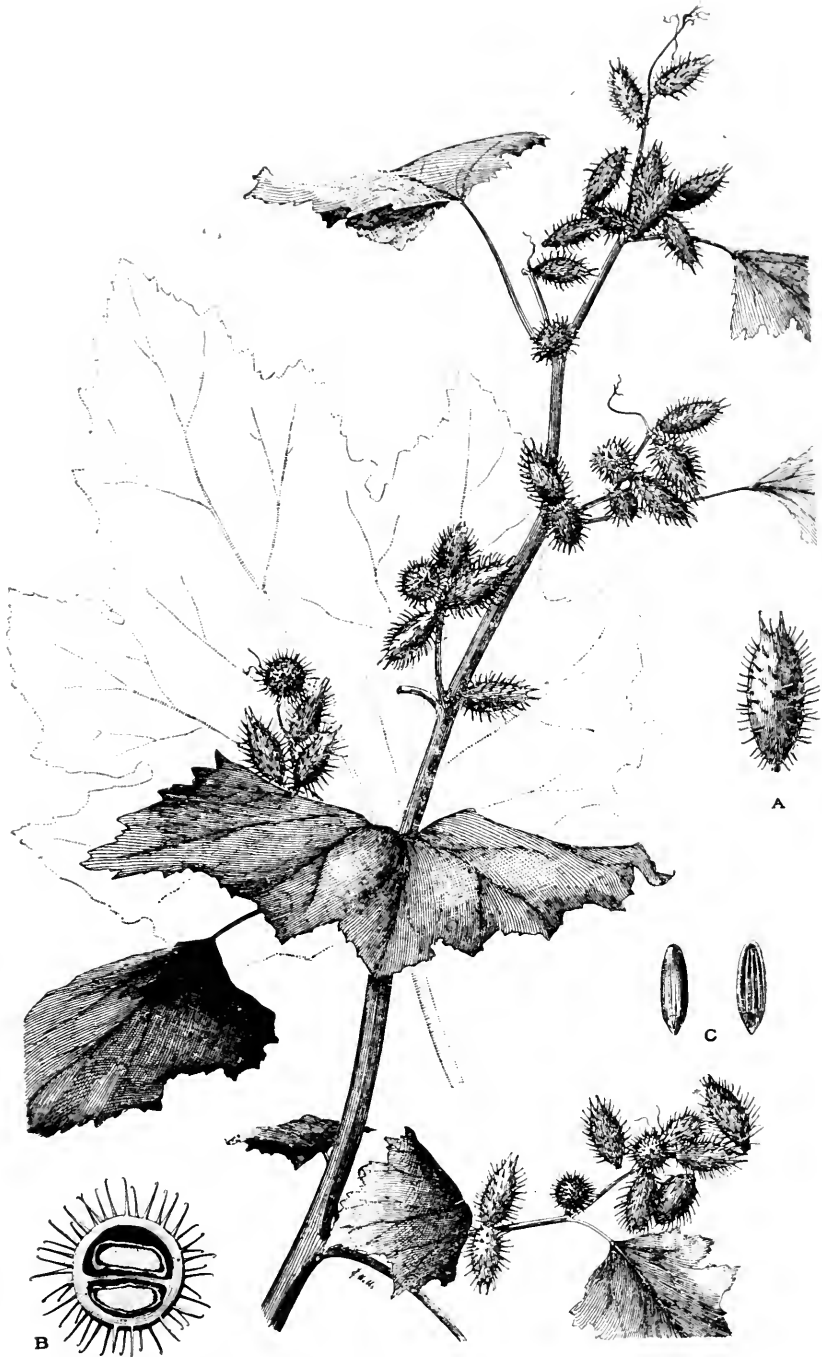
Bathurst Burr (*Xanthium spinosum* Linn.).

A. Fruiting head (Burr), covered with prickles (enlarged).
 B and C. Leaf, showing also the strong trifid spines (both natural size).



True Star Thistle (*Centaurea calcitrapa* Linn.).

A. One of the individual flowers of which the "head" is composed.
 B. A "head" or thistle, in fruit, showing the formidable involucre bracts.
 C and D. Two extreme forms of involucre bracts. E. Seeds.



Noogoora or Cockie Burr (*Xanthium strumarium* Linn.).

A. Fruit (burr). v. Transverse section of fruit. c. Convex and flat (furrowed) sides of seed.

MUNICIPALITIES.

Albury	Cootamundra	Lane Cove	Quirindi
Ashfield	Coraki	Lidcombe	Richmond
Balmain	Corowa	Lismore	Tamworth
Barraba	Cowra	Maitland, West	Temora
Bathurst	Cudgegong	Manilla	Tenterfield
Bingara	Dubbo	Molong	Tunut
Botany	Goulburn	Mullumbimby	Wagga Wagga
Braidwood	Enfield	Murrumburrah	Walcha
Burrowa	Forbes	Marwillumbah	Willoughby
Burwood	Granville	Orange	Windsor
Carcoar	Grenfell	Parramatta	Wyalong
Concord	Hay	Penrith	Yass
Cooma	Inverell	Picton	Young
Coomamble	Junee	Queanbeyan	

Noogoora Burr (*Xanthium strumarium* Linn.).

This plant, which is sometimes called Cackle burr, grows very much like a castor-oil plant when young; it attains a height of 5 or 6 feet, and has spreading branches which cover an area 5 or 6 feet in diameter. Its control should be attempted in the same manner as Bathurst burr. Hoven in animals is sometimes attributed to their feeding on young growth of this weed, though it is doubtful if it is actually poisonous as is sometimes suggested.

It has been proscribed throughout the whole of the State.

Blue Weed or Paterson's Curse (*Echium plantagineum* Linn.).

That Paterson's Curse produces some feed is undoubted, but it is a smothering, rough, coarse plant that chokes out all other grass and vegetation. On good soil it reaches a height of 5 feet, and may stool considerably, but where it is very thick, each plant is usually limited to one flower-head and to a height of 1 to 3 feet.

It should be destroyed before it flowers, and stocking heavily with sheep several times during the growing season has been found of use in this direction.

The following is a list of shires and municipalities in which this plant has been proclaimed noxious:—

SHIRES.

Abercrombie	Carrathool	Culcairn	Gwydir
Apsley	Cessnock	Dalgety	Holbrook
Bannockburn	Cobbora	Demondrille	Hume
Berrigan	Cockburn	Gadara	Illabo
Bland	Conargo	Gilgandra	Jemalong
Blaxland	Coolamon	Gloucester	Jindalee
Bogan	Coreeu	Goobang	Kyeambah
Boree	Crookwell	Gostwyck	Lachlan



"Blue Weed," or "Paterson's Curse" (*Echium plantagineum* Linn.).

A. Inflorescence. B. Corolla split and opened out. C. Ovary with style.

SHIRES—*continued.*

Lockhart	Mumbulla	Rylstone	Waugoola
Lyndhurst	Murray	Tamarang	Weddin
Macintyre	Murrumbidgee	Timbreeongie	Windouran
Macquarie	Murrungal	Tumbarumba	Wingadee
Mandowā	Narraburra	Turon	Urana
Marthaguy	Nundle	Wakool	Yanko
Mitchell	Oberon	Waradgerly	Yallaroi
Mulwaree	Peel	Warrah	Yarrowlunla

MUNICIPALITIES.

Aberdeen	Cowra	Manilla	Tumut
Albury	Granville	Murrumburrah	Wagga Wagga
Bingara	Gundagai	Muswellbrook	Walcha
Burrowa	Hay	Narrandera	Wallendbeen
Concord	Inverell	Parkes	Willoughby
Cooma	Junee	Quirindi	Wyalong
Cootamundra	Lane Cove	Tamworth	Young.
Corowa	Lidcombe	Temora	

Black or Spear Thistle (*Carduus lanceolatus* Linn.).

This plant is often known as Green thistle, but is usually confused with the Scotch thistle, from which it differs in some measure. It attains a height of 3 or 4 feet, and is very prickly; the seeds are greyish, striped, smooth and shiny. The Spear thistle is a biennial and is best controlled by cutting the first year plants below the crown of the root and mowing or cutting down second year plants before they seed. The seeds are light and are blown about from infested to clean areas.

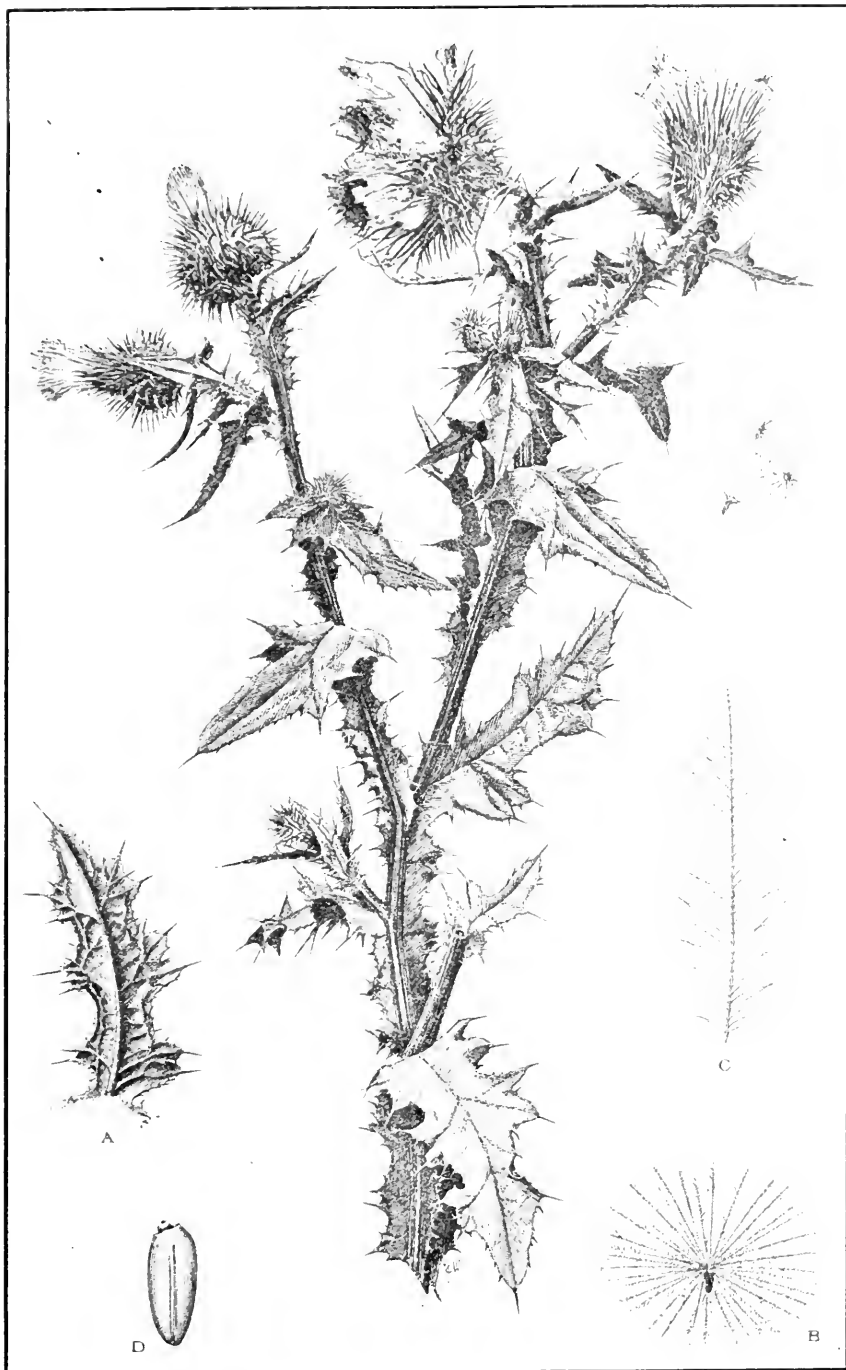
As showing what a pest this weed is considered, it has been proclaimed noxious by the following:—

SHIRES.

Bolwarra	Harwood	Nymboida	Port Stephens
Bulli	Macleay	Orara	Tarro.
Copmanhurst			

MUNICIPALITIES.

Aberdeen	Dubbo	Lidcombe	Parramatta
Adamstown	Enfield	Maclean	Quirindi
Alexandria	Glebe	Manilla	Randwick
Annandale	Glen Innes	Manly	Richmond
Armidale	Goulburn	Maitland, East	Stockton
Ashfield	Grafton	Maitland, West	Tamworth
Balmain	Grafton, South	Mascot	Temora
Barraba	Granville	Merewether	Tenterfield
Bathurst	Greta	Molong	Ulladulla
Bega	Hamilton	Mosman	Ulmara
Botany	Homebush	Moss Vale	Uralla
Barwood	Hunter's Hill	Muswellbrook	Walcha
Carcoar	Kiama	New Lambton	Willoughby
Concord	Lambton	North Sydney	Windsor
Drummoyne	Lane Cove	Orange	Yass.



Black or Spear Thistle (*Carduus lanceolatus* Linn.).

A. Under side of a leaf, showing venation (three-fifths natural size).

C. Individual bristle of the pappus (magnified).

B. Pappus, natural size.

D. Fruit (magnified).

Stinkwort (*Inula graveolens* Desf.).

As its name implies, this plant has a nasty smell, which is noticeable also in the milk of cows, and even the mutton of sheep depastured on it for some time; though stock do not eat it readily. It is a straight stemmed plant of a nice green colour, and has small yellow flowers. Methods of eradication must be started in the early stages of infestation to be effective, and they must consist of pulling up or hoeing out.

Following is the list of shires and municipalities that have proclaimed the weed:—

SHIRES.

Adjungbilly	Dalgety	Lachlan	Timbreeongie
Bannockburn	Demondrille	Liverpool Plains	Trundle
Berrigan	Gadara	Loekhart	Tumbarumba
Bland	Gilgandra	Macintyre	Urana
Bogan	Goobang	Mandowa	Wakool
Boree	Goodradigbee	Marthagny	Waradgery
Burrowa	Gostwyck	Mitchell	Warrah
Carrathool	Gunning	Mulwaree	Wangoola
Cockburn	Gwydir	Murray	Weddin
Conargo	Holbrook	Murrungal	Windouran
Coolamon	Illabo	Namoi	Wingadee
Coreen	Jemalong	Narraburra	Wollondilly
Crookwell	Jindalee	Peel	Yanko
Culeairn	Kyeamba	Tamarang	Yarrowlumla.

MUNICIPALITIES.

Albury	Granville	Murrumburrah	Wagga Wagga
Balranald	Grenfell	Narrandera	Walcha
Braidwood	Hay	Parkes	Wallendbeen
Concord	Junee	Parramatta	Willoughby
Cootamundra	Lane Cove	Pieton	Wyalong
Corowa	Lidcombe	Quirindi	Yass.
Cowra	Manilla	Tamworth	
Cudgegong	Moama	Temora	

Saffron or False Star Thistle (*Carthamus lanatus* Linn.).

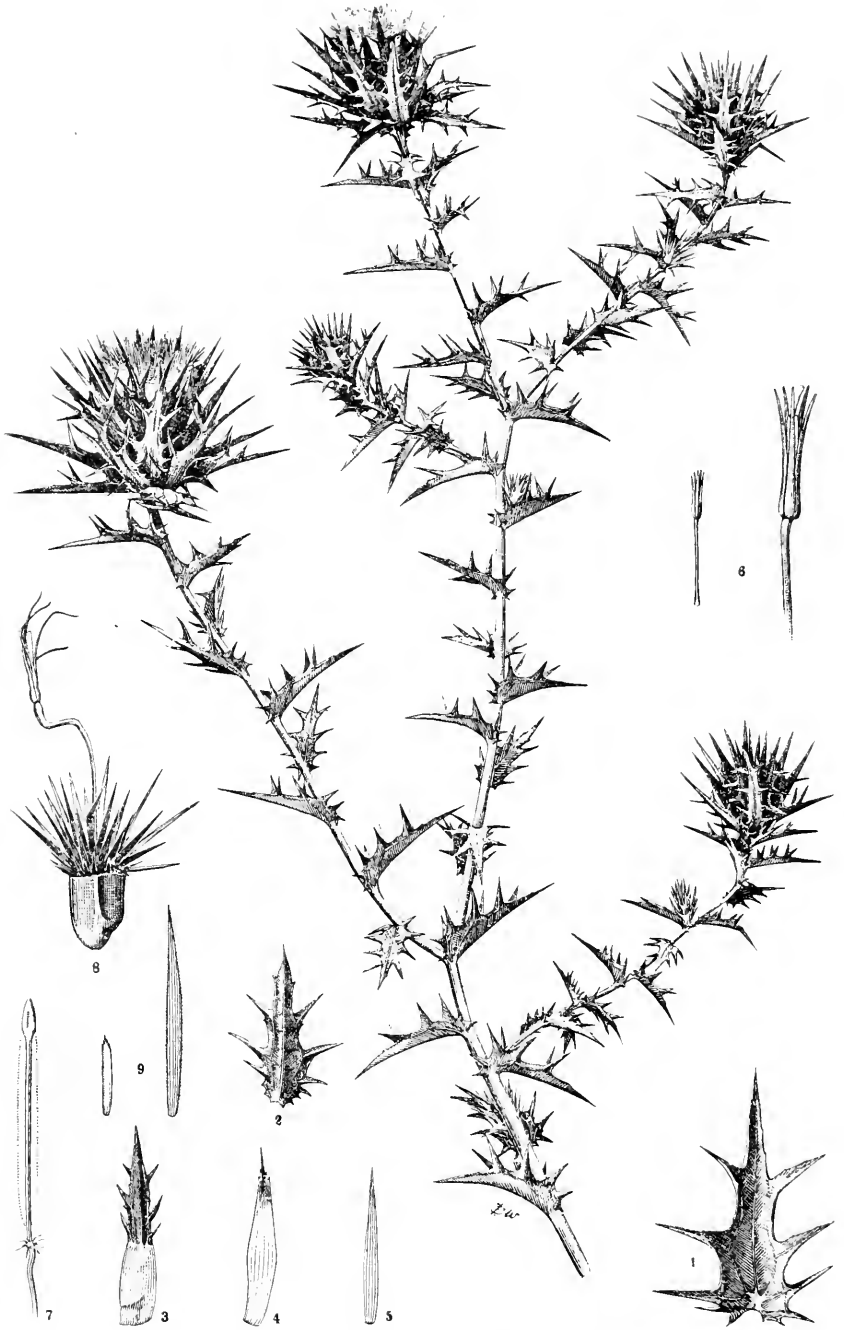
This weed is often called Star thistle, though it must be distinguished from the True Star thistle (see page 808), and it is known by the name of Chinese thistle in other districts. It is a prickly plant that grows in bushy masses and attains a height of 2 or 3 feet. The flowers are yellow and are surrounded by prickly clasping leaves, almost the same shape as those that clasp the stem. The stem is a little furrowed, and usually more or less silvery in appearance. The plant, particularly the upper portion of it, is more or less thinly-woolly, or spider-webby.

Cutting before the seed matures and burning when sufficiently dry is the only method of keeping it in control: the seeds are light and are blown about by the wind.



Stinkwort (*Lula gracilens* Desf.).

- A. Lower leaf, oblong-lanceolate and sub-dentate. E. Upper leaf, entire and nearly linear.
 C. Portion of flowering twig. D. Flower-head, passing into fruit. F. Receptacle, showing
 concave depressions and radiating bracts. F. Seed with pappus.



Saffron or False Star Thistle (*Carthamus lanatus* Linn.).

1. Stem-clasping leaf. 2, 3, 4, 5. All stages, from a floral leaf to a bract. 6. Individual florets.
 7. Anther showing bristly appearance at upper part of filament. 8. Fruit, crowned with the
 pappus and the remains of a floret. 9. Extreme forms of the scales of the pappus.

It is proclaimed in the following local government areas :—

SHIRES.

Abercrombie	Crookwell	Macquarie	Tumbarumba
Berrigan	Calcairn	Mulwaree	Wakool
Bland	Dalgety	Mumbulla	Waradgery
Blaxland	Gadara	Murray	Wangoola
Canobolas	Gilgandra	Murrumbidgee	Windouran
Carrathool	Goodradigbee	Murrungal	Yarrowlunda.
Cobbora	Gunning	Patrick Plains	
Coolamon	Inlay	Rylstone	
Corren	Lyndhurst	Talbragar	

MUNICIPALITIES.

Barraba	Drummoyne	Narrandera	Tumut
Blayney	Glen Innes	Orange	Willoughby
Braidwood	Hay	Parramatta	Wyalong
Burrowa	Lidcombe	Randwick	Yass
Camden	Manilla	Tamworth	Young.
Cowra	Moama	Temora	

Mexican Poppy (*Argemone mexicana* Linn.).

A rather tall prickly plant with large yellow flowers; sometimes known as Prickly Poppy, Blue Thistle, White Thistle, Yellow Poppy, or Binnequy Thistle. Stock do not eat it under any circumstances and it is thus a very hard weed to control. It seems to grow all the year round and not to be affected by seasonal conditions; it inhabits all classes of land and is common on waste areas.

Disc ploughing before the seed matures has been found an effective control, but this is not always possible.

It has been proclaimed in New South Wales by the following shires and municipalities :—

SHIRES.

Abercrombie	Cobbora	Lachlan	Timbreeongie
Bland	Cockburn	Liverpool Plains	Turon
Bogan	Coolamon	Marthaguy	Walgett
Bolwarra	Coonabarabran	Mitchell	Waradgery
Boomi	Eurobodalla	Namoi	Weddin
Burrangong	Gilgandra	Peel	Wingadee
Canoblas	Goobang	Talbragar	Yanko.
Carrathool	Kyogle	Tamaring	

MUNICIPALITIES.

Aberdeen	Dubbo	Maitland, West	Nyngan
Barraba	Grenfell	Manilla	Penrith
Brewarrina	Hay	Murrumburrah	Tamworth
Coonambie	Junee	Narrandera	Wallendbeen.
Cowra	Lidcombe	Newcastle	

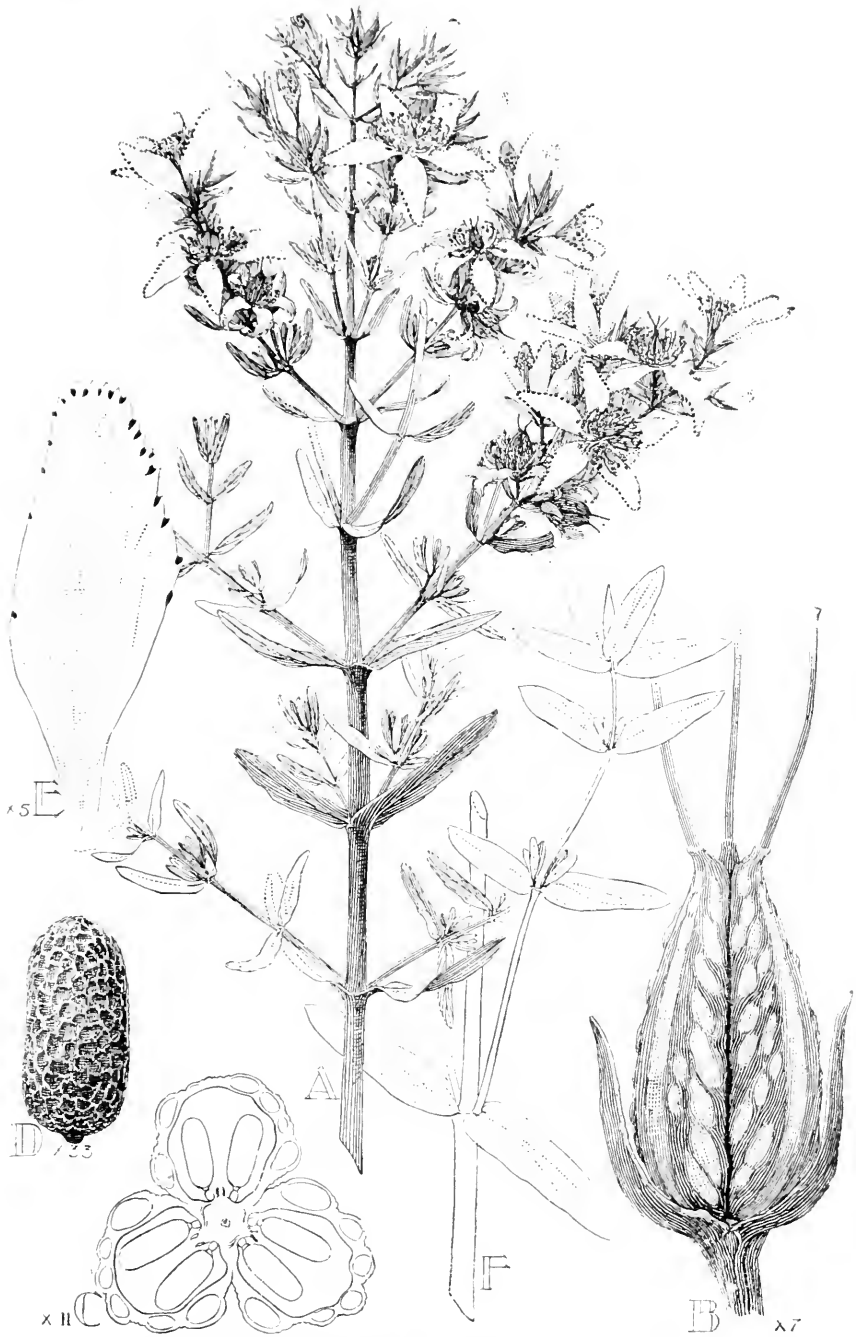
St. John's Wort (*Hypericum perforatum* Linn.).

This plant is most easily recognised by the oil-glands on the leaf. These can be seen when it is held against the light, giving the leaf a perforated appearance. The oil-dots pervade the whole plant, and are mixed with fewer dark-purple, opaque dots, especially on the flower, where the dark dots are frequently crowded along the margin of the petals, as shown in the illustration. The plant is erect, 1 to 3 feet high, with large yellow flowers; the under side of the leaves is a paler green than the upper surface.



Mexican Poppy (*Argemone mexicana* Linn.).

A. Open capsule. B. Ovary (sepals, petals and stamens removed). C. Arrangement of the stamens round the ovary. D. The pitted seeds.



St. John's Wort (*Hypericum perforatum* Linn.).

A. Flowering stem. B. Fruit, consisting of 3 carpels. Part of the calyx removed. C. Horizontal section through ovary, showing the attachment of the seeds and the large oil-glands. D. Seed, with reticulate testa. E. Petal, showing the dark oil-glands. F. Part of the stem. (Flowers yellow.)

The following is the list of shires and municipalities in which the pest has been proclaimed :—

SHIRES.

Abererombie	Culcairn	Illabo	Narraburra
Adjungbilly	Dalgety	Jemalong	Rylstone
Bannockburn	Demondrille	Jindalee	Tumbarumba
Bland	Gadara	Kyeamba	(Mitchell)
Blaxland	Goobang	Lachlan	Waugoola
Burrangong	Goodradigbee	Macintyre	Weddin
Canoblas	Gwydir	Marthaguy	Yanko
Coreen	Hastings	Mitchell	Yarrowlumla.
Crookwell	Holbrook	Mulwaree	

MUNICIPALITIES.

Albury	Grenfell	Lidcombe	Wallendbeen
Cootamundra	Gulgong	Murrumburrah	Willoughby.
Corowa	Inverell	Narrandera	
Cowra	Junee	Tumut	
Undegong	Lane Cove	Wagga Wagga	

Thorn Apple or False Castor Oil Plant (*Datura Stramonium* Linn.).

Throughout the greater part of New South Wales the common name of this weed is Castor Oil Plant, and it is greatly confused with the True Castor Oil Plant (*Ricinus communis*). It is a somewhat succulent, bright green, heavy-smelling herb of 2 or 3 feet high, growing in waste places. The leaves are rather large, irregularly cut or toothed, and paler on the underside. The flowers are large, white, and are usually described as trumpet-shaped. The fruit (the "prickly pod" of farmers) is rather large, much rougher than a nutmeg grater, and sheds a large number of black, kidney-shaped seeds, which have little dots over them.

It appears to be poisonous to stock in some cases, and in certain instances animals have eaten it without any ill effects. The seeds are poisonous to human beings when eaten.

It is now widely diffused in New South Wales, as is shown by the following information as to the shires and municipalities in which it has been declared to be noxious.

SHIRES.

Bibbenluke	Dalgety	Illabo	Tallaganda
Cessnock	Gadara	Marthaguy	Tenterfield
Cobbora	Gloucester	Mitchell	Wingadee
Coreen	Hume	Port Stephens	Yarrowlumla.
Crookwell			

MUNICIPALITIES.

Aberdeen	Drummoyne	Parramatta	Waverley
Armidale	Dubbo	Pieton	Willoughby
Barraba	Glebe	Randwick	Windsor
Bingara	Homebush	Tamworth	Wingham
Botany	Kiama	Tenterfield	Woollahra
Braidwood	Lane Cove	Tumut	Young.
Concord	Lidcombe	Uralla	
Coomamble.	Muswellbrook	Warren	

Wiser than we, Victoria has long since proclaimed it for the whole State:



Thorn Apple or False Castor Oil Plant (*Datura Stramonium* Linn.).

A. A flower laid open to show the arrangement of the five stamens and pistil.

B. The fruit, showing the leathery pericarp, dehiscing by four valves.

C. A seed, which is somewhat kidney-shaped, and covered with large shallow pits.

Tree Tobacco or Wild Tobacco (*Nicotiana glauca*, Graham).

This plant belongs to South America, and is a tall, slender shrub or tree of straggling habit, having large, grey-coloured, fleshy leaves and greenish-yellow flowers. Being a very hardy plant it withstands dry conditions, and is plentiful in most districts of the State, growing mainly along the banks of creeks and rivers.

It is poisonous to stock, but fortunately, however, is not very palatable, though some animals acquire a morbid taste for it.



Tree Tobacco (*Nicotiana glauca*).

Left, top of a flowering shoot (slightly enlarged). Right, above, ripe dehiscent capsule (enlarged five times); below, slightly enlarged young leaf showing usual form and venation.

[From "Monthly Bulletin" of Department of Agriculture of State of California, U.S.A.]

It is proclaimed noxious in the following shires and municipalities:—

SHIRES.			
Bogan	Marthaguy	Timbreebongie	Windouran
Canoblas	Murray	Turon	Wingadee.
Carrathool	Namoi	Wakool	
Cobbora	Rylstone	Waradgery	
Conargo	Talbragar	Weddin	
MUNICIPALITIES.			
Bahranald	Moama	Warren.	
Hay	Nyngan		

Castor Oil Plant (*Ricinus communis* Linn.)

This plant is often confused with the Thorn Apple, as stated above, but it is much larger and has smaller seeds than that plant.

It is proclaimed in the following shires and municipalities:—

SHIRES.

Bland	Gloucester	Mitchell	Narraburr.
Euobodalla	Jindalee	Mulwaree	Rylstone.

MUNICIPALITIES.

Burwood	Cowra	Manly	Waverley
Concord	Glebe	North Sydney	Willoughby
Coonamble	Junee	Paramatta	Woollahra
Cootamundra	Lane Cove	Randwick	Yass.
Corowa	Lidcombe	Tenterfield	

Cocksbur or Saucy Jack (*Centaurea melitensis* Linn.)

A so-called thistle with yellow flowers: it is also known as Burr, Yellow burr, and Chinese burr. The flower head is surrounded with prickly involueral bracts. The leaves are hoary and even slightly silky. The edges of the leaves are waxy. It will be observed that they clasp and run down the stem.

Cocksbur inhabits both cultivated and uncultivated land to the detriment of crops and the exclusion of better and more useful plants. It has a bitter taste, and stock will not eat it if other food is available. Being an annual it is best controlled by destruction before the seed matures.

It is frequently confused with other star thistles, and is a prescribed weed in the following Local Government areas:—

SHIRES.

Cessnock	Dalgety	Tamarang	Wollondilly
Coonabarabran	Gadara	Terania	Yarrowluma.
Culcairn	Kyogle	Wingdalee	

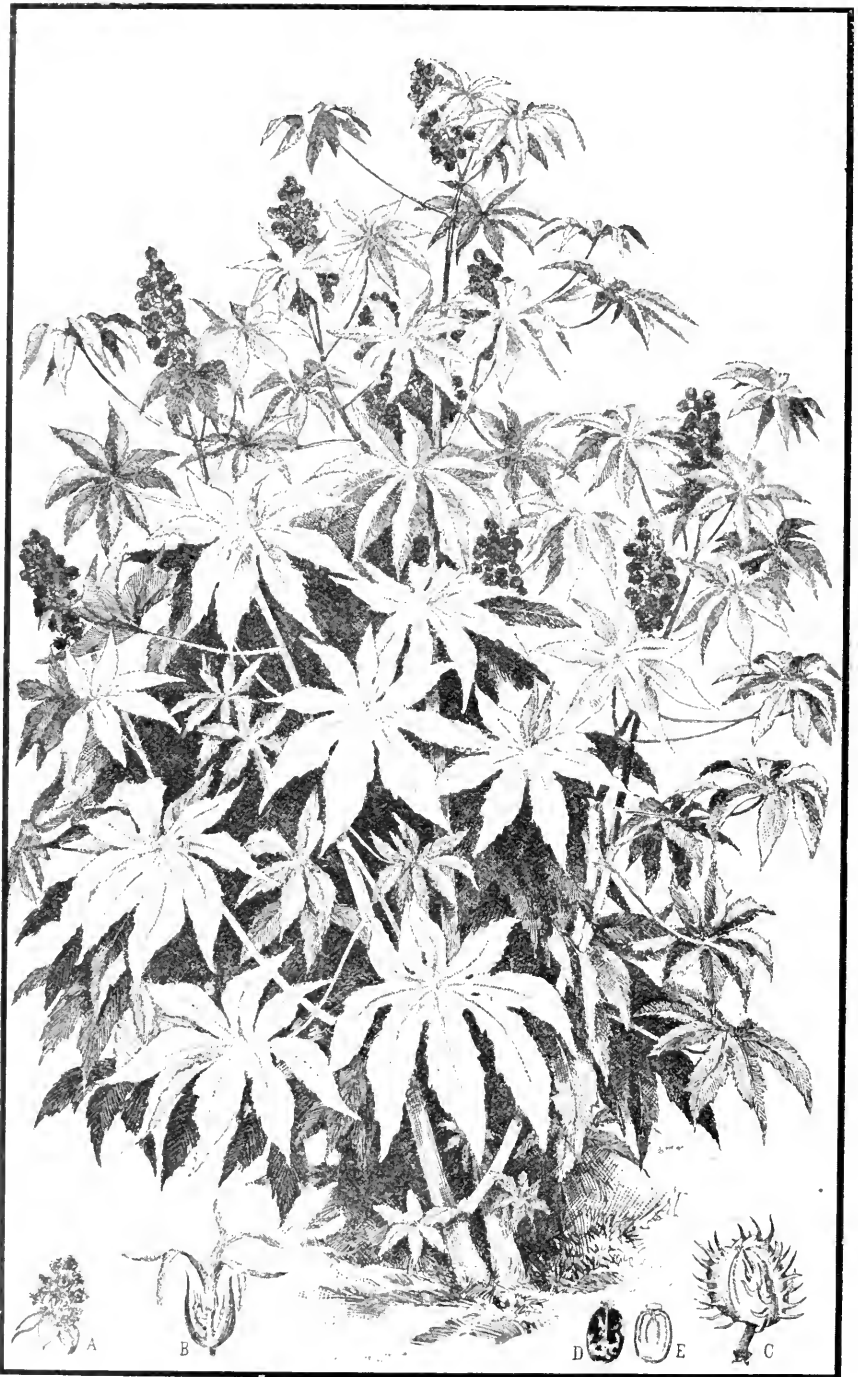
MUNICIPALITIES.

Botany	Lidcombe	Murwillumbah	Windsor.
Coonamble	Lismore	Tumut	

Blackberry (*Rubus fruticosus*).

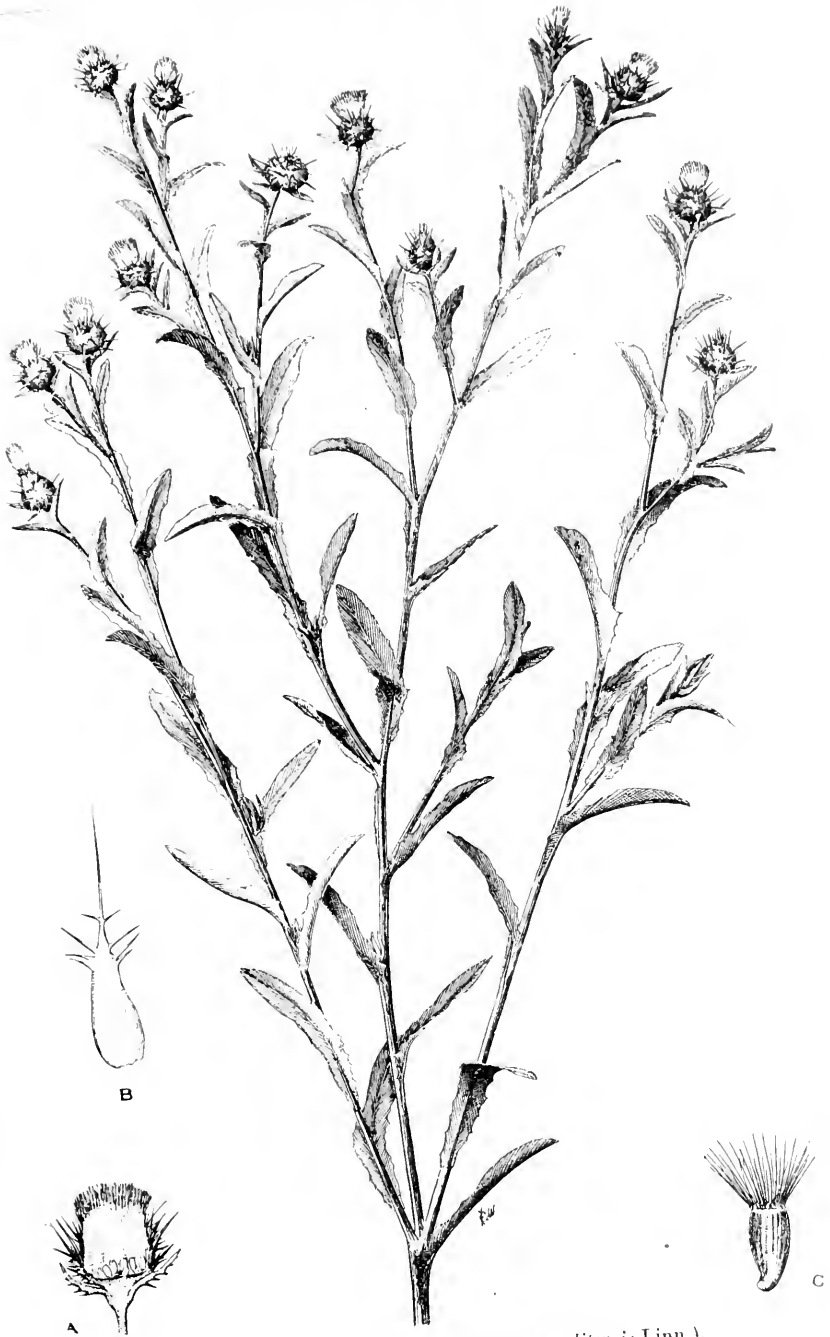
Blackberry vines are most difficult to eradicate, especially as merely cutting down occasionally tends to strengthen the root growth, and ultimately to increase the trouble.

Where the pest is confined to a small area intended for constant cultivation, trenching to a depth of 18 inches to 2 feet, and removing all growth to that depth, is the surest way, though laborious. Every part—roots, butts, and vines—should be burnt.



Castor Oil Plant (*Ricinus communis* Linn.).

A. Male flower. B. Female flower. C. Capsule. D. Seed. E. Longitudinal section of seed.



Cockspur or Saucy Jack (*Centauria melitensis* Linn.).

- A. Section of flower head, showing young seeds (natural size). B. Involucral bract (magnified).
C. Seed (magnified).

The treatment recommended by the Department is the caustic soda method. This chemical, of a strength of 1 lb. caustic soda to 2 gallons of water, has the advantage of being much less dangerous to animal life than arsenical solutions. It is best applied as follows:—

On small areas, first cut the vines down close to the ground, and remove them from the area for burning later. Then, from a watering can, with the rose attached, give the surface from which the vines have been cut a thorough soaking of the above solution. The area is then left until a new growth springs up, and has grown to 4 to 5 inches high. It is not necessary to cut this growth down, but it is advisable to give it a further soaking of the solution, which will soon kill more of the tops and root, but, perhaps, still will not kill the lot. This process will need to be repeated, so as to keep the leaf growth in check, for it is only by keeping the tops down that the roots can be ultimately killed.

On larger areas it will be best to use a mounted spray pump outfit, using an Edgell release valve to regulate the flow of spray.

A solution of arsenite of soda acts in a similar way, but owing to its highly poisonous nature, and the danger from children picking the fruit, it is not recommended.

A flock of sheep or goats kept on an infested area for a few months helps greatly in eradicating this pest. It is best to tether the goats, and to move them about as soon as they have nibbled off all the green shoots.

SECTION XIV.

The Handy Man on the Farm.

HARNESS, HARNESS FITTING, AND REPAIRING.*

MUCH depends upon the tractive power of the horse, and its effective utilisation necessitates the adoption of harness which will not in any degree tend to depreciate the value of his strength. The price of all horses, whether used for light or heavy draught, is extremely high, and, even apart from considerations of comfort, it does not pay owners to have their horses laid by through injuries contracted in the course of their work. The harness is necessary to enable the animal to exert his strength efficiently, and in selecting the harness it must be remembered that, while securing this, it must not cause more than the unavoidable minimum of discomfort. No horse put in harness should suffer any inconvenience except that arising from fatigue. Unfortunately, however, through lack of knowledge of the proper adjustment of harness, many horses do suffer considerable pain whilst at work. This gradually leads up to temporary incapacity, and in some cases to permanent injuries such as fistulous withers, &c.

Many vices—for example, jibbing and bolting—have their origin in badly-fitting harness. When the horse is compelled to work in an unsuitable collar, the undue pressure on any part of the shoulder causes chafing and soreness, and the horse naturally recoils from what causes him agony. Ultimately the best-tempered beast becomes vicious and uncontrollable, through nothing but culpable ignorance on the part of his driver.

Every horse differs in size and shape, and, to fit him properly, it is necessary to use much care. It is not sufficient to depend upon the saddler to fit horses with their harness. The owner should know the use and proper adjustment of every part. Wrung shoulders frequently occur through leaving the selection to the saddler, who, rather than go to the trouble of obtaining a proper collar for a horse that is difficult to suit, may choose the nearest fit in his ready-made stock, and justifies his choice by the contention that the collar will soon adjust itself to the shape of the shoulder. If it is not a good fit in the first instance, it will never become so, and in the so-called self-adjustment it is quite possible that the horse will be permanently injured.

Plough Harness.

This is the simplest form of harness, and consists merely of winkers, collar, and hames, backband, and chains.

Winkers are almost exclusively used as the headgear for horses doing heavy draught work. Open bridles are seldom used, as with them the horse, unless he is particularly willing, develops a cunning habit of shirking his work.

* Condensed from Farmers' Bulletin, No. 45, by A. H. E. McDonald, Chief Inspector of Agriculture, formerly of Hawkesbury Agricultural College, who was assisted by G. Cobb and H. Collins, also formerly of the College staff.

The eye-pieces of the winkers should project outwards from the eyes at the front, but must fit closely behind. The bit should be sufficiently strong to stand the work required of it, but should not be cumbersome. An ordinary snaffle-bit is suitable for most work. It should be fitted to the winkers so that it lies within a quarter of an inch of the bars of the lips—that is, the junction of the upper and lower lips. If drawn up tightly, the bit produces chapped lips, and is responsible for much pain; while if it is too low, it is also likely to cause inconvenience, and may be pushed out of the mouth.

On the winkers for draught horses it is an advantage to have the bit attached on one side with a short, light strap, so that it can be easily and quickly slipped out of the mouth if desired, without removing the winkers.

Bearing-reins are required to prevent the horse cropping at the grass as he moves along. When at work they are buckled over the tops of the hames, just sufficiently tight to allow of the free carriage of the head. Where a pair are used with a pole, the bearing-reins prevent the horses lowering their heads and so catching their headgear on the pole.

The collar is the most important part, as it is upon that the horse exerts his strength. For heavy horses they are either simply curved or rounded at the lower part, or are piped to allow of freer action of the windpipe. The latter are the more satisfactory, especially on horses with prominent windpipes.

Scrupulous care should be exercised in the selection of the collar. It should not fit too tightly on the whole or any one part of the shoulder, and it should not be too large. Chafing is caused principally by large fittings rubbing over a part, just as large boots chafe the feet.

The chief seat of injury is the point of the shoulder. This is the most prominent part, and when the collar fits badly most of the pressure is taken by it instead of being distributed over the full surface.

Injuries frequently occur at the withers. Such usually happen when the collars fit badly, or when the horses have to carry weight upon their necks, as they have in pole work. It is a form of injury which is particularly dangerous, as it may lead to an incurable fistula. The necks of some horses are very thick at the top, and the ordinary collars are not wide enough. It is necessary to get collars specially made for such horses.

The shape of the shoulder changes considerably when the horse is put to fast work, and the fit of the collar then must be noticed. It can be seen by examining the collar and surface of the shoulder immediately he is taken out after work.

Nothing is so liable to cause injury to the shoulders and to prevent the horse exerting his full strength as a flat collar. A well-fitting collar, when new, is roundly stuffed, and fits closely over the shoulder. It possesses a springiness which makes it comfortable, but after a little use the stuffing is compressed, and the inner surface becomes flat. All collars, after they have been used for a time, should be restuffed.

Collars are lined with serge or leather. The latter material is cooler and easier to keep clean, but is liable to crack. This is a discouragement to its use in all but light harness. Sweat and dirt accumulate on the surface, and should be regularly removed. If allowed to remain, a hard condition is produced, which causes chafing.

Young or fat horses have tender shoulders, and are liable to chafe, especially in the summer, and they should be carefully used until accustomed to work. Whilst a horse is in work a careful watch must be kept for indications of soreness. Immediately he is taken from his work, the harness should be removed and a careful examination made for undue heating in any particular part. Bathing the shoulders with salt and water hardens the skin and renders it less susceptible to injury.

Where galls already exist on the shoulders, it is often a difficult matter to adjust the collar so that the horse can continue his work. The best method of surmounting the difficulty is to select a collar which fits perfectly, and then make a depression in the lining immediately over the gall, sufficiently deep and wide to prevent the collar coming in contact with it. The depression is made by removing some of the stuffing and drawing in the lining with a few stitches. This is called "chambering" the collar.

Another method is to have small pads stitched to the collar above and below the seat of injury, to remove the pressure. Some horse-owners, in the absence of a saddler, use stockings stuffed with horse-hair as a substitute for the pads. By adopting means such as these, the horse can be worked while the injury is healing.

For heavy work the hames are usually made of steel, either single or double plated. The latter are more expensive, but more durable, and less likely to suddenly snap when the horse throws himself into the collar.

Hames for drays are made with short tug-chains attached, but on the farm it is more convenient to have them fitted with hooks, so that they can be used with separate short tugs for dray-work, or with chains for ploughing.

They should fit perfectly in the groove of the collar. A chain connects them at the bottom, and this can be lengthened or shortened to enable the hames to be adjusted to the size of the collar. This coupling must not be made too long, or in buckling the hames at the top they will be drawn in too closely and pinch the neck; if, on the other hand, the connecting chain is too short, they do not fit well round the collar.

The hook for attaching the tug or plough chains must be placed in such a position that the draught is not thrown on to the movable shoulder-joint. If the point of attachment is too low, the upper end of the collar is drawn slightly forward.

In some horses the body swells outwards considerably beyond the shoulders, and the chains chafe the sides. This can be prevented in most cases by putting a thick leather pad beneath the hame-hooks, to throw them outwards. If this fails, the chains must be covered with leather or strong cloth.

In plough-harness the backband is very simple, and serves merely to carry the reins and to prevent the chains falling too low and getting under the feet in turning. It should be of such a length that when the chains are tightened it rests comfortably on the back, and is not thrown up above it. When it is in the proper position the flaps should be about 9 inches behind the elbow-joint.

The chains vary in weight according to the class of work. They should be strong but fairly light, except where leading horses are used, when heavier chains are required. The length should be sufficient to allow the single-bars to clear the heels when turning the horses. If too long they

interfere to some extent with the draught, and may get under the feet in turning; while if too short, the swingle-bars catch against the heels. In hard, uneven ground, plough-chains should be fairly long. The swivels must be kept in good order to prevent twisting of the chains, with consequent risk of breakage.

The reins or lines are usually of rope in plough harness. A clasp at one end is a convenience in attaching them to the bit. Heavy lines should not be used, as they cause a drag on the horse's mouth, especially when wet. Rope of $1\frac{1}{2}$ inches circumference is the most suitable for ordinary work.

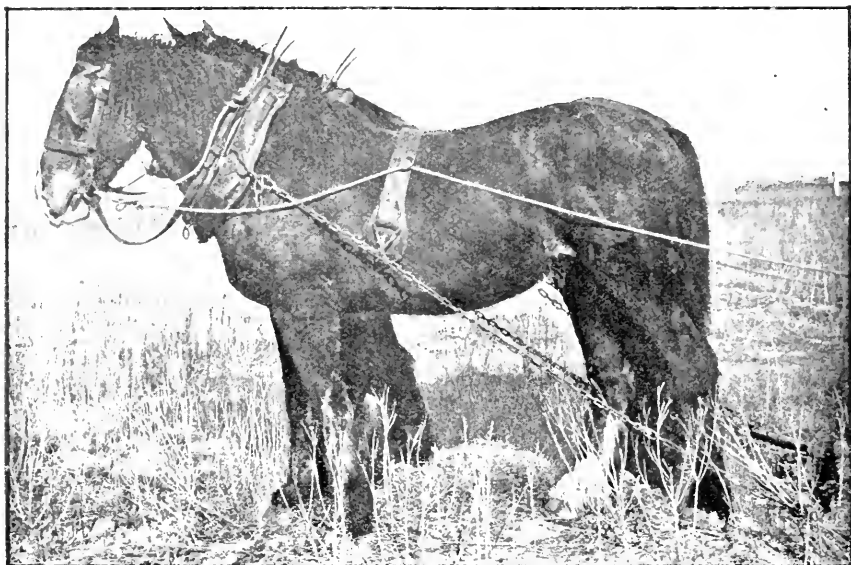


Fig. 1.—Plough Harness.

Showing the correct position of the hame hook, the position of the backband, and the method of attaching the lines.

They are passed through the terrets or rings on the backband, but not through those on the hames. If they are passed through the latter the horse's head is pulled upwards rather than outwards, and he does not answer to the rein well. They should not be too long, and if they must be taken up in length, it can be done most conveniently at the bit by tying a bowline knot; the spare rope can be tied up to the hames out of the way. (Fig. 1.)

Leading Harness.

This differs from plough harness principally in that a heavier backband and more complicated fittings are required to support the chains. The winkers, collar, and hames are essentially the same. A broad band of leather, divided into two-straps at the fore end, passes through a loop in the backband, along the back to the tail, where it ends in a crupper. Two meeter straps are attached with a loop and keeper to the hames, or are stitched to the collar itself about 5 inches below the top of the collar, and the straps attached to the backband are buckled to these to keep it in position.

The chains pass through two rings on each side of the backband, and are held up behind by hip-straps. These straps should be of such a length that they prevent the chains and spreader dropping too low (Fig. 2). The chains must not be held too high by them, or the horse will pull down against his own back; neither should they be too low.

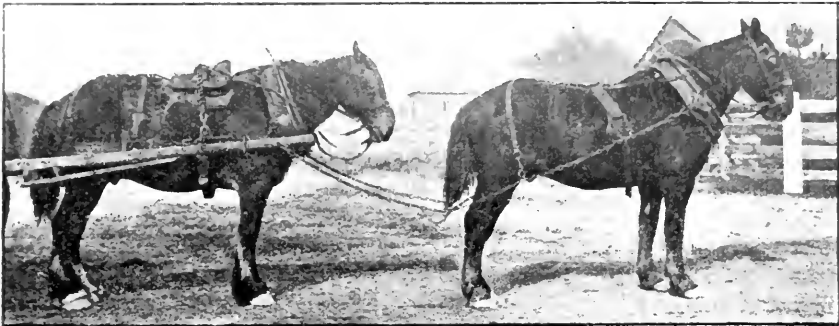


Fig. 2.—Leading Harness.

Showing the correct points of attachment of backband, hip-straps, and spreader to the chains.

The right point for the attachment of the hip-straps to the chains is about 6 or 8 links in front of the spreader. A carrier-strap is frequently buckled down over the hips and attached to the spreader. This should be buckled round the spreader about 6 inches in from the chain.

The spreader keeps the chains apart and prevents them from coming in contact with the horse's sides. It should be attached to the chains immediately behind the horse, but leaving sufficient space for the free movement of the legs. When the chains are tight the spreader should be just a shade behind a perpendicular line through the hocks.

Dray Harness.

The winkers, collar, and hames may be those used in plough harness, but they are often more elaborately mounted. This, however, does not add to their utility. The hames may have tug-chains attached, or may be fitted with hooks for the attachment of separate tugs. A saddle is used to carry the shafts, and attached to this is the breeching, designed to hold the saddle in position, and to enable the dray to be held back by the breeching-chains. The saddle consists essentially of pads to protect the back, and a groove to carry the back-chain. It must be well stuffed and properly adjusted to prevent injury to the back. Galls are almost as frequently caused by ill-fitting saddles as by collars.

The shafts are supported by the back-chain, which passes over the saddle and is attached to hooks on the runners or travelling bars on the shafts. The runners should have their centres directly perpendicular with the groove on the saddle when the tug-chains are tight. They are sometimes placed in the wrong position, and must be shifted.

The back-chain should not be too long nor too short. When the shafts are hooked up the points should be about 3 inches below where the tug-chains leave the hames. If hooked up too short the horse actually pulls against himself.

The tug-chains are hooked up so that the back-chain is kept in the centre of the runners under normal conditions, with freedom to move backwards or forwards in sympathy with the movements of the horse (see Fig. 3).

The breeching-chains should be just slack enough to allow free action of the hind legs. It is not infrequently noticed that the tug-chains are too long, and, instead of the load being drawn by them, it is drawn by the back-chain. The breeching-chains, also, are often too long, and when the horse attempts to hold the load the breeching cannot perform its function, and the load is held back by the back-chain. This pushes the saddle forward against the withers, causing pinching, and probably setting up the conditions which lead to fistula.

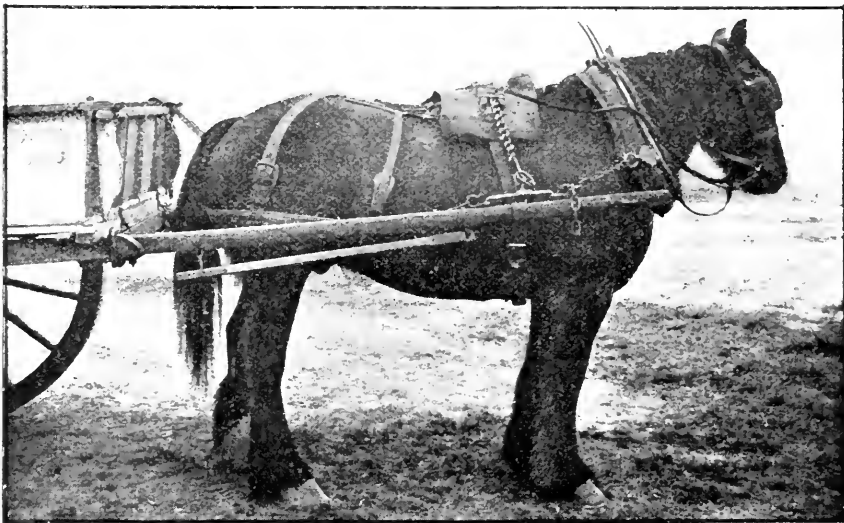


Fig. 3.—Dray Harness.

Showing the correct length of the back chain, tug, and breeching-chains; and also the right position of the travelling-bar on the shaft.

Light Harness.

In the choice of light harness, whether it be sulky, buggy, van, or any other type, the same scrupulous discrimination must be exercised as in the selection of heavy harness. Too frequently the same set is used for whatever horse is driven, but, while this is quite permissible with certain parts when the horses are of average size, each must at least have his own collar, and preferably his own blinkers also. Most of the other parts are adjustable to the size of the horse, and it is only necessary to make the required changes by taking up or letting out straps.

The parts are more elaborately mounted than in farm harness; but the principles underlying the fitting are essentially the same. Leather is used almost entirely, except in some van harness, in which chains are sometimes used for traces. The weight depends chiefly upon the type of vehicle used.

It is a matter of controversy whether blinkers or bridles should be used. The arguments advanced against the use of blinkers are that the eyes are enclosed, and become hot and irritated, and that the horse is more likely to

be frightened by anything coming from behind. Horses, especially those used in crowded thoroughfares, are certainly less likely to bolt when worked in bridles. A full vision of everything before and behind is obtained, and the horse is not so easily frightened by anything rushing by suddenly. All drivers know that a horse is less frightened by an object coming towards him, than by one appearing unexpectedly. A further advantage is that if the head-gear happens to be rubbed off, the horse accustomed to the restricted vision afforded by winkers, becomes frightened and probably bolts, while the one used to a bridle is unperturbed. One of the main obstacles to the use of open bridles is the patience which is required in accustoming young horse, to them. The winkers have a subduing effect immediately they are put on which the bridle does not possess.

With good going horses, it matters little whether bridles or winkers are adopted; but where teams are used, and the driver has not the horse directly under his eye, winkers are necessary to prevent the horse seeing behind him. A lazy horse which can see behind is constantly watching his driver, rather than sticking closely to business and minding where he is going. He works well when his driver is watching; but acquires the habit of loafing when he is not. When the winkers are used, a steady pace is usually maintained.

The heat and irritation caused by close-fitting eye-pieces can be prevented by using winkers with the eye-pieces thrown well outwards at the front.

The collar must fit perfectly; otherwise it causes discomfort, and frequently creates the habit of jibbing. Few horses are naturally vicious or obstinate, and in most cases the stupidity of drivers is the prime factor in the formation in them of habits alien to their nature. Jibbing can frequently be cured by the removal of the cause and by kindly treatment, especially if the handling is done by some person who has not been responsible for the trouble.

In light harness the hames buckle at the top and bottom, but it is more convenient to use the lower buckle. The best traces have buckles near the hames, by which they can be lengthened to suit the horse. The point of attachment to the hames should be just above the point of the shoulder, so that the movable joint between the shoulder-blade and the humerus does not receive the pressure of the draught.

If the traces are too long, the vehicle is not drawn by them, but by the backband. On the other hand, if they are too short, the shafts push the saddle-pad forward against the withers, and also draw the crupper up tightly under the tail, causing chafing.

Breast-plates are used to some extent instead of the collar, but whilst little exception can be taken to them for very light work, they cannot be recommended where the draught is at all heavy. When they are used the traces interfere with the free movement of the shoulder-joint, and cause discomfort to the horse. With the ordinary collar, provided the hames are properly adjusted, the force exerted by the horse is against the portion of the collar lying against the immovable shoulder-blade, and consequently the free movement of the joint is not interfered with.

The shafts are supported by shaft-tugs attached to the saddle-pad. These should be long enough to suspend the shafts level with the swell of the flaps. The pad is kept in position by a band running along the back and terminating in a crupper, and by the belly-band. The crupper should be fairly thick to avoid chafing. The breeching is also attached to this band.

The correct position for the pad is just where the withers swell upwards. If kept further back it has a tendency to slip forward, drawing the crupper too tight.

The right position for the breeching is about 3 or 4 inches below the hip joints. Here it does not interfere with the action of the horse, and he is able to throw his whole weight into it if necessary. If allowed to drop down too low it causes irritation, and may lead to kicking.

The breeching-straps should not be buckled too tightly, or the breeching will interfere with the free action of the hindquarters and also cause kicking. It should be just so tight that when the horse is fully extended it does not tighten on the legs.

Kicking-straps are required on some horses doing vehicle work. A kicking strap is a strong leather band which is passed over the rump, and attached to the shafts just behind the breeching staples. The further it can be kept back towards the tail the more effective it is. It is kept in position by attaching it to the crupper.

The reins sometimes consist of black leather throughout, but for the sake of cleanliness some stained leather is frequently used for the grip. They should be sufficiently long to leave a margin of about 3 feet when the horse is trotting. If too long, the loose ends are troublesome.

It is a controversial point whether bearing-reins should be tolerated. If misused, they are an instrument of torture, but on some horses are very useful when carefully adjusted. Some are such inveterate pullers that, without the bearing-reins, they pull heavily on the hands of the driver, to his exceeding discomfort. When used, the bearing-reins are brought up and hung over a hook placed in the saddle-pad. They should be long enough to allow the ordinary free carriage of the head.

Care of Harness.

Harness perishes very quickly if neglected, but if reasonable care is exercised it will last for years. Plated harness should not be kept in the stables, as the gases arising from the decomposition of the excreta tarnish the fittings. Immediately the harness is brought in the dust should be carefully wiped off with a soft cloth or leather, and mud or sweat removed by washing with water, but on no account should too much be used. The bits should be well washed in clean water, thoroughly dried, and rubbed over with a little neatsfoot oil. The leather should be kept soft and pliable by using some dressing. Any one of the proved commercial compositions is suitable and cheap.

Heavy harness does not require the same attention, but it must be kept pliable and tough by oiling at regular intervals. Leather which is not treated soon becomes hard under our dry conditions, and cracks, while the stitching decays. A very suitable dressing is pure neatsfoot oil. Some very effective and cheap mixtures are on the market for dressing heavy harness.

The Line of Draught.

By the line of draught is meant the direction in which a force acts in moving a load. In practice the line of draught in ploughing lies for part of its distance in the chains. The direction may be correct or incorrect; if the latter, it means that a portion of the horse's energy is being expended uselessly. To obtain the fullest advantage from his strength, it is necessary that the line of draught be so placed that nothing obstructs its direct action on the load.

The force exerted by the horse in traction consists of pushing. The term "pulling," although customary, is incorrect, inasmuch as a horse can only pull when he is attached to a load by the tail. The force is obtained by the propulsion of his own weight, the forward movement being due to the contraction or expansion of the muscles attached to the various bones. These bones form a system of levers, acted upon by the muscles. Propulsion can only take place when one extremity of the lever is fixed while the other is movable. This is the case with the horse. The fixed point is the foot, which is against the ground, while the movable point is the surface of the shoulder carrying the collar. In practice it is found that this force can be exerted most efficiently when the traces are attached to the hames just above the point of the shoulder (Fig. 1), provided, of course, that the proper line of draught between this point and the load is maintained.

The weight of the horse, which is very important when considering his power, becomes effective only when the body is thrown forward beyond the centre of gravity. In the horse this lies about the seventh rib, in the middle of the girth. It is evident that the heavier the shoulders, neck, and head of the horse, the greater is the force which he can exert.

This is appreciated and taken advantage of by draymen, who load their drays "heavy on"—that is, in such a way that a portion of the weight is thrown on to the horse's back. This increases the weight which can be thrown into the collar; but in loading in this way, care must be taken that the horse is not overweighted. A considerable strain is thrown upon the front feet, which rapidly causes fatigue, and may lead to injury. The weight thrown on to the horse should not be more than can be fairly comfortably lifted by raising the point of the shafts.

In light vehicles no weight should be thrown on to the back, especially on slippery roads, as the horse is more likely to stumble.

The weight can only be exerted efficiently against the collar when the line of draught is right. The feet act as a fulcrum, and the system of bones, embracing the legs, haunch, spinal column, &c., acts as the lever. The weight is most effective when it acts downwards on this lever against the fulcrum. If the horse were attached to the load in such a manner that the line of draught lay above his back, the effect would be to lift him from his feet, and consequently render his weight ineffective. This occurs when a dray is loaded so "light on" that the shafts are lifted, and are only prevented from rising into the air by the belly-band. This takes a part of the horse's weight off the fulcrum (the feet), and renders it useless.

By lowering the line of draught to the horizontal, greater effectiveness would be secured, but the horse would still be unable to exert his full power.

The actual efficient angle of the correct line of draught varies according to the height of the horse, and also his length, but generally it should form an angle of about 20 degrees with a horizontal line taken through the

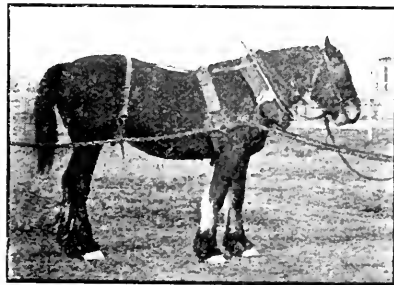


Fig. 4.—An incorrect method of attaching leading chains to those of the rear horse.

point where the force acts on the load. In ordinary plough harness, with the chains tight and long enough to prevent the swingle-bar catching the heels, this angle places the swingle-bar just a shade lower than the hocks.

When attached to the back-chain, the shafts must not be brought up too high, or they will be pulled downwards by the tugs, and portion of the horses strength will be expended against his own back. The back-chain,



Fig. 5.—Six-horse Plough Team.

when of the proper length, allows the points of the shafts to lie about 3 inches below the hame hooks (Fig. 3).

In team work, where horses are harnessed in tandem, inattention to the importance of securing a direct line of draught may lead to a serious loss of power. In some cases the chains of the leading horse are hooked to those of the horse immediately behind, close up to the hames (Fig. 4), with the result that the leading horse draws downwards on the chains. This means that the strength of the rear horse, instead of acting directly on the load, acts partly against the power exerted by the leader, and is thus to some extent rendered ineffective.

A direct line of draught can be secured by adopting some simple arrangement. A good appliance is shown in Fig. 6. This is a simple half-inch iron bar, 12 inches in length, with a ring at each end and one at the centre. The rear chains are attached to the ring in the centre, while the upper ring is attached to the hame hook, and the



Fig. 6.—An appliance for obtaining a correct line of draught when leading harness is used in ploughing.

lower ring receives the chains of the leader (Fig. 5).

Another simple and very effective arrangement, which can be fitted by anyone, is obtained by the attachment of short auxiliary chains to the rear chains to receive the leading chains. These auxiliaries are attached to the rear chains about 18 inches or 2 feet from the large end links, and are held up by short drop chains. They take the leading chains, and preserve the direct line of draught, preventing the downward pull on the rear chains.

Repair of Harness.

Although this is commonly considered to be within the province of the saddler, and consequently is neglected by the farmer, there is no reason why the latter should not make many of his own repairs. Those required are often very simple, and the following details are given, so that those who are not in a position to obtain training may be able, by studying them carefully, to acquire a knowledge of the work.

It is necessary to bear in mind that, although the process may appear complicated, it is not really so, and can easily be mastered. Time is always available for doing odd jobs, and by following the instructions no difficulty will be encountered in making ordinary repairs, and the harness will be kept in good order at little expense.

It is not proposed to deal with the more complicated work, such as the restuffing of collars, &c.—this must be left to the trained man—but merely to show how many simple repairs can be neatly and strongly made.

The following list comprises a fairly complete outfit for effecting repairs. Whilst with these almost any class of work can be done, the possession of them all is not essential; for instance, much useful work can be accomplished with an awl, needle, and thread. Costs are given, but are only approximate.*

	s.	d.		s.	d.
1 pair clams	6	6	1 edge tool, No. 2	1	6
1 ,, pliers, No. 3	3	6	2 tongue punches, Nos. 35 and 37,		
1 dozen awls, assorted	2	0	at 2s. 3d.	4	6
1 ,, awl-handles	2	0	4 round punches, Nos. 3, 4, 5,		
1 ,, collar needles, assorted	9	0	and 6, at 1s. 6d.	6	0
2 packets needles, Nos. 2 and 4	1	0	1 fine saddler's shoulder-crease	5	0
1 saddler's compass	1	6	1 single hand-crease	2	6
1 round knife	7	6	1 saddler's palm	1	6
1 hand knife	1	6			
1 saddler's hammer	3	6	Total	£2	16 6

A saddler's plough, which costs about 30s., facilitates the cutting of leather, but is not essential.

The different materials which are required in renovating harness, with the approximate costs are* :—

	s.	d.		s.	d.
Pitch, per lb.	0	4	Tacks, per packet	0	6
Resin ,,	0	4	Bridle leather, per side	30	0
Beeswax ,,	2	6	Harness leather, per lb.	2	0
Black wax ,,	1	3	Collar-check, per yard	5	6
Best brown hemp, No. 2, per hale	1	6	Brown serge	8	6

A small leather apron, about 12 inches by 4 inches, is required. This is suspended from the waist and hangs over the right thigh. A small **S** hook, for holding the hemp whilst making the thread, is also needed. A suitable bench is shown in Fig. 11.

Use of the Tools.

The Plough is somewhat expensive, and its work can be done by other tools, such as the round knife. The chief parts are a cutting blade and gauge. By setting it to the right width a strip of leather can be rapidly and accurately cut. (Fig. 7.)

* These prices are subject to variation.

The Round Knife is almost indispensable. It is the most suitable tool for shaving or bevelling leather, and is also used for cutting leather into straps or any other form. The line of cutting is marked with the compasses, and the round knife entered and steadily pushed forward along the line, keeping the left hand in front to hold the leather firm. The cutting is done on wood in the direction of the grain, and the surface must be free from nails. (Fig. 8.)

Compasses are required for marking the lines for cutting, and for marking distances.

The Edge Tool is used for taking the sharp edges off the leather after it has been cut. If these edges are left, the leather readily frays or cracks. The tool is run along the edge with the right hand, and the work steadied by keeping the left hand in front. (Fig. 9.)

Punches are used for making the different holes required in leather working. The round form is used for making the holes in straps for receiving the tongue of the buckle. The tongue punches are used for cutting the hole for the heel of the tongue.

The Creases are used for making ornamental lines on the leather (Fig. 10). These lines do not increase the strength of the leather, but add much to its appearance. The crease is heated over a candle, and after wiping off the candle-black the crease is pushed along the leather until a sufficiently marked depression is made.

Awls and Awl-handles.—The awl blades are attached to the handles by first pushing the heel of the blade into the handle as far as possible with the hand. The handle and blade are carefully examined to see that they are fitted truly, and then the blade is securely held in the vice, while the handle is driven down on to it with a light hammer.

Three kinds of awls are used:—

- (1) A curved awl, slightly flattened at the point, but otherwise round. This is used when the work cannot be stitched right through, but from one side only.
- (2) A round straight awl, tapering gradually from the handle to the point. This makes a round hole, the size of which depends upon the distance the awl is pushed through. It is used where single holes are required, and in beginning and ending long stitching.
- (3) A diamond awl, used in ordinary stitching. Several of these to suit the different sized threads used, are required.

Confidence is the chief requirement in handling the tools, and a little practice soon makes the learner familiar with their use.

The Thread.

A good thread is the first essential in making strong, lasting repairs. Good hemp must be selected, and considerable care exercised in the making. For convenience the hemp is kept in a small tin, with the end passed through a hole in the lid. The end is caught between the second and third fingers of the left hand, passed round the S hook, which should be about 3 feet away, and brought back and caught by the thumb and first finger of the same hand. Break the hemp by gently pulling with the left hand, while unravelling by rolling it downwards and away on the apron with the right hand. The breaking must be carefully done to obtain a fine tapering point.

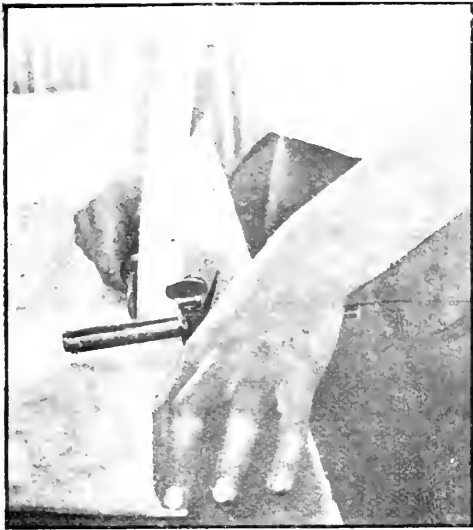


Fig. 7.—Cutting leather with the Saddler's Plough.



Fig. 8.—Cutting with the Round Knife.



Fig. 9.—Trimming a strap with the Edge Tool.



Fig. 10. Creasing a strap.

This process of passing the hemp round the hook is repeated until sufficient strands are brought together to give a thread of the required strength. This is determined by the class of work to be done. In light work two strands are used, while five or six are usually required for heavy stitching.

When sufficient strands have been brought together, the end is taken between the thumb and first finger of the left hand, and the thread twisted by rolling with the right hand on the apron. The twist is kept in by catching the thread up by the finger and thumb of the left hand. The amount of twist determines its fineness, strength, and evenness. When well

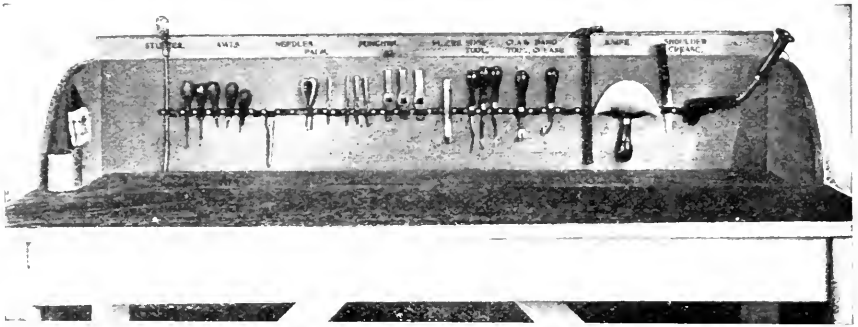


Fig. 11.—A convenient bench for leather-working, showing arrangement of tools.

twisted, wax freely but quickly by rubbing the wax briskly up and down right to the tips. A little more wax is applied to the tips than to the remainder, so that the needle can be more easily and securely attached.

It must be remembered that the threads are not doubled before twisting. A fine tapering tip is required at each end for the attachment of a needle, and this can only be obtained by twisting the thread from end to end without doubling.

Wax.

Wax is applied to retain the twist, to give strength and smoothness, and to preserve the thread. Two kinds are used, beeswax where black threads are not desirable, and cobbler's-wax.

The latter is most suitable for heavy stitching, and is composed of—

1 lb. Pitch, 4 oz. Resin.

The pitch and resin are heated until thoroughly liquefied and intermingled, when the composition is poured into cold water, in which it can be conveniently preserved. When required for use, a piece about as big as the top of the thumb is cut off with a wet knife, and held whilst being used in a piece of soft leather to prevent it sticking to the fingers.

These proportions of pitch and resin make a suitable wax for use in warm weather, but in winter it becomes hard and brittle. This can be overcome by making a mixture of—

1 lb. Pitch, 3 oz. Resin, 3 oz. Mutton fat.

The thread sometimes becomes hard or sticky when cold, and will not run well. This can be remedied by smearing the fingers with raw beef or mutton fat and passing them up and down the thread a few times.

Threading the Needle.

In saddlers' work stitching is not done with a needle and thread such as is used in stitching cloth. A single thread is used, and a needle attached to each end. The needles must be threaded securely, and in such a way that the thread, where it leaves the eye, is not thicker than the needle. If it is larger, either the thread or the needle will be broken in stitching.

To thread the needle, pass about $1\frac{1}{2}$ to 2 inches of the tip through the eye (see A, Fig. 12); pass the needle through the thread (B); draw the thread through as far as it will go, and twist the loose end which is shown, well round the thread (C); draw the needle through the thread two or three times at a place near to the point where the end of the tip has reached, but between that point and the eye of the needle (D). By drawing the needle and thread through itself in this way, the tip is woven to the thread and kept from unravelling. The finished thread, after smoothing down with the finger and thumb, is shown at E.

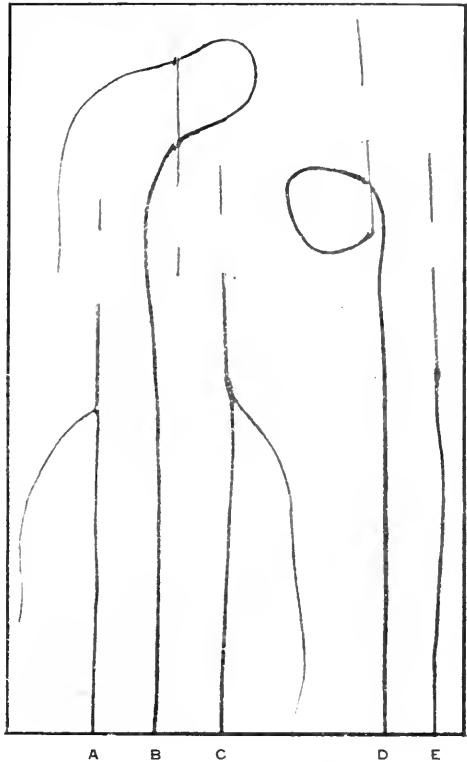


Fig. 12.—Threading the Needle.

The Requirements of Good Stitching.

To obtain good stitching, it is necessary that—

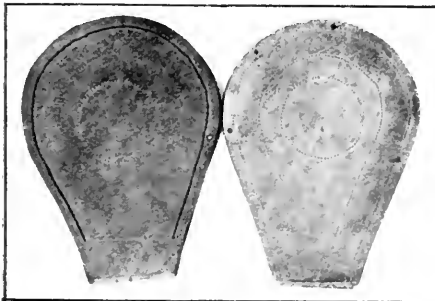


Fig. 13.—Marks left by the Wheel-pricker as a guide to stitching.

1. Thread of a kind and strength suited to the nature of the work be selected.
2. The thread be smooth, well twisted, and well waxed.
3. The stitches be all drawn equally tight, and made as firm as possible without cutting the leather.
4. The needles be used in the right way.
5. The right kind of awls be selected and correctly used.

6. The stitches be made towards the operator.
7. The work be closely and firmly held in the clams.
8. The stitches be of equal length.
9. The holes be of equal size and angle.

Preparing for Stitching.

When neat work is required, wheel-prickers are used to mark the line of stitching. These can be fitted with wheels to mark for any number of stitches per inch. The points on the wheel cut into the leather and make a distinct mark where the holes are to be made with the awl (Fig. 13).



Fig. 14.—Shaving leather with the Round Knife.

It is necessary to have the work securely fastened so that it will not move whilst being stitched. Cut tacks are used for this purpose, and are drawn when the work is finished.

The sharp edges of the leather must be removed. This is done with the edge tool. Edge tools are made in various sizes to suit the class of leather.

The ends of the leather must frequently be bevelled before stitching, to obtain an even thickness and smooth surface; as, for instance, in stitching on a buckle. This is done by shaving the ends down with a round knife (Fig. 14).

This is done by shaving the ends down with a round knife (Fig. 14).

Stitching.

The work, whilst being stitched, is held by the clams. These are held between the knees, and are kept in position by resting the end on the floor, passing the clams under the right leg, and resting them on the left. By their use the hands are left free for stitching. The operator must sit with his thighs horizontal, or the clams will tend to slip away.

The awl is pushed through the leather from the upper side at a slight angle. This, besides preventing the holes tearing



Fig. 15.—Using the awl.

into each other, allows the thread to be drawn tighter. To facilitate the use of the awl, saddlers usually cut a flat place on the handle, and by always keeping the thumb on this, the right angle is secured without difficulty. (Fig. 15.)

When the first hole has been made the needle is passed up from below, and the thread drawn through until an equal length is on each side. The next hole is then made with the awl and the lower needle brought upwards through this, and when the thread has been drawn through about 3 inches, the upper needle is passed downwards through the same hole. (Fig. 16.) The awl makes a diamond-shaped hole, and the thread brought up from below must be kept in the angle nearest the stitching already done—the lower end—while the thread taken downwards must be kept in the upper angle. This can be done by pulling downwards a little with the upper hand, while the lower hand is drawn slightly towards the operator. Each thread must be firmly drawn when pulled through.

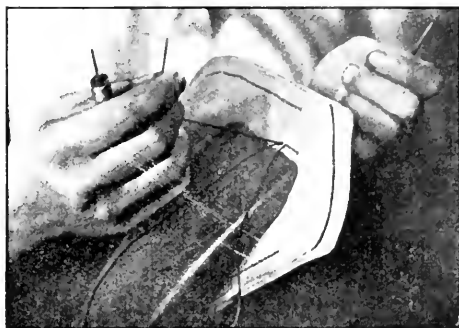


Fig. 16.—Stitching.

This is continued until the required amount of stitching has been done, when the thread is secured by turning back a stitch, using a round awl for making the hole. The thread when passed through is cut off flush with the surface of the leather.

By following the above directions, much useful repairing may be done by the farmer in his spare hours, and besides being profitable the work will be found interesting.

Broken winkers can be repaired, lost buckles replaced, and backbands and belly-bands, which are damaged, made strong again. Traces can be made safe, and the unsightly, dangerous knots, often seen in reins and other parts of the harness, replaced by strong, neatly-stitched repairs. It will be found that neat, strong work can be easily done, and that the details are soon mastered. Much of the work is merely cutting-out and stitching, and by close examination of the harness and imitation of it, nearly all repairs can be accomplished. Many articles, such as bridles, straps, belly-bands, &c., can also be made without difficulty. These can be cheaply bought, but provided good leather and hemp are obtained, the home-made article will probably have the merit of greater strength and durability.

Horse Rugs.

Some difficulty is often experienced in securing a rug to the horse so that it fits him comfortably without slipping off. The best method of accomplishing this is to attach flank straps, instead of the crupper that is often used, and to have the usual girth and chest straps. When flank straps are adopted it is not necessary to buckle any of the straps as tightly as when a crupper is used.

Although rugs can be bought cheaply, they are often home-made, and the following instructions will be useful:—The rug consists of a canvas covering and an inside lining of some warm material such as serge. For ordinary horses the covering is made 6 feet square, and when the strips of canvas have been stitched together, a curved piece is cut out over the withers. This piece is cut out 10 inches deep in the centre, and is 4 feet wide at the base.

The edges of the canvas are doubled up twice to give a good firm hem about half an inch wide. The inside lining is 4 feet wide, leaving 1 foot on each side of the canvas covering unlined.

The buckles for the flank straps are put just in front of the back hem, 1 foot in from the edges on the outside, and the straps taken through a slit near the hem of the canvas. A "D" is stitched on the inside of the rug about 20 inches forward from the back hem, and 1 foot in from the side, for the attachment of the flank straps by clips. The straps are made about

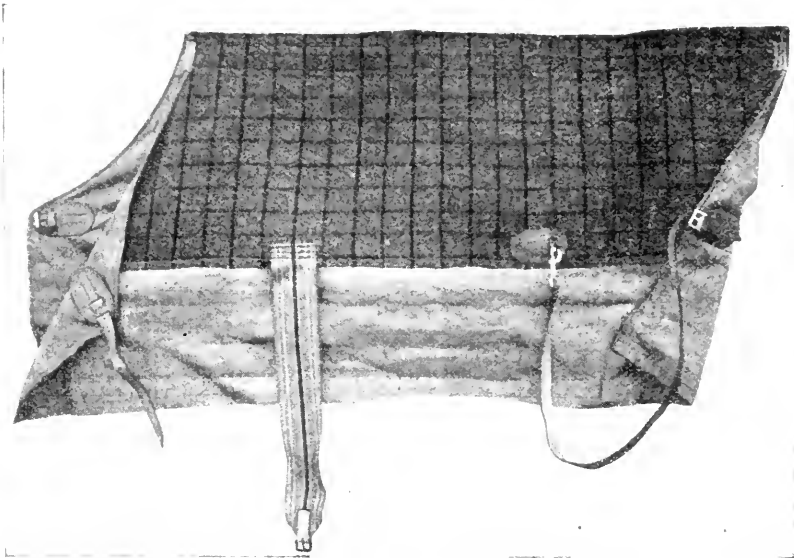


Fig. 17.—Horse-rug, showing the position of the straps, buckles, &c.

5 feet long so that they can be adjusted to the size of the horse. The girth, which is 2 feet 6 inches long, is stitched on the inside, 22 inches back from the front hem, and 1 foot in from the side.

The girth strap is 18 inches long, and is attached in the same relative position as the girth on the opposite side. The chest strap and buckle are placed on the front hem on the outside, 1 foot from the side. To make the rug stronger, a strip of leather about $2\frac{1}{2}$ inches wide, may be stitched down the centre on the outside.

In attaching all buckles and straps, care should be taken to have them stitched on to the inside lining as well as the canvas covering, and not placed where the stitches will pass through the canvas only.

Fig. 17 illustrates a horse-rug and the positions of the buckles and straps.

BLACKSMITHING FOR FARMERS.*

The farmer is perhaps called upon more than anyone else to exercise his ingenuity and to meet emergencies, and in the present time of keen competition he must be in a position to help himself. He is called upon in turn to be carpenter, saddler, blacksmith, &c., and it must be admitted that farmers generally have adapted themselves well to circumstances. At the same time, it is noticeable that blacksmithing work is not taken up in the same way as, for instance, carpentry, although in the matter of time, and also of money, it would mean a great saving. When the ironwork of some machine

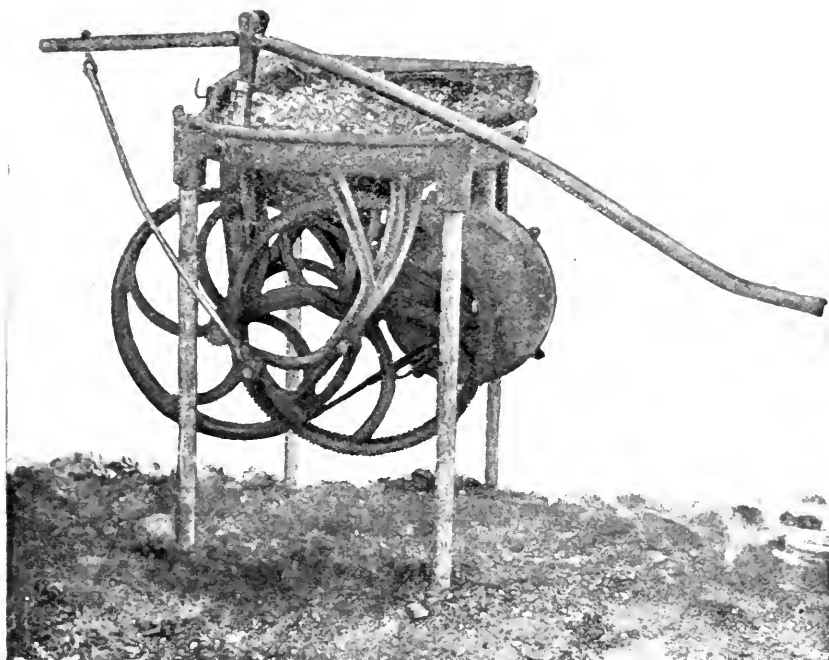


Fig. 1.—A Portable Fan-blast Forge.

breaks, it often means a long journey to the blacksmith, and in many cases if a forge were on the farm this work could be done by the farmer himself.

Another aspect of the question is worthy of consideration. The forge has a peculiar fascination for boys, and placing the facilities at their disposal provides them with a source of amusement, and with an occupation that, with a little skill, can be turned to profitable account, and at the same time will tend to make farm life more interesting.

Forges.

These can be roughly divided into two classes—fan-blast, and the bellows forges. Fan-blast forges are either self-contained—that is, the hearth and blast are in the one forge; or the forge merely consists of a hearth, and the

* Condensed from Farmers' Bulletin, No. 46, by A. H. E. McDonald, Chief Inspector of Agriculture, formerly of Hawkesbury Agricultural College, who was assisted by D. H. Reay, blacksmith at the College.

blast is taken from a pipe connected with a blower. The blower may deliver air to several forges, each being equipped with a valve to regulate the flow. Such forges are only used in the large machine shops.

The portable fan-blast forges, an illustration of which is seen in Fig. 1 are very suitable for farm work. They are made in different sizes, but as the farmer does not usually have to take in hand very heavy work, a medium size will be satisfactory. At the same time a larger forge gives more room for working, and metal can be heated more rapidly. It is doubtful whether it is economy to purchase one of small size, when the outlay of a little more money results in a much superior forge being obtained.

Bellows forges are the kind generally used by blacksmiths. Like the blast forges, they are made in different sizes.

Probably the portable fan-blast forge is the most suitable for farmers' purposes. The fan action produces a very even blast, and the forge has the additional advantage that, being made of iron throughout, it can be exposed to the weather without danger of serious deterioration. When bellows are used the forge must always be housed in a proper shed, or the leather soon perishes.

It is a convenience, especially to those who work on large areas, to have a forge which can be moved easily from place to place. For instance, when tanks are being excavated, or distant paddocks ploughed, it is an advantage to have the forge on the spot. Unless it is portable it cannot easily be moved about.

The prices of fan-blast forges vary considerably. One with a hearth of about 22 or 24 inches square is a good size for most purposes, and costs about £11.*

Smithy.

A good building is required to house the tools and protect the workman from inclement weather. If the tools are not kept together in a definite place they soon become scattered, especially when only occasionally used, and are not at hand when required. Many odd jobs for the smithy accumulate on the farm, and not being matters of urgency are, in the rush of work, left over to a more convenient season. Wet days can be profitably filled in doing work of this class, and necessarily some shelter must be provided as a protection from the rain. Such a building should be located in a high and dry spot, as dampness causes rusting of the tools.

A suitable size is about 12 feet square and 8 or 9 feet high. The roof may be of iron or any other waterproof covering, and the sides of slabs. An opening must be made in the roof to allow fumes to escape readily.

Large numbers of tools of various descriptions accumulate in a shop after a time, and racks should be made for these so that they can be kept in a place where they can be found without difficulty.

The Tools.

The Anvil.—A solid anvil is required. A light one, or a heavy piece of iron, such as is sometimes used, lacks solidity and gives too freely under the hammer. The price charged for anvils is about £5 10s. per cwt.,* and one weighing at least 2 cwt. is required. A second-hand anvil, quite suitable for amateurs, can often be obtained cheaply from a local blacksmith.

Vices.—A good strong vice is a necessity. Small vices are very well for light work, but they are practically useless for much of the work a farmer has to do. The ordinary blacksmith's vice, known as a "tail" vice, is very good. These are generally sold by weight. One with a 5-inch j.w.,

* These prices are subject to variation.

and weighing between 65 and 80 lb., is a good workable size. Parallel vices cost slightly more than tail vices, but they possess the advantage that a full-faced grip is obtained, regardless of the extent to which the jaws are opened.

Hammers.—Different sizes and shapes are used by smiths, but for farmers' work, a hammer weighing about 2 lb., with a ball end, is all that is required. (Fig. 2.) The ball end, or "pene," as it is called, is used in riveting, searing, and other work. In some hammers straight or cross penes take the place of the ball end. A straight pene is tapered, somewhat like a blunt chisel, and runs longitudinally with the handle, while a cross pene is at right-angles.



Fig. 2.—A Smith's Hammer

Sledges are not urgently required by an amateur, but nevertheless a sledge-hammer is very useful on a farm for many purposes. A 10 or 12 lb. sledge is a good size.

The hammers, sledges, and other tools must be firmly attached to their handles. Well-seasoned wood should be used; it is an advantage to have the wood in the shop for some time before making the handles, so that it will be well dried out. Unless it is well-seasoned the heat of the forge shrinks the wood, and the hammer head becomes loose.

The Flatter.—This tool has a broad, flat face, and is used, as its name implies, to flatten or smoothen surfaces after the hammer. The hammer leaves the surface somewhat rough, and a better finish can be obtained with the flatter. Farmers, however, scarcely require this tool, as for all practical purposes sufficient finish can be obtained with the hammer.

Swages are small tools with the faces grooved in different sizes to fit over bars. Some have semicircular grooves, while others have angular ones. What are called top and bottom swages are used. They are ranged in pairs,

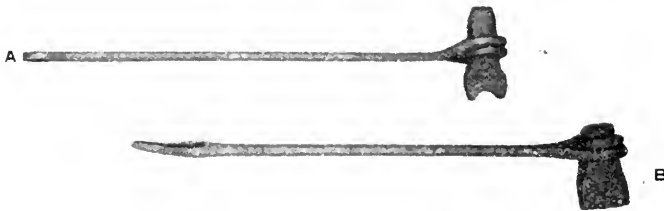


Fig. 3.—A—Top Swage.

B Fuller.

one for the top and the other for the bottom. The top swage is fitted with a handle (Fig. 3A), while the bottom one has a stem for fitting into the hole in the anvil. These tools, like the flatter, are generally used for giving a finish, and can well be dispensed with.

Instead of the single swages a *swage block* is occasionally used. This is a large iron block, bearing on its outside surface a series of grooves of varying kinds and sizes, and having its centre pierced with holes. A swage block is of little use on the farm.

Fuller.—This tool has a convex face. It is chiefly used for forming semi-circular grooves or depressions in bars, and sometimes for finishing up corners where a hammer cannot be used. The rounded face does not cut the fibres of iron, but merely alters their direction. The fuller, therefore, when used to make a groove, does not lessen the strength of the iron.

They are made in different sizes. The face forms half of a circle, and the size is taken at the base of the semicircle, or what would be the diameter of a complete circle. Fullers are spoken of as $\frac{1}{2}$ -inch, $\frac{3}{4}$ -inch, &c. (Fig. 3B.)

The *Hardie* is a tool with a sharp edge, adapted for cutting hot or cold iron or mild steel. It is fitted with a stem, so that it can be held in the anvil. When a bar of iron is to be cut, it is laid on the sharp edge of the hardie, a smart blow is struck with the hammer, and the bar is then moved round a little for the next blow, and so on until the bar is nicked all round. It is then easily broken by striking a sharp blow on the end, after laying the bar on the anvil with the nicked place just over the edge.

Hot and cold sets or chisels are steel tools used for cutting either hot or cold metal. They are fitted with handles and are forced into the metal with the hammer or sledge. Hot sets are kept thinner in the blade than



Fig. 4.—Cold Set.



Fig. 5.—Set Hammer.

cold sets. Cold sets must be kept thicker on account of the risk of breakage. These are tempered, but it is little use tempering the hot sets, as the heat of the metal cut by them soon withdraws the temper. (Fig. 4.)

Set Hammer.—This is somewhat similar to the flatter, but is made smaller in the face. (Fig. 5.) It is chiefly used for reaching those places where ordinary hammering cannot be done, as in angles. It is placed on the spot which requires working and struck with the sledge.

Punches are made circular, oval, oblong, and square in different sizes, and are fitted with handles for use.

Mandrels are slightly tapered tools used for finishing up holes after punching, shaping rings, &c. They are made in different sizes.

Bolster.—This is a steel or iron bar or block, containing holes or cavities for forming up different classes of work. The holes are round, square, and slotted, according to the class of work for which they are intended. If a

head is required on a bar or bolt it is upset a little to thicken the end so that it will not slip right through the bolster; the bar is then heated and dropped as far as it will go through the selected hole, and driven with the hammer. The effect of the hammer is to form a head on the bar from the up-set metal.

The *tongs* vary in size and construction according to the nature of the work, and each blacksmith makes them to his own liking. The illustrations show some forms which have been found very handy where the work consists chiefly of repairs to farm tools or implements.



Fig. 6.—A—Tongs for holding Links.

B—General purpose Tongs.

Fig. 6A shows a pair of tongs adapted for holding small links whilst welding. The jaws should only be about $\frac{1}{2}$ inch wide, and have a small groove near the points to enable a firm grip of the link to be obtained.

Fig. 6B shows a pair suitable for general purposes.

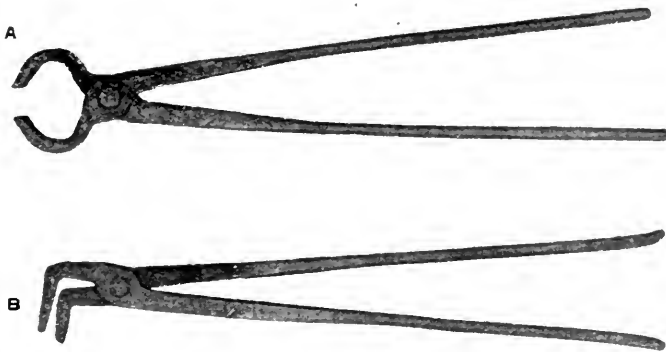


Fig. 7.—A—Tongs for holding Bolts.

B—Tongs for holding Round Stocks.

Fig. 7A illustrates tongs for holding bolts. The rounded jaws leave room for the head, and enable the points to take a firm hold of the bolt.

The tongs in Fig. 7B are designed for holding hoops and flat rings, such as the round stocks of dray wheels, &c. This form gives such a grip that, when hammering, the work can be brought into the required position by merely turning the wrist. This is an important point, as iron cools quickly, and everything must be arranged so that no time whatever is wasted.

Fig. 8A shows a pair of tongs for holding a ploughshare. The lower two-pointed curved jaw is obtained by making an ordinary flat jaw about $1\frac{1}{2}$ inches longer than the upper one. This jaw is split down the centre, and each section curved as shown, and the tips turned in at right-angles to prevent the share from moving from side to side. Similar tongs, smaller in size, are used for holding coulters.

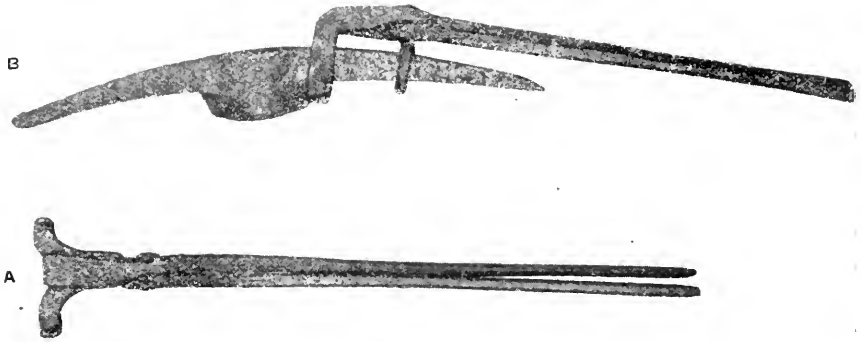


Fig. 8.—A—Tongs for holding Ploughshares.

B—Tongs for holding a Pick.

Fig. 8B is an illustration of tongs for holding a pick. The jaws are curved round as shown, and are held by a ring, an end of which holds the two parts of the tongs together instead of the usual rivet.

The Fire.

The best coal must be selected. Coal which crumbles up when firmly pressed in the hand, and has a bright glassy face on the fractures, as a rule gives the best fire. Hard dull-coloured coal, or bright splintery coal, does not make a good fire. Some of the dull hard coal is very unsuitable. It often contains a good deal of gas, burns away rapidly to white ash, does not bind when heated, and instead of forming a close-textured coke, falls to pieces. In a fire of this class a high heat cannot be obtained, and the fire does not last long.

Coal is generally used by smiths for firing, but in some of the bigger shops coke is used. As a matter of fact, it is coke which produces the heat in the small smith's fire also, the only difference being that the coke is produced from the coal by the smith on his own hearth.

Where coal is not obtainable, charcoal is a good substitute. In the pioneering days of the State, when transportation was difficult, charcoal was much used, but during recent years coal has almost altogether taken its place.

The place for the fire is immediately in front of the tue pipe, or, in those forges where the tue opening is in the centre, immediately above it. The tue pipe is the pipe which leads the blast to the fire.

The cinders, ashes, &c., of the last fire should be scraped away to leave a depression exposing the mouth of the tue pipe. All the coal, cinders, &c., on the top of the forge must not be removed, as these are required to keep the heat in the fire. The actual space on the hearth occupied by the fire is comparatively small, and the remainder of the surface, with its coal, &c., acts, so to speak, as an insulator.

Shavings, small chips, &c., are placed in the bed of the depression and lighted. When they are well ablaze, coke from the previous fire is put on, and the fire forced with the blast. Green coal, *i.e.*, fresh coal moistened with water, is finally added.

The actual heating material in the fire is coke, which is produced on the hearth by the action of the fire. In its formation from coal the volatile components, such as gases, &c., are driven off, and practically little left but carbon and ash. The special value of coke lies in its difficulty of combustion, which enables it to be brought to a high temperature under blast, and its freedom from flame and smoke.

In practice, green coal is backed up behind the fire. The heat converts it into coke gradually, and when the fire begins to get low, some of this coke is drawn down. At the same time the coal forces the fire forward and prevents it coming in contact with the tue pipe.

The coke, in addition to acting as fuel, serves as a coat to keep the heat in the centre of the fire. If the fire breaks through this coat, the heat passes out into the air, and it is difficult to secure a good welding heat.

The fire is not ready for use until a good supply of coke has formed. It must be cleaned regularly, as the coke burns away, by throwing out the clinkers, and fresh coke drawn in from the back or sides. The character of the fire has a most important influence upon the nature of the work turned out. It is, in fact, practically impossible to produce good work with a bad fire. This applies particularly to welds.

Effect of Heat upon Iron.

To appreciate the importance of the fire, its effect upon iron and steel must be understood. These metals, when cold, are hard, and cannot be changed in form without in some way injuring their strength. When, however, they are properly heated they can be worked at will without in any way impairing the strength. Heat causes marked changes in the metal. It becomes easily flexible, and if heated still further, plastic, and finally passes into a molten condition. A homely illustration of the behaviour of iron is seen in the change which takes place in wax when heated. It gradually passes from a hard state into a pliable, then into a plastic, and finally into a molten condition. The changes in iron are not quite the same, but are near enough for illustration.

It is owing to the properties of iron when in the heated condition that it is so valuable. Thick bars can be made thinner, thin bars can be thickened, it can be twisted into all conceivable shapes without impairing its strength, and, finally, separate pieces can be welded into one so firmly that where the joint is made the iron is as strong as in any other part.

When iron is being heated, one point must be borne in mind:—The right heated condition can only be obtained in a fire where there is little or no excess of air. A certain amount of air must be forced into the fire. If insufficient is forced in, heating takes place slowly, whilst on the other hand, if the blast is made too strong, burning takes place rapidly, but still the fire cannot use up all the air. The iron becomes very hot on the surface, while the inner part is still comparatively cool. Now when its temperature becomes very high in the presence of air, *iron burns*. It is probably difficult to realise that practically the same burning that takes place in wood can occur in iron. It is, however, the case, that when iron is heated to a very high temperature and air is present burning does occur.

This can be proved by placing a piece of iron in a fire and forcing in a heavy blast. In a short time brilliant sparks begin to fly off, and in a little while the iron is all burnt away. When such burning iron is removed from the fire, shooting sparks continue to fly off until it cools.

If the substance composing the sparks is collected and examined after cooling, it will be found very different from iron. It has a dull, slaty or bluish appearance, and is very brittle. It is iron changed into oxide of iron; that is, the iron has combined with oxygen and formed a material which has not the properties of the original metal. This oxide is seen in the scale found on and around the blacksmith's anvil.

The burning of iron is one of the first difficulties with which the amateur has to contend. So long as the fire cannot be so controlled that burning is prevented, good work is almost impossible.

From what has been said it will be seen that burning is due to iron at an intense heat coming in contact with air. The burning, therefore, can be largely prevented by blowing in only just as much air as can be used by the fire. If much over this is blown in, the iron commences to burn. The degrees of burning vary considerably; in the hands of a raw beginner a considerable portion of the iron may be burnt away, and even experienced workmen cannot altogether prevent the formation of some scale. This is objectionable in any class of work; proper welding is interfered with, and in ordinary forging the iron is pitted and roughened.

Fluxes are used to aid in preventing the formation of scale. Those generally used are sand or borax, either singly or mixed in the proportion of 3 of sand to 1 of borax. The flux should be sprinkled on the iron when it has reached a yellow heat, using sufficient to cover the whole of the surface, especially the parts to be welded. It melts under the heat, flows over the surface of the iron, and forms a protective covering or coat. This covering prevents the air coming in contact with the iron, and burning does not take place; or at least not nearly so easily. Besides this, the molten flux causes any scale which has already formed to melt, and when a weld is being made this fluid scale is forced from between the parts. The objectionable features of scale are its hardness and brittleness, and that when it covers the surface of iron, and an attempt is made to weld, it prevents perfect union.

Welding.

This is often looked upon as a most difficult operation, and one which can only be satisfactorily performed by an experienced smith. Whilst most men are ready to do many of the rougher kinds of forge work, few care to attempt welding. In many cases this is due to failure in attempts made when the underlying principles have not been understood. If the why and wherefore are not known, attempts at welding are gropings in the dark, and the rare successes due merely to chance.

To obtain a good weld, the first requirement is to secure the right heat in both pieces. Where iron is to be welded to iron or mild steel, this is comparatively easy. Other kinds of metal are more difficult to weld and require some skill. If the pieces of iron are of unequal size, care must be taken that the smaller is not overheated. This can be done by starting one before the other, or, if one shows greater heat than the other, by taking the hotter out to cool a little.

When iron and mild steel are heated they gradually change from a hard condition into a softer state. When a certain temperature is reached they become pasty, and if two pieces in a like condition are brought into contact a certain stickiness is noticeable. This is the right welding heat. It is only metals like iron and steel, which become slowly softer before passing into a molten condition, that can be welded. Some cannot be. Lead, as an example, passes suddenly from a hard condition into a molten state without any perceptible intermediate stage.

A further essential to a good weld is that the iron is thoroughly heated right through, and not merely superficially. A comparatively slow fire is required to obtain this. If heating is done too rapidly, only the outer surface is heated, and when the iron is taken from the fire it rapidly cools, so that the time required to form the weld is not available. Perhaps the best rule to follow is to heat slowly and notice when the metal comes into the sticky condition shown when the two pieces touch each other. If the iron is too cold welding of course cannot be done, while if the temperature is taken too high, burning will occur and the iron become crumbly.

A clean fire is required. In a dirty fire pieces of clinker, cinder, &c., adhere to the metal and, getting in between the two pieces, cause flaws in the weld. As mentioned before, the fire must also consist of compact burning coke, fed with the right amount of air.

Everything must be in readiness to proceed at once when the iron is sufficiently heated. When it is taken from the fire it cools rapidly, and no time must be lost. The anvil should be clean, and all tools at hand, so that they can be picked up without even looking for them.

Different forms of welds are used according to the nature of the work. Each differs in some respect, and different methods of preparing for the weld are adopted. The main preparation consists of upsetting and scarfing. The hammering when welding tends to reduce the thickness of the iron at that particular point, and to compensate for this both pieces of the weld must be upset as described a few pages further on.

Scarfing is the thinning down, with the hammer, of the tips of the parts to be welded, so that they will fit together and weld without much hammering. A more perfect weld is obtained, and less drawing down will be required to finish up the work after welding.

Scarfing is done usually with the pene of the hammer. Generally it can be done by the smith, but, to secure exactitude, it is necessary in some cases for the smith to hold the pene in position while the helper strikes with the sledge. It is done whilst the iron is just at a yellow heat, and before the pieces are returned to the fire for the final welding heat, they should be carefully fitted so that they are in close contact with each other. If this is not done, welding cannot be proceeded with at once, and the lost time results in defective work.

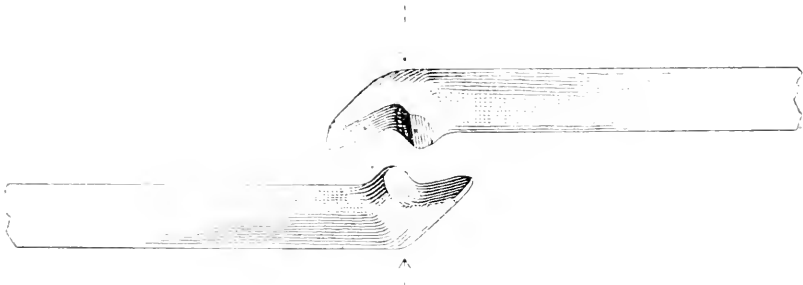


Fig. 9.—Lap Weld.

Different kinds of Welds.

Fig. 9 shows one of the best methods of scarfing when simple straight bars are to be welded. A weld scarfed thus, is made by hammering directly downwards as shown by the arrows, and there is no danger of the two

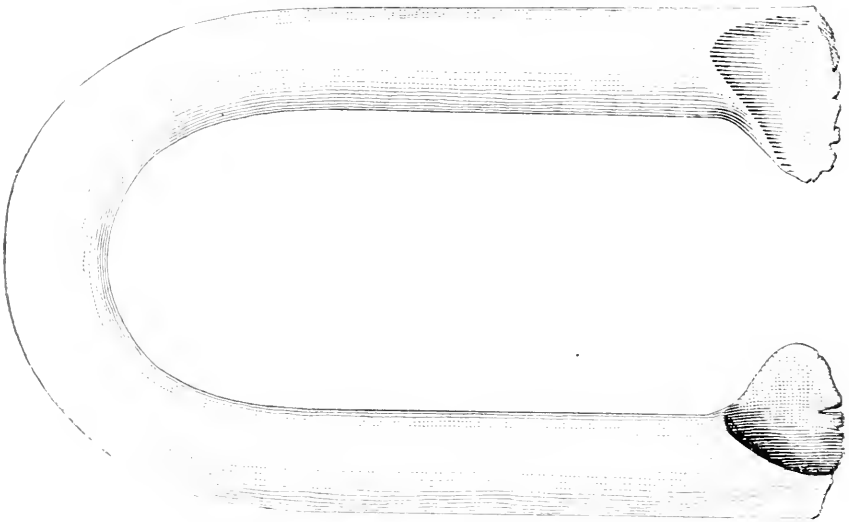


Fig. 10 — Link or Ring Weld.

parts being forced away from each other by the pressure of the blows. Other kinds of welds are recommended for this class of work, but in most of them the blows cannot be directed at right angles to the work and the anvil, and consequently it is more difficult to obtain a satisfactory weld.

Fig. 10 shows the scarfing for a link or ring. It is a simple form, and requires little explanation. As shown in the illustration, not much scarfing is required. After scarfing, the two ends are brought round and overlapped.

In welding, and indeed in any work, it is most important that a firm hold be obtained with the tongs. Those shown in Fig. 6A, which have slight grooves in the jaw, are very good for holding links and rings.

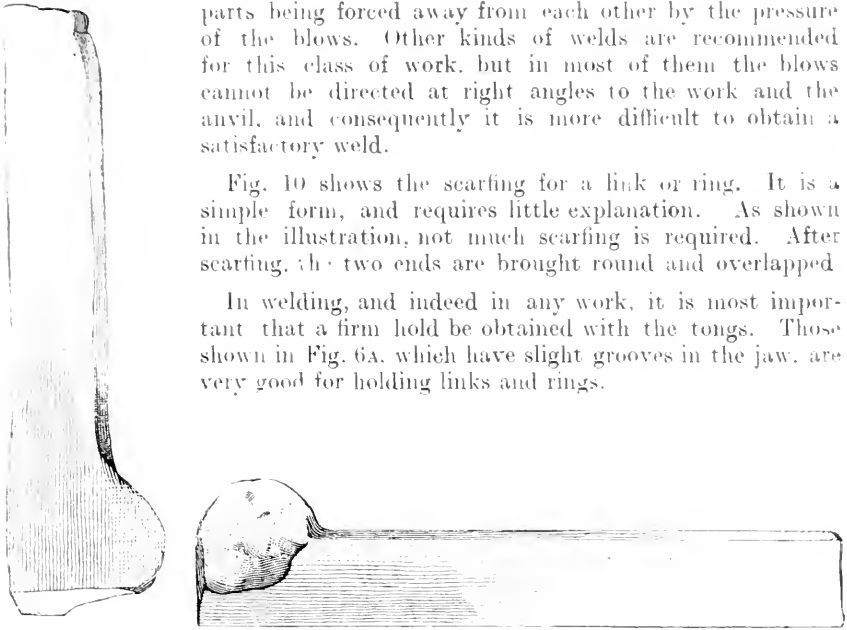


Fig. 11.—Angle Weld.



A method of scarfing for angle welding is illustrated in Fig. 11. By using this scarf, any required angle on the inner or outer side can be obtained. As in other welds, the ends must be slightly upset before scarfing.

Scarfing for either round or rectangular iron is shown in Fig. 12. The upper bar, A, is upset at the point of scarfing by heating and cooling off in water except where the



upsetting is done, to localise the heat. The bar is then held vertically on the anvil and hammered on the end. After every two or three blows it bends, and this must be corrected on the face of the anvil, and the upsetting proceeded with until a sufficient thickness is obtained. The scarfing of B is done by the smith holding the bar with the pene in position on it while the striker uses the sledge.

Fig. 13 illustrates a good method of welding for certain classes of work. The bar A is heated, and with a pene and sledge, a cavity is made as shown.

Fig. 12.—T Weld.

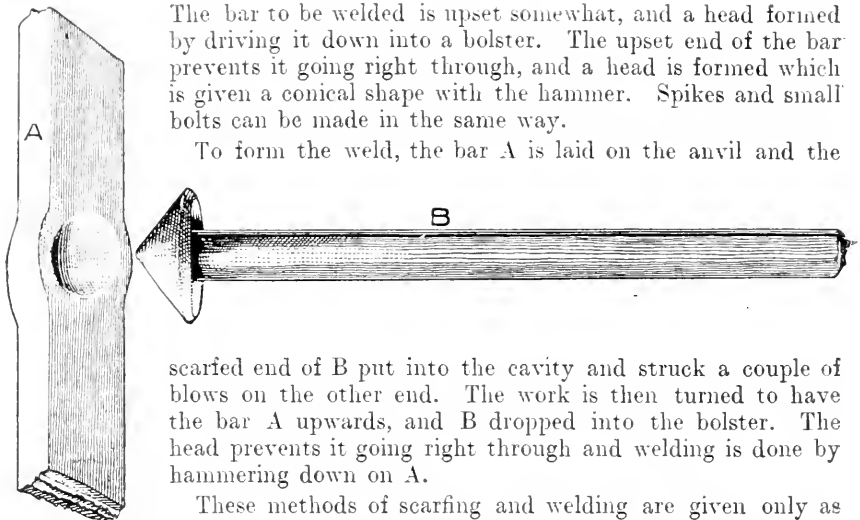


Fig. 13.
Butt Weld.

The bar to be welded is upset somewhat, and a head formed by driving it down into a bolster. The upset end of the bar prevents it going right through, and a head is formed which is given a conical shape with the hammer. Spikes and small bolts can be made in the same way.

To form the weld, the bar A is laid on the anvil and the

scarfed end of B put into the cavity and struck a couple of blows on the other end. The work is then turned to have the bar A upwards, and B dropped into the bolster. The head prevents it going right through and welding is done by hammering down on A.

These methods of scarfing and welding are given only as a guide and to illustrate the principles. Many other forms are used, but the smith who grasps the idea of what is required can adapt himself readily to circumstances and devise methods for himself.

In welding, the length of the material decreases somewhat. A rough rule followed by many practical smiths is to allow a length equal to the thickness of the bars for shrinkage.

In the actual process of welding the scarfed points must be stuck together as soon as possible, as these, being thin, cool out quickly.

Drawing Down.

This means the reduction of the size of a bar of iron by hammering whilst it is at a high temperature. By proper direction of the blows the iron can be drawn down into any shape without injuring the strength. This can only be done at a high temperature and even then, the process is a slow one, and only advisable when it means a saving of labour in other ways, or better work being turned out. Where an article varies considerably in size at different points, as, for instance, a pair of tongs, less labour will be involved if a bar large enough to form the jaws is taken, and (after the jaws have been formed) is drawn down, than if a thinner bar is taken and upset to give size for the thick section. In the case of tong-making, the necessity of drawing down a thick bar sufficiently to form the handle is avoided by drawing down a little and welding on a sufficient length of a thinner bar.

A blacksmith at work may draw down, upset, or weld his iron as it suits his purpose. As his whole object is to turn out work with the least amount of labour, it is difficult to set definite limits to the place of each.

The manner in which drawing down is done is determined by the kind of work. If it is merely a matter of tapering off to form a point, as when making a hook, the procedure is different from that followed when the size is suddenly reduced as in Fig. 14.

The first essential is a good heat. What is called a good welding heat gives the best results. If not heated sufficiently the bar will almost certainly split during the process.

When it is required to reduce the thickness of a bar from A to the thickness B, the first step is to fuller the bar, as in Fig. 14A. The fullering reduces the thickness abruptly at the right point, and it is an easy matter to get the thickness in 14B.

When the rounded fuller is used, no injury is done to the iron. A bar if broken shows a fibrous structure like the grain in wood, and it is this property which enables it to be bent at the will of the smith. It is absolutely essential

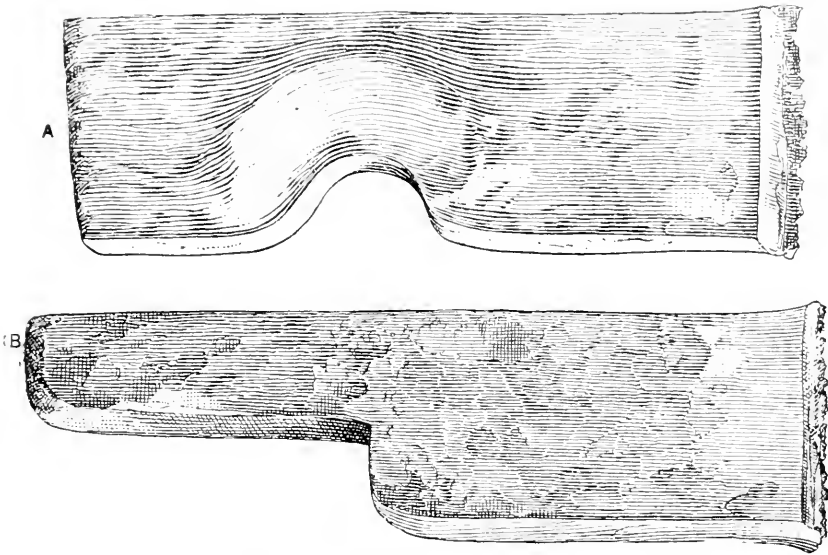


Fig. 14.—DRAWING DOWN. A—Bar fullered. B—Bar drawn down.

that the fibre of the iron should be maintained. If iron is nicked with a sharp tool the fibre is destroyed, and it can easily be broken. A peculiarity of iron is that if a bar is cut round with a chisel it can be snapped off readily, and the fractured structure shows a crystalline nature instead of the fibrous condition seen when it is broken without nicking. When the fuller is used to make a depression, it merely changes the direction of the fibre without causing any break.

To draw the bar down after fullering, it is taken up to welding heat, laid upon the anvil and hammering commenced about $1\frac{1}{2}$ inches from the end farthest from the smith. The bar must be worked down in square section without regard to its ultimate shape. For instance, if a $\frac{3}{4}$ inch round bar is to be reduced to $\frac{1}{2}$ inch round, it must be worked down to about $\frac{1}{2}$ inch square before commencing to round it. If an attempt is made to draw it down in a round form, splitting is sure to occur. When the bar is laid on the anvil and struck with the hammer, the effect is to make it spread sideways as well as to increase in length. The side-spread must be prevented by turning the bar a quarter round quickly so that it is hammered on every side.

The cooling of the bar prevents it being drawn down very much after each heating. The thickness of the bar, the quality of the metal, and the skill of the smith determine the amount. As a rule, with ordinary sized work, about $1\frac{1}{2}$ to 2 inches are all that can be drawn down at each heating with safety.

When the size has been reduced sufficiently in square form, finishing off is commenced. The corners of each side are hammered flat, forming an eight-sided section. The corners are again flattened, until finally the round form is obtained. This procedure must be carefully followed, otherwise the iron will split.

When a bar is to be merely drawn down to a point, fullering is not done, but the procedure is otherwise the same.

Upsetting, or Jumping Up.

This is a process followed by smiths to increase the bulk of metal at a certain point, and is the reverse of drawing down. It takes more time and care than the latter. A high temperature is required, and the heat must be localised—that is, confined to the spot where the upsetting is to be done. It follows therefore that a bar can be upset either at the ends or at any point along its length.

Different methods are followed. The bar may be taken in the hands and jumped down vertically on the anvil; it may be laid on the anvil and upset with the sledge; it may be held in the vice and upset with the hammer; or it may be held vertically on the anvil and upset in the same way.

When upsetting, it is necessary to see that the spread of the metal is in the right direction. If the blows are not carefully delivered, and the work straightened as required, the thickening may be in the wrong direction. During upsetting the fibres in the iron are forced apart, and hammering must be done after upsetting to restore the close texture.

Punching.

Different methods of punching are followed. Where it is not desired to expand the size of the section, a punch only a little smaller than the hole required is used. The metal is held over a bolster, or the hole in the anvil, and punched half-way through, then turned over and punched from the opposite side. A piece of the iron is punched out, leaving a hole nearly the right size. It is finished up to the correct dimensions by tapping in a mandrel and working on this. By this method a good deal of the metal is taken out, but the size of the section is not increased.

Another method is to punch out a small hole and gradually expand this hole with tapered tools until it is sufficiently large. When the holes are thus punched, very little metal is cut out, but the iron is swelled outwards a good deal. The eyes in hooks are often made in this way.

Tempering.

The temper of steel means the degree of hardness and the condition of the grain. Temper in rough tools is generally obtained by heating the steel and then cooling in cold water. If the temperature is too low the steel will be left soft, with a coarse grain, while if it is heated too much the steel will be brittle, and will probably have a coarse grain. The cooling also plays an important part. If it is too rapid the steel will be very hard, while if it is too

slow it will be soft. To get a good temper, therefore, the temperature must be right, and the cooling must be done properly. This is a matter of some difficulty, and a little practice is required. It is better not to cool off too rapidly, because if the temper does happen to be a bit soft, it is a simple matter to temper again, but if the tool is made too hard and used, it will probably break at once.

The following method is generally adopted in tempering picks, mattocks, cold chisels, &c.:—A dull red heat is obtained, and the tool is chilled by immersing about $\frac{1}{2}$ to 1 inch of the point in cold water for three or four seconds. It should be kept moving in the water. It is then withdrawn, and in a moment a pale straw colour should come into the point. After this a dark blue comes, and finally this turns into a pale blue. This pale blue colour must be waited for. Each colour is quite distinct. If the pale blue does not come the tool will be too hard, while if it passes off quickly the tool will be too soft. After the pale blue comes the tool is dipped in water and cooled right out. After tempering in this way the tool should be so hard that the file just grips it.

Examples.

A description of the methods followed in actual practice will indicate in the best way the different operations. In a short article of this kind it is impossible to deal with the more complicated work; and indeed it is not necessary, as the amateur can only expect to do simple work.

Laying a pick is a class of work that farmers sometimes require to do. Blister steel is used for the work. A convenient sized bar to take is 1 in. x $\frac{1}{2}$ in., about 2 inches long.

It is drawn down in wedge form to about 3 inches, and left slightly wider than the blade of the pick. After drawing down, the lay and the pick are put into the fire and brought to a welding heat. Then with a few sharp



Fig. 15.—Laying a Pick.

The steel lay is shown stuck on to the pick.

blows the steel lay is stuck to the point of the pick, keeping the thick end of the lay at the point (Fig. 15). It is sufficient if the two are stuck together at the first heat; the welding is completed at the next.

If the pick has worn back into a very stumpy state, the steel point is stuck on as above but not completely welded, and a piece of tapered iron is stuck to the upper side of the lay, extending back with the thin end almost at the eye of the pick. The work is then returned to the fire, a fresh welding heat obtained, and the iron and steel lays welded to the pick together. About 3 inches can be welded at each heat, and about three heats will be required to complete the welding. The object of laying with the iron is to increase the length of the pick blade. The steel lay is inserted between the iron and pick, but the subsequent hammering, when drawing the pick into shape, brings it out to form the hard cutting point.

In some cases the laying is done by splitting the point of the pick and inserting the lay. Welding then proceeds as usual.

After the welding has been done, the pick is drawn down into shape and tempered.

Laying a Ploughshare.

The laying consists of welding a piece of iron on the point and wing to replace the loss by wear. The size and length of iron used for the lay is determined by the size of the share. For a large share, 1 in. x $\frac{5}{8}$ in. iron, long enough to extend from about 2 inches in front of the worn point to the rear point of the wing, with a little over, is used. This is prepared in the form shown in Fig. 16A, and bevelled on the lower side, leaving the upper side nearly level. Beveling increases the width of the lay.

The share is prepared for laying as shown in Fig. 16B. The curving is done by heating the share and hammering it down while held in the vice. The object of the curving is to allow for the bending backwards that takes place

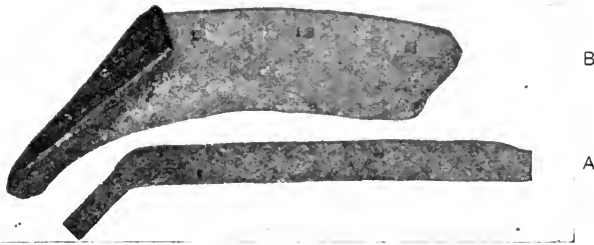


Fig. 16.—A—Lay for a Ploughshare. B—Share prepared for laying.

when welding. The result is that when welding is finished, the share is practically straight, while if the bending were not done the hammering during welding would leave the share bent back, and some difficulty would be experienced in getting it straight again.

The share is scarfed for welding by heating the wing and hammering it down, so that when the lay is put on, the two fit together well. When both are ready they are brought to a welding heat, and the share is held bottom up on the anvil by the smith with one hand, while with the other the point of the lay is laid on the point of the share and struck with the sledge by the striker. The point is finished up by the smith with the hammer.

With the two attached in this way it is a simple matter to bring the lay down to the shape of the wing. It should project about $\frac{1}{4}$ inch out along the side of the wing.



Fig. 17.—The lay ready for welding.

Fig. 17 shows the lay attached to the point and hammered into shape ready for welding. It is got into place by first knocking the lay into the right position on the rear point of the wing,

and it is then grasped there with the tongs and held while it is hammered in the centre and along the wing until it projects the same distance right along.

So prepared, the share is ready for the welding, which is done from the point backwards. The depression forming the frog of the share makes welding somewhat difficult at that point. This difficulty can be overcome by using the set hammer shown in Fig. 5. This is placed on the lay in the frog and struck with the sledge.

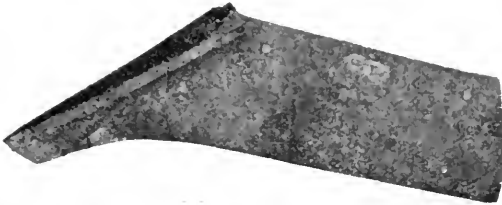


Fig. 18.—The finished Share.

About four or five heats are usually required in welding a share such as that shown. The welding of 3 or 4 inches at a time is fairly good work. Fig. 18 shows the share after laying has been finished.

Laying the Point of a Share.

This consists of welding a piece of iron to the point of the share. Bar iron $1\frac{1}{2}$ in. \times $\frac{5}{8}$ in. and 3 inches long is taken and scarfed as shown in Fig. 19. The lay is welded to the underside of the point, and when scarfing the lay, the hammering should be done on the opposite side from that which is to be in contact with the share, so that the projection shown in the lay will fit down well on to the share. The welding is similar to that adopted when laying a pick.

It will be noticed that iron is used in laying both the point and wing of a share. This is so soft that in its natural state it wears away rapidly. The wearing can be prevented by what is called "casting." After the share is laid, it is brought up to a welding heat, and at the same time a thin piece of cast-iron is heated to a dull red. While the welding heat is on the share, the red hot cast-iron is rubbed over it in the fire. The heat of the iron melts the cast-iron, and a liquid coat is obtained. When suffi-



Fig. 19.—Laying the point of a Ploughshare.

cient of the cast-iron has been melted, the share is taken from the fire, and with an old file or rasp the molten coating is spread evenly over the point of the share. The effect is to give a coating of intense hardness, which makes the share last very much longer. Any cast-iron, such as a broken saucepan, kettle, &c., can be used. The thinner it is the better, as it melts more easily.

CARPENTRY.*

For a man acquainted with the art of carpentry, or even slightly gifted in that direction, it is not a difficult matter to pick up a saw, hammer, chisel, or plane, and to set about the making of a gate or a wheelbarrow: but when one who knows little of anything about the business finds that his chisel, plane, and saw are blunt, and that things are otherwise "cranky," it is a different problem altogether, and it is then, perhaps, that the truth comes home to him that what he requires is not only the tools, but the knowledge of how to handle them and to put them in good order.

Elementary as it may appear, it is nevertheless necessary to know both how to hold and how to adjust a tool, and before the beginner can turn out a satisfactory job these things must be mastered. In the hope that the information will be useful to farmers, it is proposed to offer a few pages about the tools that may usefully be found in a farmer's kit.

PLANES.

Plane irons differ slightly—not in angle, but in shape. They may be briefly described thus:—

Name.	Width of iron.	How edge is ground.	Use of tool
German jack ..	1½ inches ...	Convex (see Fig. 1) ...	For very rough work.
Jack ..	2½	Slightly convex (Fig. 2)	For rough work and straightening slightly.
Try ..	2½	Straight across. Tips of of each corner rounded off on oilstone (Fig. 3).	For making surface perfectly straight.
Smoother ..	2½	Do (Fig. 4),	For finishing off job smooth.

It is evident that, while all planes must receive careful handling, the two last-mentioned require to be ground and sharpened with special attention, in order that they may do the fine finishing work satisfactorily. But this is not all. The planes themselves require proper care and handling if the best work is to be got out of them. In my opinion and experience, wooden planes are the best to work with, the easiest to keep in order, and the least like'y to be broken, and it is with these that I am dealing. A beginner will be well advised to procure second-hand planes (provided they are still in fairly good order), as new tools may be seriously damaged in the process of learning their use.

Wooden planes, old and new, should be regularly oiled all over with raw linseed oil. Great care should be taken of the sole—that is, the bottom—especially of the "try" and "smoother" planes.

The smoother, try, and jack planes all have double irons—the cutting iron and the back iron. The cutting iron is, of course, the only one that requires sharpening, and during that operation the back iron should be put aside, but otherwise the two irons are handled as one. The back iron acts as a spring, and keeps the cutting iron rigid. The back iron of the smoother and try should be kept not more than one-sixteenth of an inch from the cutting edge; that of the jack should be not more than one-eighth of an inch from the cutting edge, being brought correspondingly closer for finer work.

* M. H. Robertson, Instructor in Carpentry, Hawkesbury Agricultural College.



Fig. 1.
German Jack.



Fig. 2.
Jack.

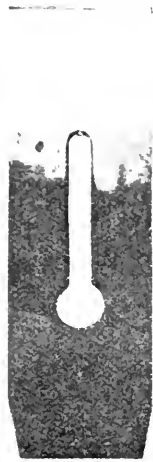


Fig. 3.
Try.

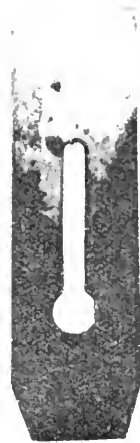


Fig. 4.
Smoother.

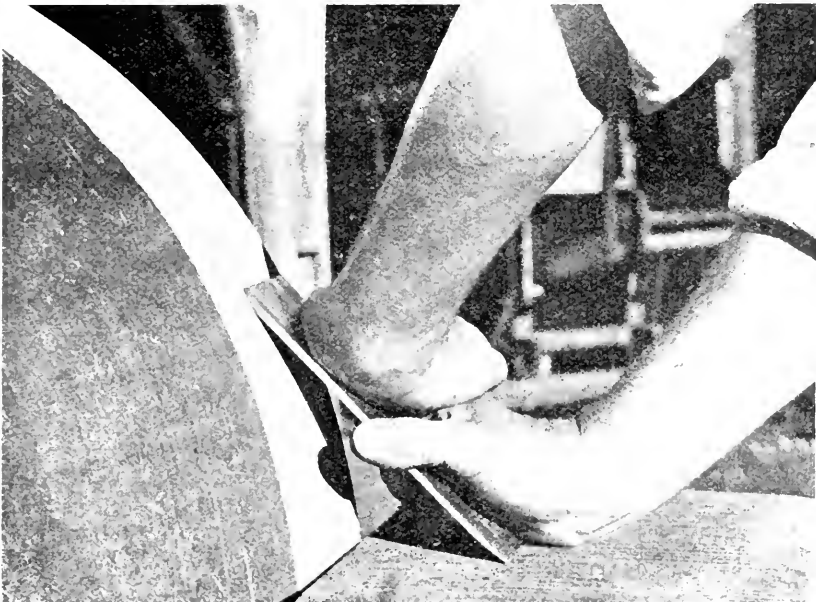


Fig. 5.—Grinding a Plane Iron on the Grindstone.

Sharpening the Planes.

The sharpening of plane irons and chisels is very similar, and if the former is mastered, the latter will not be found difficult. Two angles have to be kept in mind—the grindstone angle, which is the angle at which the iron is held on the grindstone (about 30 degrees) and the oilstone angle, which is the angle at which the iron is held on the oilstone to get a fine cutting edge.

To grind a plane iron or a chisel, rest the handle or end of the iron on the frame of the stone with the iron against the stone (see Fig. 5). Plenty of water must be played on the stone while the stone is turned on to the iron. Care must be taken to keep on the outside edge of the stone, or the stone will be worn hollow, which will make it very hard to grind the irons true—a most important point.

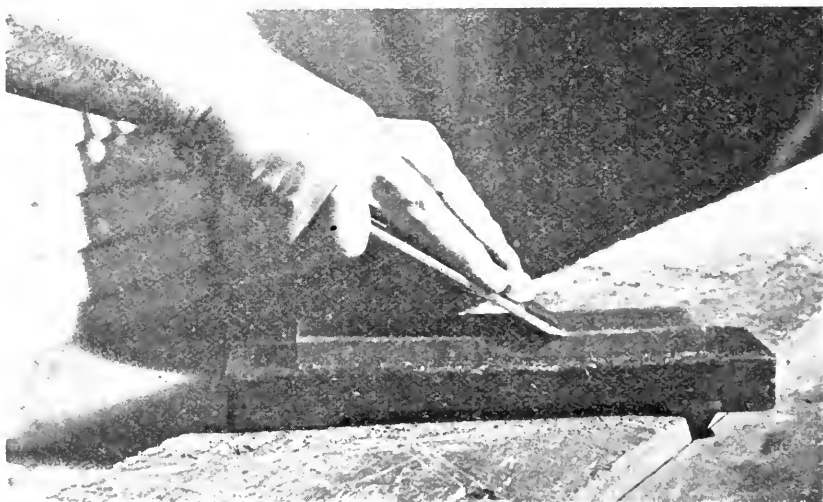


Fig. 6.—Sharpening a Plane Iron on the Oilstone.
The method of treating a Chisel is the same.

On the oilstone, the angle should be about 36 degrees. The stone should be placed firmly on the bench, lying straight away from the body (Fig. 6). Keep plenty of oil on the stone, and work the iron as near as possible the full length of the stone, keeping the iron square on it, and at the same time moving from side to side, so that the stone shall be worn evenly. A light burr will often form on the edge as the sharpening on the oilstone finishes, and this must be removed by laying the iron upside down on the stone and giving it a few sharp rubs. For this operation the iron must be quite flat on the stone, or another angle may be formed, which will spoil the cutting edge. Even a slight angle when the "burr" is being removed will have the effect of spoiling the edge. The tool must be sharpened in such a way as to have no bevel on the face side.

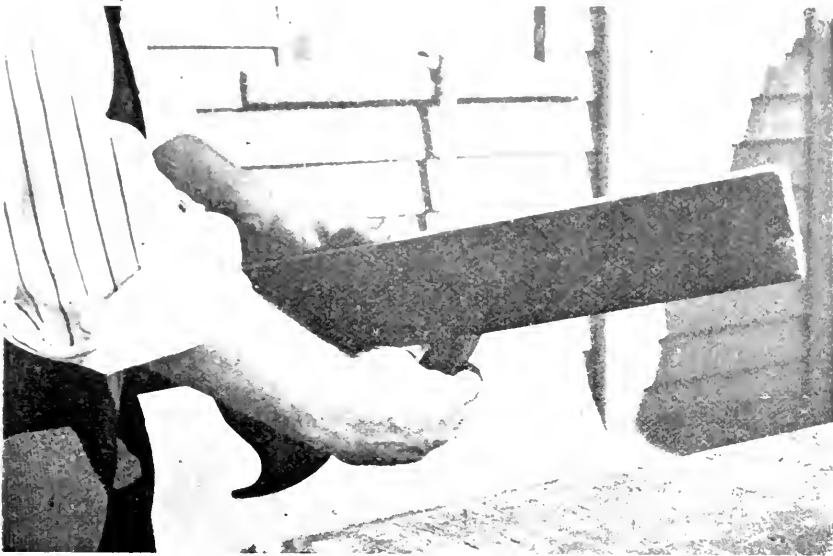


Fig. 7.—Taking the Iron and Wedge out of the Try and Jack Planes.

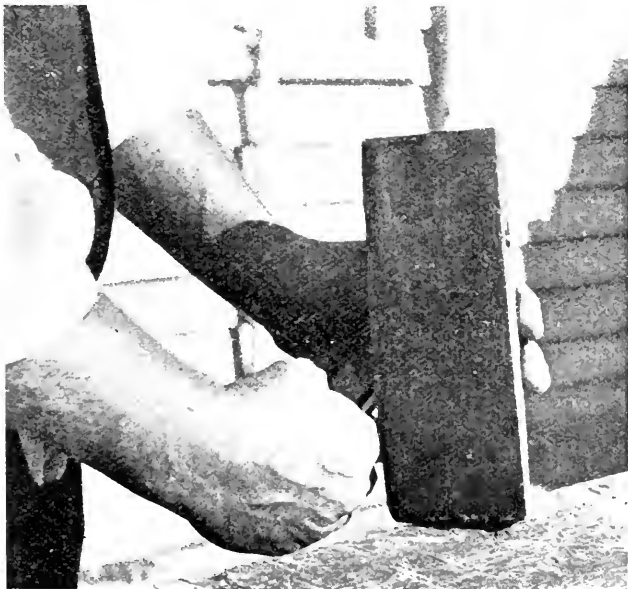


Fig. 8.—Taking the Iron and Wedge out of the Smoother and German Jack Planes.



Fig. 9.—Inserting the Iron and Wedge in the Try and Jack Planes.

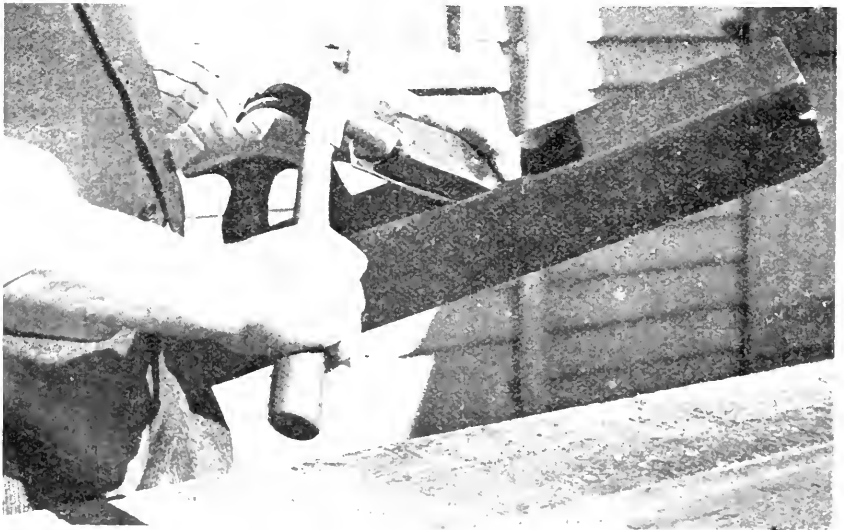


Fig. 10.—Tightening the Wedge and Iron.

The method is the same in the case of all four planes—Smoother, Try, Jack, and German Jack.

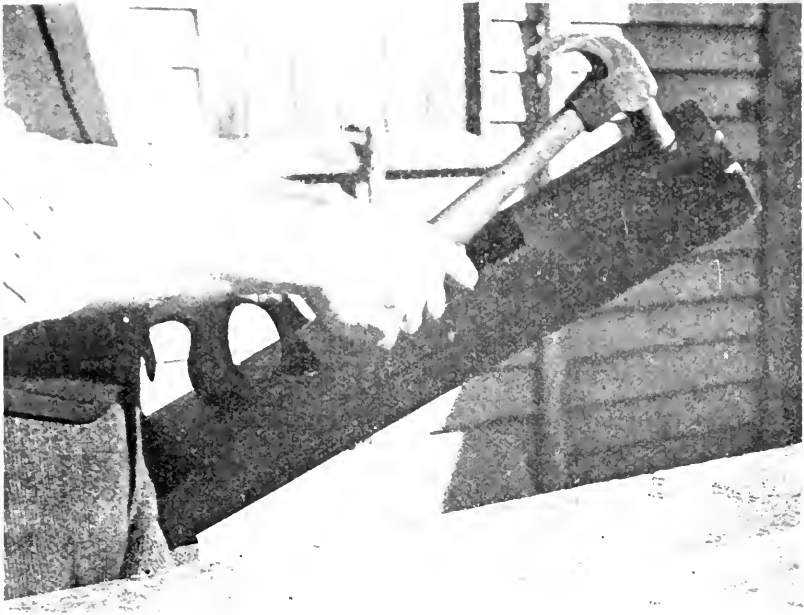


Fig. 11.—Drawing the Iron back a shade.
This method applies to Try and Jack Planes.

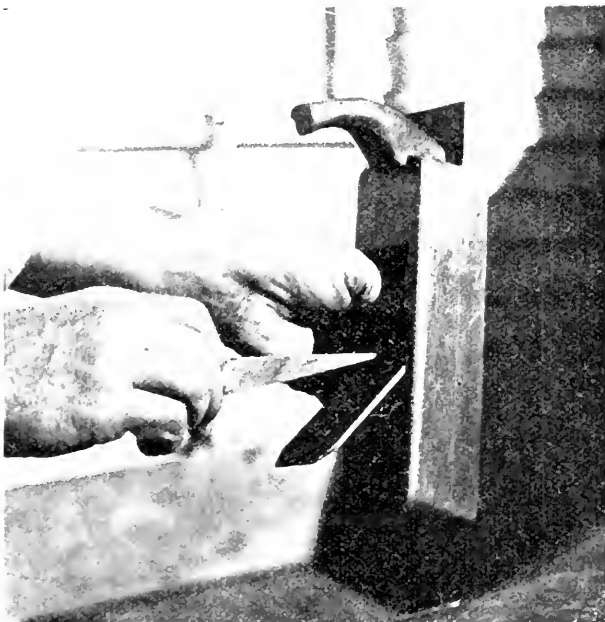


Fig. 12. Inserting the Iron and Woëge in the German Jack.

It is essential that the hands shall not be rocked up and down. The angle of 36 degrees must be maintained on every portion of the stone, or a round edge will be made which will not remain sharp, but will soon necessitate more grinding and more sharpening. Nothing is more disheartening to a beginner than continually to be grinding and sharpening. What should be aimed at is a good, clean, square edge.

Chisels of all sizes are ground and sharpened the same way.

Adjusting the Irons.

The planes are not all handled and adjusted the same way. The two largest—the try and the jack—being adjusted in the same way, may be dealt with first.

To withdraw the wedge and iron of the jack, grip the plane in the left hand, and then with the right hand grip the wedge and iron, and strike the front top side of the plane on the solid portion of the bench (see Fig. 7). This will release the wedge and iron.



Fig. 13.—Inserting the Iron and Wedge in the Smoother.

Though the extremes in the classes of work they are intended for, the German jack and the smoother are the two smallest planes, and they are handled and adjusted alike. To withdraw the wedge and iron, grip the plane in the left hand, then with the right hand grip the wedge and iron (Fig. 8), and strike the back end of the plane on the solid portion of the bench. This will release the wedge and iron.

The releasing of the wedge and iron of all four planes can be effected by striking with the hammer on the same part of the plane as was struck on the bench, but the hammer tends to spoil the plane, and tradesmen who take a pride in their tools are particular how they strike their planes with the hammer on account of the danger of disfiguring them.

The setting up of the planes next occupies us, and again we take the two larger planes first. Grip the plane (try or jack) with the left hand, and resting the plane end on the bench, with the thumb in the throat (see Fig. 9),

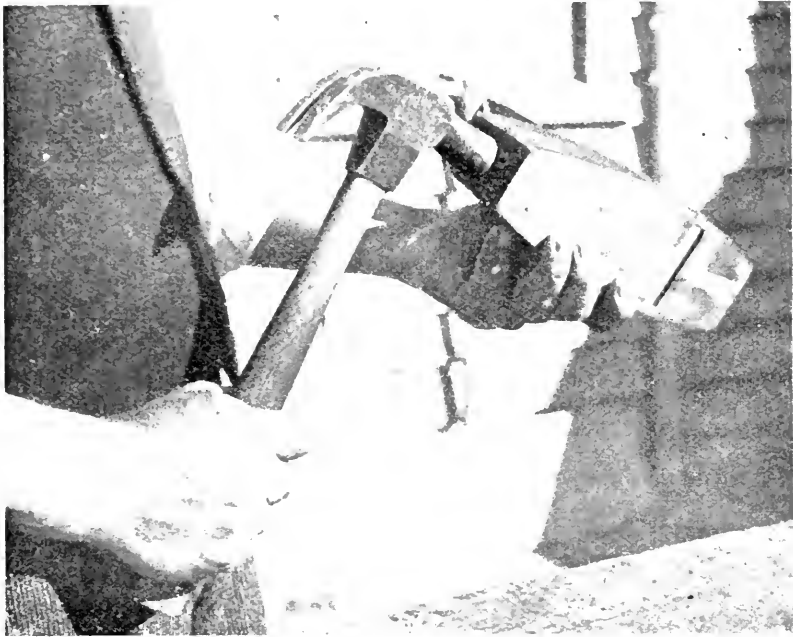


Fig. 14.—Drawing the Iron back a shade

The method is the same for Smoother and German Jack Planes.

take the irons and slip them into position, holding them with the thumb: now slip the wedge into position, still keeping the thumb of the left hand on the irons, but so that the points of the wedge slip up on either side of the thumb. Then with the hammer give the wedge a light tap—just enough to hold the irons in place (Fig. 10). Now turn the plane over and sight it along the sole to see how the iron is. It will be observed by the tyro how easily the plane is handled when gripped in the manner suggested. If the iron is too far out, give the plane (still held in the left hand, the thumb in the throat, and resting on the wedge and iron) a light, sharp tap with the hammer on the front top side. The plane must be struck quite square with the face of the hammer, so that it will not be marked (Fig. 11). The effect of the blow is to draw the iron back a shade. After each tap on the front of the plane give the wedge a light tap (Fig. 10), to make sure that the iron does not fall out and get “gapped.”

Turning now to the two smaller planes, the method of gripping them with the left hand is the same as with the larger planes. Slip the iron and wedge into position, as described, then give the wedge a sharp tap with the hammer, and inspect the sole of the plane as before (Figs. 10, 12, and 13). If the iron is too far out, still holding the plane with the left hand, as before, give the plane a light, sharp tap with the hammer on the back end of the plane (Fig. 14); this will draw the iron back a shade. If one corner of the iron projects more than the other, give the top of the iron a tap the opposite way, and again tighten the wedge. Finally, when the irons are set to satisfaction, give the wedge a couple of sharp taps, making the iron and wedge secure.

The Use of the Planes.

The correct handling of tools is one important factor in obtaining success with them. In using the planes, the correct position in which to stand at the bench is with the feet about 2 feet 6 inches apart, the left foot parallel with the bench and the right foot at right angle to the bench. This position gives a firm foothold. The two large planes are held alike. The handle is gripped with the right hand and the front top of the plane with the left hand, the elbow pointing directly ahead (see Figs. 15 and 16).

In the case of the smoother, which has no handle, grip the back of the plane with the right hand, at the same time holding the wedge and iron with the thumb and first finger, and with the left hand grip the front of the plane (see Fig. 17). The German jack is gripped at the back with the right hand, just as in the use of the smoother, and the left hand takes hold of the horn in front (see Fig. 18).

A brief description of how to square a rough piece of sawn timber may be of interest, as the initial part of any job. It is necessary first to know what amount of reduction is required. If the rough timber is only to be reduced one-eighth of an inch, for instance, the whole of that reduction must not be taken off the first side, or the discovery will be made that the other side has yet to be planed off and that there is no margin on which to do it without spoiling the job. The first thing to do is to get one side absolutely true. This involves getting the timber true as to length and breadth, and also as to anything in the nature of a twist. It might be thought that provided timber is true as to length and breadth it is absolutely true, but not necessarily so. There may be a twist (or "wind") in it, and this must be carefully worked out in getting the first side true.

The German jack will be used to take the rough or "dirt" off, the jack will partly straighten the piece of timber, and the trying-plane should make it perfectly true.

To ensure that it is free from a twist, two "winding sticks" are required. These are two pieces of timber, each 12 inches long by $2\frac{1}{2}$ or 3 inches with and $\frac{1}{2}$ to $\frac{3}{4}$ inch thick. They are bevelled on one edge, and one has side straight edge painted white while the other has the straight edge painted black (see Fig. 19). To test a piece of timber, the two sticks are placed on the timber and sighted to see that they are perfectly level. In the case of a long piece of timber the winding sticks should be tried in several places to make sure that the face is perfectly level and uniform. If the winding sticks discover a twist it must be planed out before the other sides of the timber are attempted.

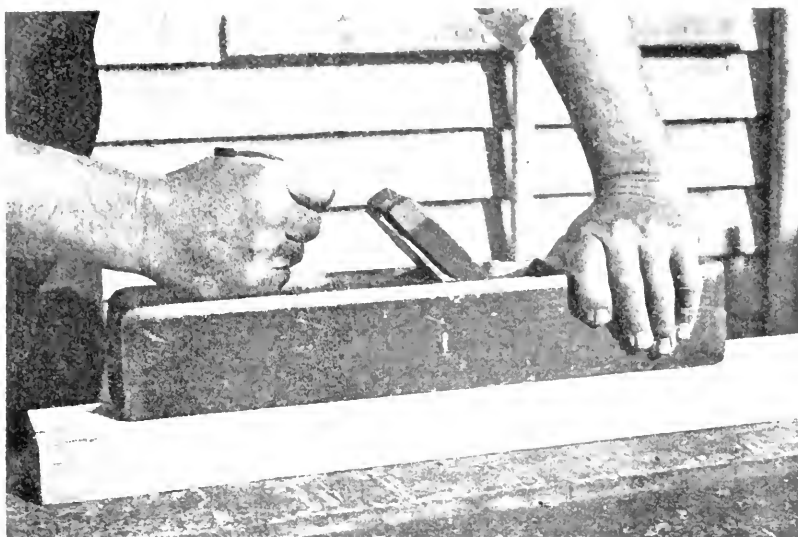


Fig. 15.—The Correct method of holding the Jack Plane while planing a surface.

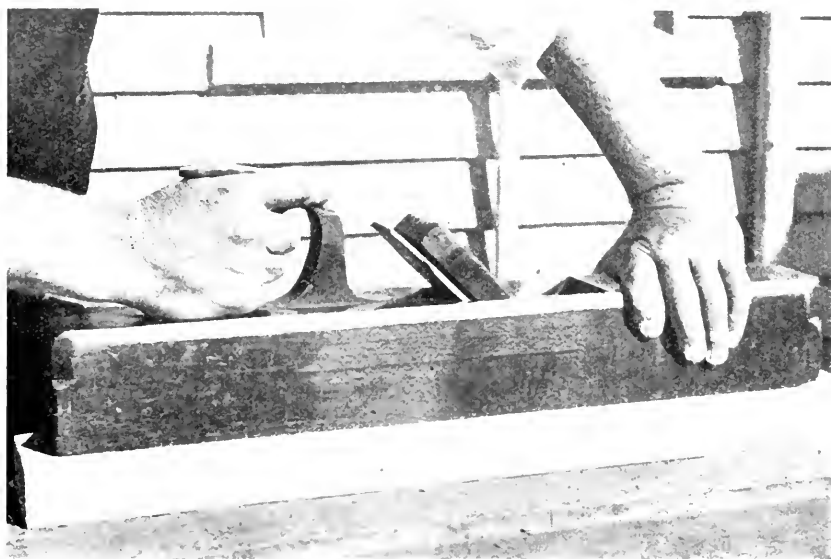


Fig. 16.—The Correct method of holding the Try Plane

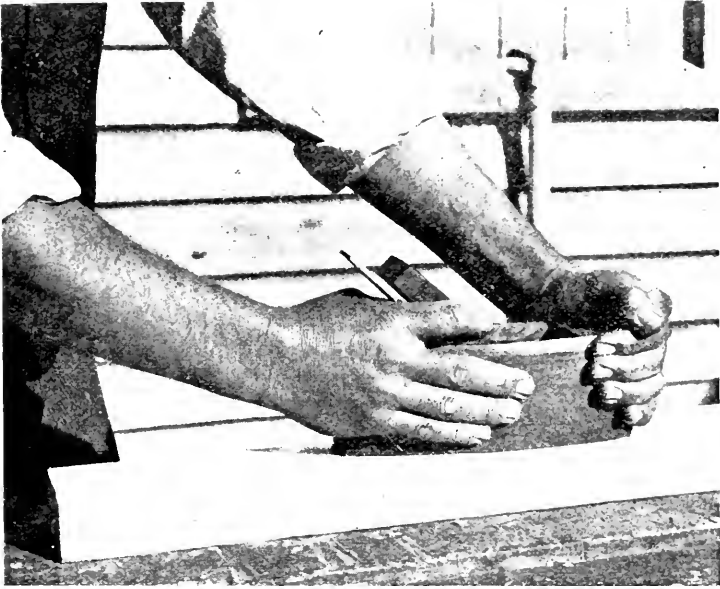


Fig. 17.—The Correct method of holding the Smoother.

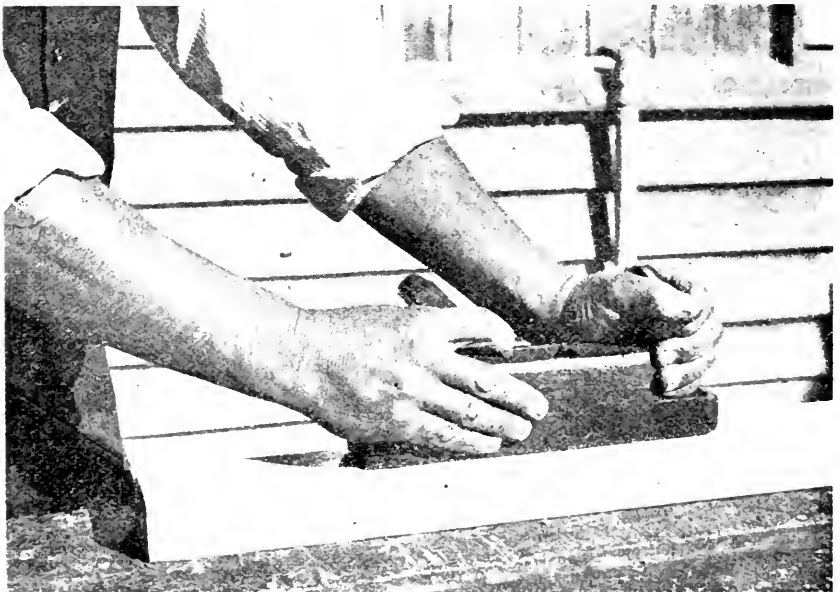


Fig. 18.—The Correct method of holding the German Jack.

Many beginners have a bad habit of continually planing away where the plane will bite, but it has to be learned that the plane may be biting where further planing is only spoiling the job. It is an illusion to imagine that because shavings are coming off that that is the spot for further planing. Sometimes a hollow exists where the plane is not biting, and it is necessary to work the hollow out. To do this the high portions of the timber must be planed off until the plane takes an even shaving off the full length. Sometimes the failure of the plane to bite is due to the condition of the tool.

The face side of the timber, which is the most important, must be made quite true. From it the "face-edge" is next worked straight and square. This is done with the same set of planes and also with the square. The brass plate of the square must be kept up against the face side, bringing the steel plate down on the edge, and drawing it from end to end to ensure that no

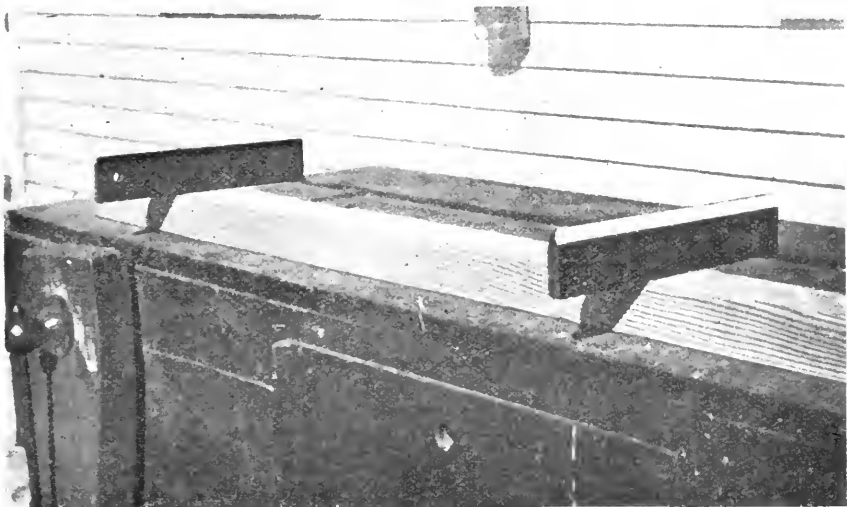


Fig. 19.—The Winding Sticks.

daylight can be seen under the steel edge. The face-edge must be tested with the square until it is right, and at the same time watch must be kept along the edge to see that it is true. Having two sides thus trued and planed up, take the single-tooth marking gauge, set it to the finished thickness, and run the gauge round on the untouched sides, one at a time, gauging off the face side. The thickness of the timber has to be reduced to the gauge-line with the same set of planes. Both winding sticks and square are done with now, and there is only the gauge-line to watch.

The width of the final side of the timber is gauged in the same way and planed down. If any smoothing has to be done it should be done now with the smoother, but only very lightly, or the timber will be put out of shape again.

SAWS.

The saws commonly in use number four, namely, (1) the rip-saw, for cutting down the grain, No. 4 (four points to the inch); (2) the hand or panel saw, for cutting across the grain, Nos. 7, or 8 (seven or eight points to the inch); (3) the tenon-saw, for cutting tenons and shoulders and for fine work (14 inches long); and (4) the turning saw, for cutting circles, &c.

As everyone who uses tools knows, there are such things as saws that are too stiff and those that are too limp, and to choose what one wants in these respects is not hard. A saw can be tested by taking the handle in one hand

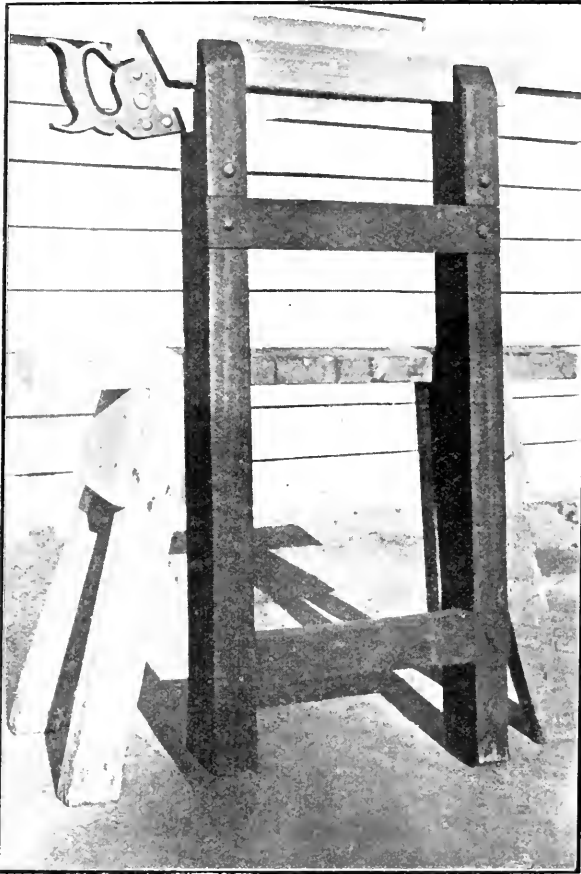


Fig. 18—A Saw Clamp.

and the tip in the other and bending the tip around to the handle; if it is hard to get them to meet the saw is too stiff, but if it is too easy to bend in this way and if a buckle appears in the saw it is too limp. A saw that comes round fairly stiffly and springs back straight without leaving a buckle is the one to pick. The quality of the steel is indicated by the ring. On the whole, however, it must be admitted that there is a good deal of luck in buying tools and especially in buying saws.

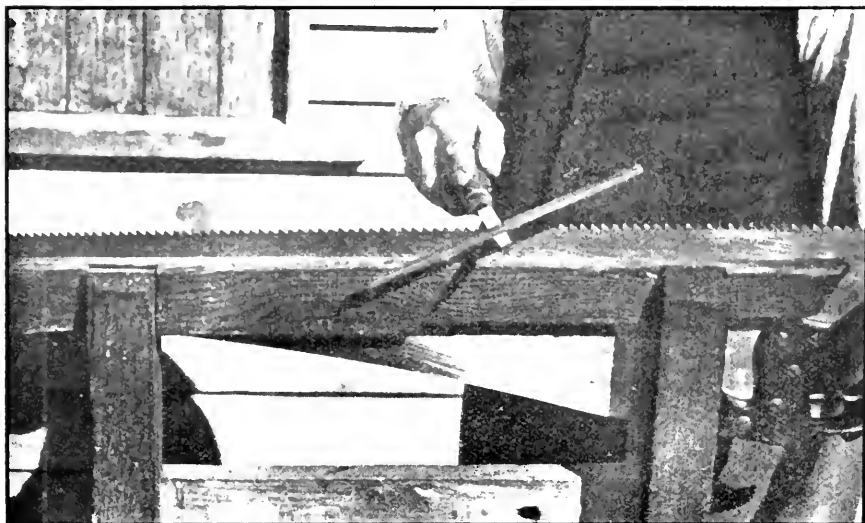


Fig. 19—The most important angle to watch while Sharpening a Saw.

The angle is indicated by a flat file laid on the top side of the triangular file with which the actual sharpening is done.

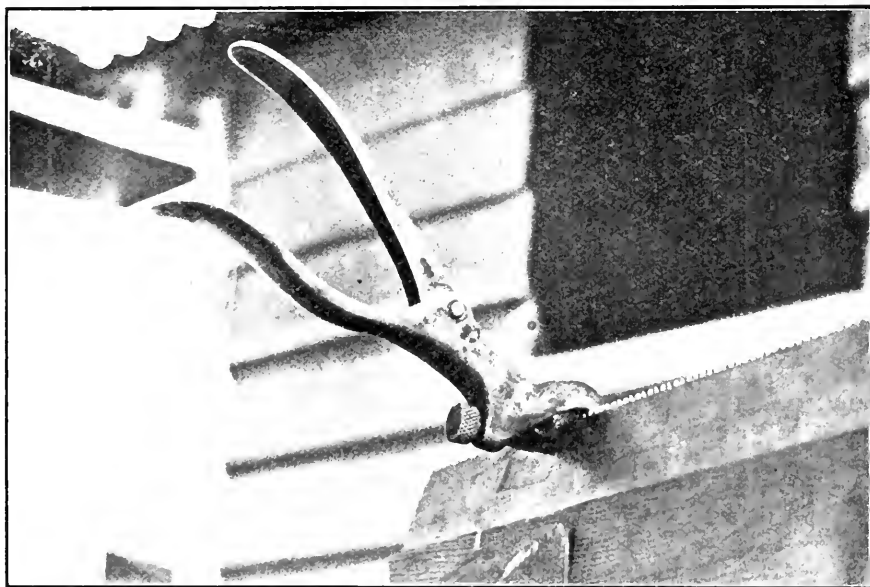


Fig. 20—An Adjustable Saw-set.

Sharpening the Saw.

Before being sharpened, all saws should be run over from handle to tip with a flat file, an old mill-saw file being the best for the purpose. This is done by holding the saw by the handle, laying the file along the tips of the teeth, and running it down the tips. The effect is to bring all the teeth to a uniform height and remove any unevenness such as may have been caused by several teeth striking a nail and having the tips taken off. The rip, hand, or panel saws should have a slight belly in the centre, but a tenon-saw should be straight.



Fig. 21—The Correct Use of the Saw.

Starting the stroke.

The teeth now being all of one height, we shall start to sharpen with a triangular file. This, be it admitted, is a most difficult matter for a beginner, who, if not very careful, will reduce the teeth to all shapes and sizes and leave the saw worse than it was before he touched it. The saw must be held in an upright position in a vise of some kind. The best hold of all is

obtained with a pair of saw chocks or clamps (see Fig. 18), but if these are not available, an ordinary vise may be used. If the vise is an iron one, then the saw should not be gripped between the metal jaws, but between pieces of wood on either side, by which it will be found a much better hold will be obtained without damage to the saw.



Fig. 22 The Correct Use of the Saw.
Finishing the stroke.

Start filing at the tip of the saw, filing the back of every tooth that is leaning away from you, and the front of every tooth that is leaning towards you. As the teeth lean alternately to you and from you, this means that you use the file on each alternate tooth, leaving the other tooth to be dealt with afterwards from the other side. Most attention must be given to the filing of the tooth that is leaning away from you; it will be found in a little while that the front of the tooth leaning towards you is at the same time receiving attention, but the thing to watch is the back of each tooth that leans away.

The operation is, needless to say, a delicate one and three things are essential in handling the file :—

1. The top side of the file itself must be held at exactly the same angle on every tooth. By merely altering the angle at which the triangular file is leaning a very uneven job will result. If, for instance, the top side of the file leans first at the angle shown in Fig. 19 and then at another angle, it is impossible for the job to be a satisfactory one. It is this angle that determines the amount of "hook" on each tooth, and it is most important that it be uniform. The angle indicated in Fig. 19 (the top side of the file not quite flat, but leaning slightly to the tip of the saw) will give a satisfactory "hook." This hook should be greater in the case of the rip-saw than in other types.
2. The hand must be held at a uniform height throughout ; it should not be held first high and then low, or an uneven set of teeth must result. Some men drop the hand and file upwards, but this is not satisfactory. The file should cross the saw at right angles to the side of the saw—in other words the point of the file should neither be elevated nor depressed, and it should be so throughout the job.
3. The direction at which the file is worked across the saw must also be uniform. Swinging the hand from one side to the other will be as unsatisfactory as swinging up and down. In the case of a rip-saw, the file must go straight to and fro at right angles to the length of the saw. With other saws, the handle of the file should be slightly inclined towards the tip of the saw. The effect is to form a sort of diamond point.

If the teeth are in good order and regular it is only necessary in sharpening to see that the file is pressed firmly into the angle between the teeth, but if the teeth are uneven the file must be used with a little weight on it, one way or the other, to put the teeth in order again. Where a saw is in very bad order indeed, it is sometimes necessary to run the teeth down and retoothe the saw, cutting out new teeth.

The alternate teeth having been treated in the way described, the remaining teeth are treated in the same way and with the same care from the other side.

Setting the Saw.

The "set" of the saw is a term employed to suggest the amount of spread that the teeth have sideways, the teeth being pointed alternately one way and then the other. Only one-third of the tooth should be bent outwards—the whole of the tooth should not have an outward lean.

With the rip-saw, very little spread is needed—sometimes none at all, but with the hand-saw (used for cutting across the grain) there should be more set, especially for green timber. When the teeth are set, there should be a distinct V or slight depression down the centre if the saw is held so that you look along the tips. The teeth must be evenly set, one side having no more spread than the other. A special "saw-set" can be obtained, which can be simply adjusted to the size of tooth and amount of spread desired (Fig. 20).

Saws must be kept away from all dampness, and may be smeared with oil at times to protect them from rust. The fumes of muriatic acid (spirits of salts) are also very destructive to them.

Handling the Saw.

Everyone can handle a saw, or thinks he can, but those who do it to the best advantage are not so numerous. In starting a cut, it is a common mistake to allow the weight of the end of the saw to rest on the timber, with the result that the teeth catch and fail to run free, the work being poorly



Fig. 23 The Correct Use of the Saw.
Keep the arm-pit plumb over the saw-cut.

begun. It is in the effort to avoid the catching that results from this error that so many people begin a cut by drawing the saw up to them. The right way is to start the cut with the tip of the saw (Fig. 21), striking the timber very lightly at first, and then, as the saw runs down the edge, allowing an

increasing weight to come on the timber. In this way the cut is properly started in the first movement of the saw (Fig. 22). The novice, watching a cut started in this way, will remark on the ease, balance, and surety with which the tool is handled, and no doubt the secret of the successful use of all tools lies just there; but no way to acquire this command over the implement under discussion is to learn to strike correctly—to allow no weight of the saw, or hardly any, to rest on the timber at first, and to increase it slightly as the saw comes down the first time. M.H.E.E.

The position in which the operator stands is also of importance. He should stand with the saw in the right hand, leaning over his work, with the armpit in line with the cut that is to be made, so that as the saw is brought up, the handle is brought up into the armpit (Fig. 23). This brings the saw up straight in the cut. The tendency with the beginner is to draw the saw-handle towards himself as he brings his hand up, the result being that the blade not being straight, the cut is a rough one, the work is hard, and the result unsatisfactory. A long steady stroke, with a free movement, is what is required.

“Let the saw run itself,” says the tradesman, and so, too, the man with a little practical experience.

TOOLS SUITABLE FOR USE ON A FARM.

The following list of tools has been prepared as an indication of the equipment likely to be most useful on a farm. The prices quoted are a little approximate in some cases, perhaps, but in the total the variation in any retail shop of repute will be very trifling. Fluctuations in market values must, of course, be expected:—

Tools.	Prices.	Tools.	Prices.
	£ s. d.		£ s. d.
1 Smoothing-plane, 24"	17 0	6 Chisels, Firmer Socket, 3", 1/2", 5/8", 3/4", 1", 1 1/4"	16 3
1 Trying-plane, 2 1/2"	1 7 0	1 Brace, all iron, 16"	10 9
1 Jack-plane, 24"	1 1 0	6 Bits, double twist, 1/2", 3/4", 1/2", 5/8", 3/4", 1"	1 1 0
1 German Jack-plane, 1 1/2"	10 6	11 Bits, Nail, Nos. 2 to 12, @ 6d. each	5 6
1 Rebate-plane, 1 1/4"	10 3	1 Screwdriver, 10"	3 6
1 Rip-saw, "Disston's," 28"	16 5	1 Mallet	4 9
1 Hand-saw, "Disston's,"	16 5	5 Augers, 1/2", 5/8", 3/4", 1", 1 1/4"	1 9 3
1 Tenon-saw, "Disston's," 14"	12 6	1 Spokeshave	3 6
1 Nest of saws, "Disston's,"	7 6	1 Adze, No. 2	9 9
1 Saw-set	6 9	6 Bradawls	3 0
1 Oilstone	5 0	1 Hatchet	5 6
1 Rule, 2 ft	2 1 1/2	1 pair Compasses, 8"	3 9
1 Claw-hammer, No. 5	6 3	1 Wood Rasp, 12"	2 3
1 Square, 12"	6 0	1 Oil-can	2 9
1 Square, 6"	3 0	1 Spirit-level, 24"	7 6
1 Bevel, Sliding, 10"	3 0	1 pair Pliers, 7"	3 3
1 Draw-knife, 10"	5 0	1 pair Pincers, 7"	3 0
1 Marking-gauge, Single	1 3	1 Metallic Tape, 66"	15 9
1 Mortise-gauge	5 0		
1 Carriage Clamp	5 6		
4 Chisels, Socket, 1/2", 5/8", 3/4", 1"	12 0		

SOLDERING AND BRAZING.*

Solder is the name given to several different alloys used for the purpose of making joints between different metals, which, if properly done, do not consist merely of sticking the metals together, but form a real weld or a fresh alloy.

The composition varies very much. Every solder should, and must, be more fusible than the metal to be united or joined together; therefore, hard solders can only be used on metals that will stand a high temperature without melting. Soft solders melt at a low temperature, and may be more generally used.

In preparing to solder, the surfaces to be united must be perfectly clean and lie close together, and the surfaces so cleaned must be protected from the air by a coating of a suitable flux. The usual flux for iron and tin is muriatic acid, more commonly called "spirits of salts," which is weakened or killed by adding water or zinc.

The Tools.

The necessary tools required are a soldering iron, about 1 lb. weight; a block of sal ammoniac; a small brush, usually made of horse-tail hair, bound in a piece of tin as a handle; a glass or earthenware pot to hold the spirits of salts; an old flat file; an old pocket knife; and a fire-pot. The last-named is an oil-drum with a few holes in the bottom, and, say, three holes about 2 inches square in the sides, near the bottom, through which to pass the irons while heating. Where much work is to be done, it is as well to have at least two irons, so that one is in the fire while the other is in use.

Wood and coke are the best fuels to use.

The iron should be drawn out to a point (not sharp), about a quarter of an inch, and slightly rounded off. To prepare it for use, it must first be heated to a dull red heat, and the point for about 1 inch back filed clean while hot; then rub it on all sides on the sal ammoniac, lay a little solder on it, and dip it into the killed spirits. This will tin the point of the iron, and unless it is overheated in the fire when reheating, it should keep the tinning for some time. The use of the sal ammoniac is sometimes dispensed with; but the tinning is not so good a job. Each time it is heated (not a red heat, but just enough to melt the solder easily) it must be wiped off on a piece of bag, or similar material, and the point dipped into the spirits. It is then applied to the joint in such a way as to heat the metal, and the strap of solder, placed against the point of the iron, runs into the joint and forms the weld. Never use the iron if not hot enough to melt the solder easily.

Solder.

To make your own solder is the surest way to have the right sort. Melt down, in an iron pot, 2 parts lead and 1 part block tin; and when melted, the pot being red hot, skim off the refuse that floats on top. Then with a ladle, first slightly heated, pour the solder into the hollows of a sheet of small corrugated iron, making long or short sticks as required. This mixture will do for ordinary work on galvanized iron or heavy tinware, such as dairy cans.

* A. Brooks, Works Overseer, Department of Agriculture.

Brazing.

Brazing is done with granulated spelter and borax, spread over the surface of the joint, and exposed to a clean open fire. The joint to be made must be well cleaned and otherwise prepared previous to heating.

The following table shows mixtures for different solders and brazings to be used for the purposes mentioned:—

Solders.	Materials.				Purposes.	Fluxes.
	Tin.	Lead.	Zinc.	Copper.		
Brazing spelter, soft	...	...	1	1	For brass-work.	} Borax.
Do hard	...	...	2	3 to 6	For copper, iron, and steel.	
Plumber's solder, fine	1	1½	...	...)	For ordinary work.	} Muriatic acid or spirits of salts.
Do ordinary	1	2	...	...)
Do coarse	2	1	..	...	For tinman's work.	

PAINTING.*

The object of painting is to preserve the more perishable parts of a structure from the effects of the weather; and, properly speaking, all woodwork to be painted should be thoroughly seasoned, otherwise the paint, by confining the sap and moisture, only hastens decay. New work usually receives three coats, the first or priming coat and two more, and each coat should incline towards the required finished shade or tint of colour.

The selection of colours is a matter that requires some experience if the blending is to be agreeable with the surroundings. Generally, the wish of the owner of the house is consulted; but after a little argument it is usual to find that the painter's suggestions are taken and acted upon.

For outside work on weatherboard cottages, it is now very fashionable to paint the walls in red, terra cotta, or green, with the windows and other parts picked out in either white or buff. Doors may be dark greens or in browns.

It must always be borne in mind that when two different colours are placed side by side they must be of a very different shade, one being light and the other dark. Stone colours are much used, one reason being because they are more easily mixed by an amateur than greens, greys, or buffs. The durability of the various colours, or rather the materials used to produce them, varies less than is generally supposed. All colours fade somewhat, and the darker colours, such as olive or sage-green, show the effect of fading more plainly than most others. These will stand better if put on over a coat of red—that is, white lead covered with Venetian or Indian red, and yellow ochre. Yellows bleach out by exposure, and browns take on an ashy appearance.

* A. Brooks, Works Overseer, Department of Agriculture.

Staining and varnishing is often done to the walls of wooden buildings externally instead of painting, and, besides looking well, is cheaper. The stain may be boiled linseed oil, oil of creosote, or linseed oil mixed with umber, vandyke brown, sienna, or other staining pigments, and a coat of varnish put on to finish with. This may be done on either hardwood or pine boards.

All work, whether inside or outside, should be carefully prepared if a good job is desired. The whole should be carefully cleaned down, all knots of a resinous nature treated with a coat of knotting varnish or glue size, and the first coat carefully applied. When this has dried, all cracks, nail holes, &c., must be properly stopped with putty, and rubbed off smoothly. The putty must not be put in until the first coat has been applied, otherwise the wood will absorb the oil out of the putty and it will fade out. Before the second coat is applied the first must be thoroughly hardened and dry, and the same applies to the last coat.

In preparing old work for painting, it is necessary first to see that all repairs to windows, doors, mouldings, &c., are done by the carpenter, and then to clean down as before mentioned, raking out all loose putty; and where the surface is bad or blistered, it will be necessary to rub off with pumice-stone and water. Use a lump of pumice with a flat face on it, and rub off the old paint down to a smooth surface. All putty in the sashes should be looked to, and, if necessary, cut out and renewed. All ironwork, such as verandah roofs, gutters, down-piper, and tanks, should be scraped off clean, and these should be painted in one coat only, to a finish.

Materials used.

Briefly, the materials of which ordinary paint is composed are white lead, linseed oil, driers, turps, and various other ingredients to obtain the required colours. The latter are called 'stainers.'

The oil soaks into and fills the pores of the wood, forming a resinous surface, which keeps out the air. The driers quicken the drying process of the oil, and the white lead gives a body to the paint, combining with the oil. Turps (or turpentine) is used merely to save oil and make the paint spread or work more freely. It soon evaporates, and takes no part in protecting the wood. Red lead is generally used with the first or priming coat, as it dries well and sets hard.

Proportions of Lead, Oil, &c., to use.

The following should make sufficient paint to cover about 100 square yards of new work:—

	Red Lead.	White Lead.	Raw Oil.	Turps.	Driers.
	lb.	lb.	pints.	pints.	lb.
First coat	1	15	6	.....	.....
Second coat	.....	15	4	$\frac{1}{2}$	$\frac{1}{4}$
Third coat	.....	13	$2\frac{1}{2}$	$1\frac{1}{2}$	$\frac{1}{4}$

For flatted work mix the lead with turps only.

For outside work $1\frac{1}{2}$ pints of raw and $1\frac{1}{2}$ of boiled linseed oil may be used for the last coat, instead of $2\frac{1}{2}$ pints of raw oil.

Colouring Pigments generally used for common colours.

Stone colour: Burnt Turkey umber, raw Turkey umber, yellow ochre.

Drabs: Burnt umber and yellow ochre.

Bufs: Yellow ochre and Venetian red.

Greys: Lamp black, Indian red, ultramarine blue, vermilion.

Brown: Burnt sienna, Prussian blue, yellow ochre.

Greens: Brunswick greens, dark and light; with blue and chrome yellow.

Mixing.

The white lead is ground to a paste in oil, ready to mix with more oil, &c., as stated, to prepare it for use. The colouring matter is mixed in a similar way and added to the white lead and oil until the required tint is obtained. The whole is then strained, either through a piece of canvas (usually a piece of chaff bag tied over the mouth of an oil drum), or a fine-mesh wire strainer, the paint being worked through with an old brush. If found to be too thick for immediate use, a little oil and turps may be added. The strainer when finished with should be placed under water, to keep it soft and fit for future use. If mixed paint has to be laid aside for a few days, it should be covered with a little water to prevent a skin forming on the surface.

Brushes.

The most useful brushes for ordinary work are the flat type, in sizes from $1\frac{1}{2}$ to 5 inches wide. They may be used for all work, including cutting in around sashes, mouldings, &c., or for painting of broad surfaces, such as weatherboards. New brushes should be set for a few hours in clean water or raw oil before being used. At no time when out of use should they be exposed to the air, but set into clean water, say, 2 inches deep, sufficient to keep the ends of the bristles soft. To clean a dark colour out of a brush so that it can be used in a lighter colour, work it briskly in a little raw oil, which can afterwards be used in other paints. To clean a brush that has been neglected, soak it in hot turps, kerosene, or a strong solution of washing-soda.

Application.

See that the surface to be painted is cleaned down—that is, all dust brushed off and anything that requires rubbing down is attended to, as previously recommended, either with pumice-stone or glass-paper.

Start at the top and work downwards, so that if any paint falls off the brush it will not injure the finished work. Apply quickly and evenly, leaving no brush marks, and finish with the grain of the wood. If the paint seems to run, it is either too thin or the surface is not clean—probably greasy, if you are painting old work. This should be given a coat of hot lime-wash, and allowed to dry before paint is applied. Always allow one coat to be thoroughly hard and set dry before applying the next.

If doing outside work, select fine weather when neither dust nor flies are about, as nothing makes the painter more annoyed than to have a dust-storm rise when he is applying the finishing coat.

It is a general idea that the first coat should have only a small proportion of white lead in it. It should really be just the opposite, and have rather more than the next coat, because white lead clings to the wood with far

more tenacity than any other of the ingredients in paint. The best lead will keep its hold after the oil with which it has been mixed has disappeared, forming the "chalky" surface so familiar on old buildings, fences, or gates.

A Useful Lime Wash.

The following mixture may be used on rough timber, brickwork, or corrugated iron, and will reduce the temperature of houses when applied to the roof equally as well as the best refrigerating paint sold:—

10 lb. of fresh unslaked stone lime; 1 lb. glue; 1 lb. powdered alum.

Slake the lime with hot water, keeping it well covered over during slaking. Dissolve the glue, also the alum, in boiling water, and add to the already slaked lime, taking care not to make too thin. Strain the whole as for paint, and cover over for two days or more, when it is ready for use. Apply with an ordinary two-knot whitewash brush, giving the work two coats, the first to be thoroughly set before the next is applied; and if on roofs or tanks, apply in cool weather. Colouring matter (ochres) may be added if necessary. A little blue improves at all times.

THE USE AND CARE OF ROPE.

A large assortment of fibres, either pure or in mixtures, are made into cordage. In a rapid survey of all these rope-making materials, none stands out with such pre-eminence as Manila hemp. The fibre is produced from the Abacá (*Musa textilis*), a plant closely related to the banana. Its cultivation is almost exclusive to the Philippines, where it forms three-quarters of the total export. The fibre is 6 to 12 feet long, and is wonderfully resistant, forming one of the strongest and most satisfactory ropes for farm work now manufactured. It is moderately pliable, nice to handle, and will stand the wet so successfully that it is rarely if ever tarred.

Manila hemp is one of the few fibres that can be used with success in self-binding machinery. Sisal is also used quite extensively for binder twine either pure or mixed with New Zealand and Manila hemp, and, with the rapid development of self-binding machinery, its use will probably become more and more extensive where Manila cannot be procured. A trial of sisal in the reapers and binders was conducted at Hawkesbury Agricultural College some years ago, but it was found too stiff and liable to kink, while the tie did not hold with the tenacity of Manila. It is estimated that sisal has only about two-thirds the working strength of the best Manila.

The maximum strain could be resisted by a rope if the fibres were laid parallel. This being impracticable, the fibres are first twisted into yarns; these are laid up into strands; and finally three strands go to make the rope. The object of twisting is to make the rope portable, and to ensure that, by mutual friction, the fibre, yarns, and strands may hold together when the strain is applied. Laying up or twisting a rope decreases the strength, but increases its durability. The farring of rope results similarly in excluding the wet, and preserving the rope at the expense of the breaking strain.

Rope is measured by its circumference, and sold by weight. The following table will give an idea of the approximate weights of convenient lengths of Manila:—

TABLE showing Approximate Weights for given Lengths of Manila Rope.

Coils.			Weight.			Coils.			Weight.		
feet.	Size.		cwt.	qr.	lb.	feet.	Size.		cwt.	qr.	lb.
800	$\frac{1}{2}$		0	0	14	100	$3\frac{1}{2}$		0	1	16
800	1		0	1	0	100	4		0	2	0
800	$1\frac{1}{2}$		0	2	10	100	5		0	3	4
800	2		1	0	5	100	6		1	0	14
800	$2\frac{1}{2}$		1	1	22						
800	3		2	0	12						

To prevent rope, and more especially binder twine, from kinking, it is necessary when commencing to use it from the centre of the coil, to make it unwind in the opposite way to that in which the hands of a clock revolve. The end is usually protruding from the correct side of a ball of binder twine, but before threading it, or tying it to the upper ball in the twine box, this point should be looked to, and if necessary the end pushed through to the other side.

Splicing.

In studying splicing, it is essential to have a clear understanding of the

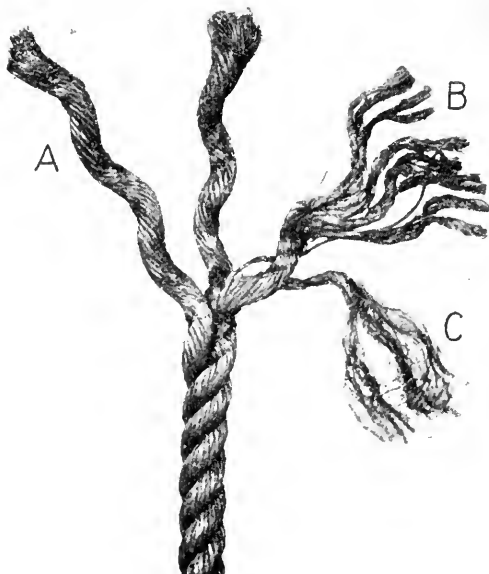


Fig. 1.—Analysis of a Rope.

a. Strands. b. Yarns. c. Yarns unraveled to show fibres.

analysis of a rope. The yarns are formed by twisting the fibres to the right, *i.e.*, clockwise. Several yarns twisted anti-clock-wise form a strand, while three strands laid clockwise, like the yarns, go to form the ordinary three-strand rope. (Fig. 1.)

Before continuing further, the fact should be emphasised that this article will prove practically valueless unless the reader takes a three-strand rope into his hand, and endeavours to follow out the instructions given with the aid of the illustrations. It should not take more than an hour to learn the elementary principles, and it will be found surprising how often a knowledge of splicing can be applied in everyday work.

There are two common splices, the short and the long. For average work on the farm, where the rope is not to be used in block and tackle, a short splice is all that is necessary. But where a uniform thickness is required

throughout, the long splice is essential. There is little difference in the relative strength of ropes spliced by these two methods; the quality of the work is a far more influential factor in determining which should be used. A well-made splice will reduce the strength of a rope by about one-eighth.

The Short Splice.

In a short splice the strands are laid back a distance which will depend upon the thickness of the rope. A little practice will soon enable one to gauge how far, but as a guide to start with, it may be mentioned that 9 inches will amply suffice to splice ordinary ploughreins of $1\frac{1}{4}$ inches circumference. Such rope is the best to practise on, and it should preferably be moderately new, as old worn rope unravels too easily and makes the work doubly hard.

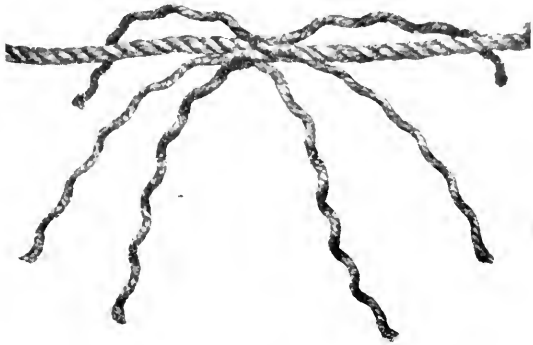


Fig. 2.—Short Splice. The two ropes laid back and brought end to end, ready for splicing.

The ropes are then brought end to end, as hard up as possible, with each strand of No. 1 rope between two strands of the opposite rope, No. 2 (Fig. 2). No. 1 rope and the strands of No. 2 rope are held very firmly in the left hand, and to commence with may be temporarily lashed in position. The strands of rope 1 are then interwoven with those of rope 2, by taking each one separately, jumping over the strand immediately the other side of it, and under the next one further on. (Fig. 3.)



Fig. 3.—Short Splice. The position of the hands, placing the first strand of Rope 1 under Rope 2.

the first finger of the left hand underneath the strand to keep it open.

The strand that is to be interwoven is then pushed through with the thumb of the left hand. Twisting thus to make room for the strands loosens the rope, and it should be twisted back again every time to its original position before starting with the next strand. Continuing, the other two strands of rope 1 follow suit, going over the strand immediately the other side, and under the next. To make it convenient, the rope is gradually turned over, taking the greatest care not to loosen the grip in the left hand. When one side is completed,

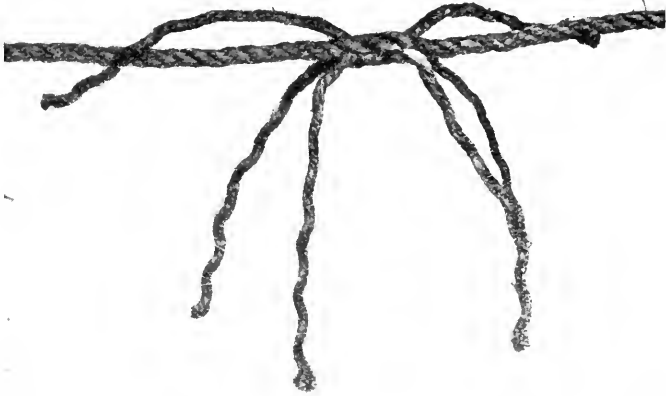


Fig. 4.—Short Splice. Each of the six strands woven once and hauled taut.

the rope is turned so that the strands of rope 2 can be woven into rope 1 with the right hand. The six strands are then hauled taut (Fig. 4), the durability of the splice largely depending on whether this is done thoroughly. The weaving continues in the same way, working at each end alternately, hauling the strands taut, and twisting the rope back into its original position to prevent its getting slack.



Fig. 5.—Short Splice finished. For comparison, one end has been tapered, and the other ended abruptly.

For thick rope, especially when new, a sharpened piece of iron or hardwood called a marlinspike has to be used for levering up the strands, as the rope is too stiff and rough for the fingers.

To taper a short splice at each end, and thus enable it to pass over obstacles with less likelihood of jamming, one or more yarns, according to the

size of the rope, are cut off the strands every time the latter are interwoven, till, at the end of the splice, only one or two strands are passed under, and thus the thickness increases gradually to the centre (Fig. 5).

It is always a good plan, before cutting off the ends, to roll the spliced portion under foot: the ends can then be cut off close, but if this is done before rolling, they soon work their way from under the last strand where they were placed. In old rope the fibres are broken to such an extent that this method of tapering will not succeed, and the best way is to flay out the strands with a knife. The resulting splice is never so neat, nor perhaps quite so durable, but it is the best that can be done under the circumstances.

The Long Splice.

Where the thickness of a short splice will interfere with the convenient handling of a rope, or where any rope above 2 inches in circumference is to be spliced, the best method is to use what is termed the "long splice." It entails the use of more rope, and is harder to make, but the resulting splice is much neater, and its advantages will usually justify the extra trouble.

Somewhere about three times the amount of rope used in the short splice (*i.e.*, about 2 feet in a $1\frac{1}{4}$ -inch rope) is laid back, and the ropes are brought together in the same way. One of the strands of rope 2 is then further laid back, and its place taken by the corresponding opposite strand of rope 1. A strand of rope 2 then takes the place of the opposite and corresponding strand of rope 1. They should be laid up so far that there remains sufficient length to weave into the main rope in finishing off. Each pair of strands should now be equidistant from the pair that remain in the centre, though the ends, except in the centre, will naturally be of unequal length (Fig. 6).

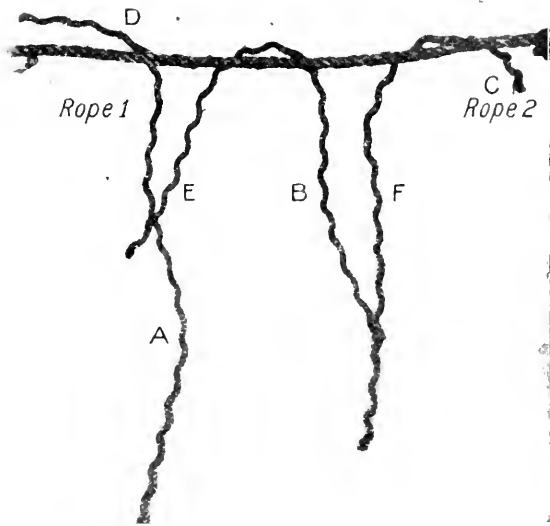


Fig. 6.—Long Splice. The strands laid up into position, ready for finishing off.

Strands A, B, and C belong to Rope 1.
Strands D, E, and F belong to Rope 2.

There are a number of ways of finishing off. The most general is to take half or three-quarters of each strand, and tie with each pair an overhand knot, being careful that when finished each end still lies in the direction it did before. These six ends are then interwoven several times with the main

rope, tapering them gradually off. The quarter or half strand that remains may also be interwoven with the rope, or else cut off, and the ends just tucked away. (Fig. 7.)

The splice must be very carefully made when it is to be used for rope belting, and every care taken to prevent the slightest "belly."

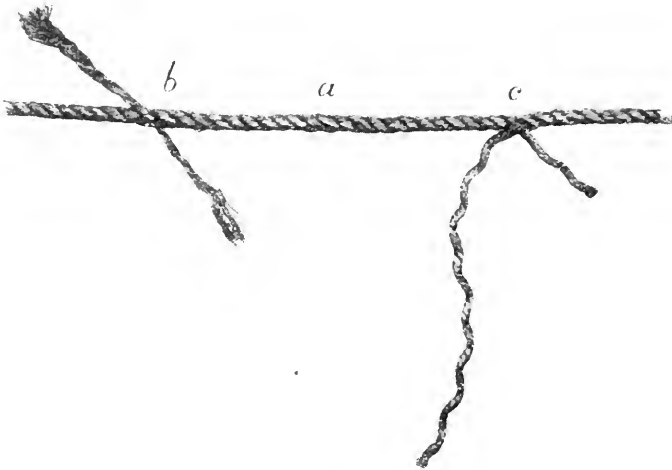


Fig. 7.—Finishing off Long Splice.

- a.* Two centre strands, woven and finished off. *b.* The overhand knot tied, ready for weaving.
c. The two strands not yet touched, after laying up.

The Eye Splice.

The eye splice is easy to make, once the short splice has been mastered, and is very useful for leg-ropes, or wherever a running noose is used. It may be also made around a post or some similar object, but requires very careful manipulation to make it tight.

The strands are laid back as in the short splice, and the rope doubled to make the necessary sized loop. This loop is held in the left hand, while the strands, commencing with the middle one, are interwoven with the right. (Figs. 8 and 9.)

Two precautions must be taken in weaving—first, that the middle strand of the three comes over from the top of the doubled back portion; and secondly, that each of the strands is woven across and not with the twist of the rope. Special care must be taken of the latter when weaving the strand that is nearest the operator, as there is every likelihood of making a mistake at this point.

The Turk's Cap and Crown.

The ends of ropes will unravel very quickly if not prevented by some means. A common method is to lash the end with twine. This takes time, and necessitates the wherewithal to lash it. For certain work it may be an

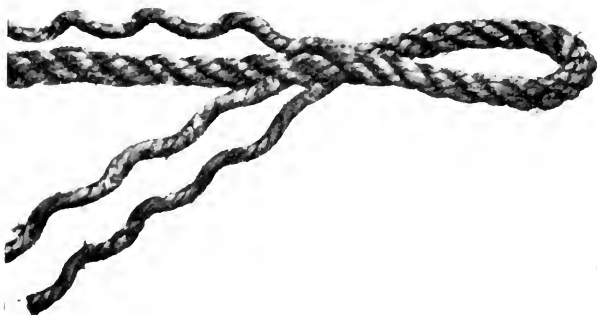


Fig. 8.—Commencing the Eye Splice. The middle strand turned under.



Fig. 9.—The Eye Splice finished. Not tapered.

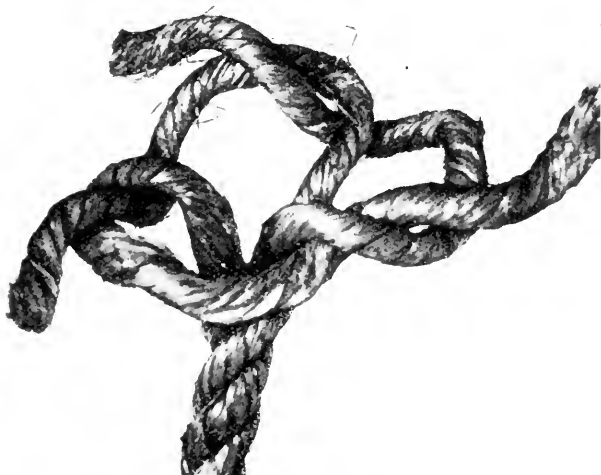


Fig. 10.—The Wall Knot, showing the position of the three strands before hauling taut

advantage to have a knob on the end of the rope, when a Turk's cap or wall



Fig. 11.—The Wall Knot below and the crown above, showing position of the three strands before hauling taut.

knot is the most satisfactory. If, on the other hand, only a moderate thickness is wanted, the "crown" is made, and the strands spliced back two or three times, tapering if necessary.

The Turk's cap or wall knot is shown in Fig. 10. The strands are laid back, and each takes a turn around its neighbour. The third strand, after taking a turn around the second, is inserted upwards through the loop made by the first strand, and all three are pulled taut. The ends can be cut off, but half an inch or more should always be left to flay out, and thus

materially assist in preventing the knot from becoming undone.

For general purposes this is sufficient, but to make it more secure a crown is placed on the top by crossing the strands one over another as in Fig. 11, and hauling taut. The three strands are now all pointing downwards, and to make one of the most efficacious ends to a rope, these can be spliced back. The result is a large knob on the end, and to avoid this an excellent plan is to make only the crown, as shown in Fig. 11.



Fig. 12.—The crown made by itself, and the strands spliced back a short distance down the rope (not tapered).

By itself, the crown will not last, and the strands must be spliced back (Fig. 12.) For convenience they should be tapered while being spliced, as this precaution will be found of very material assistance when drawing the end out of tight loops in undoing knots. All plough reins and halters should either be lashed, or finished off in this way.

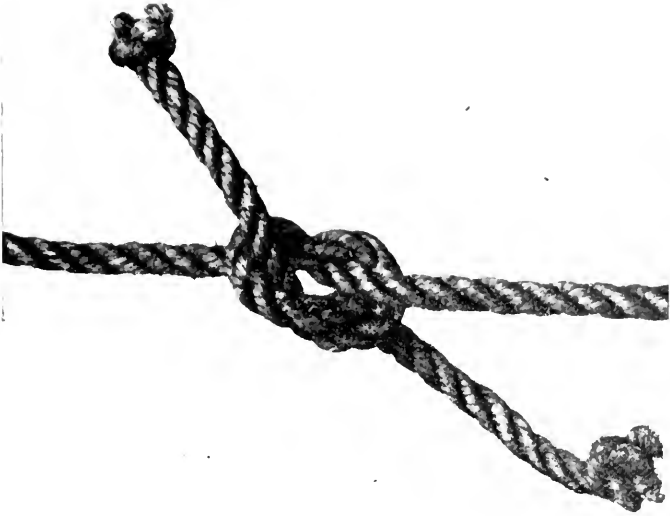


Fig. 13.—The Granny. The worst knot to use when joining ropes.

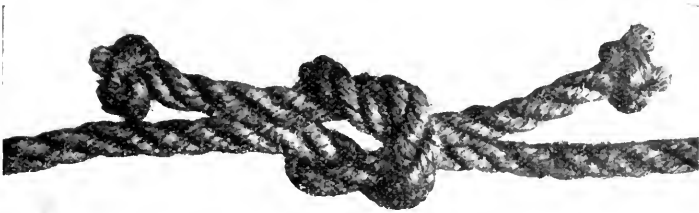


Fig. 14.—The Reef Knot.

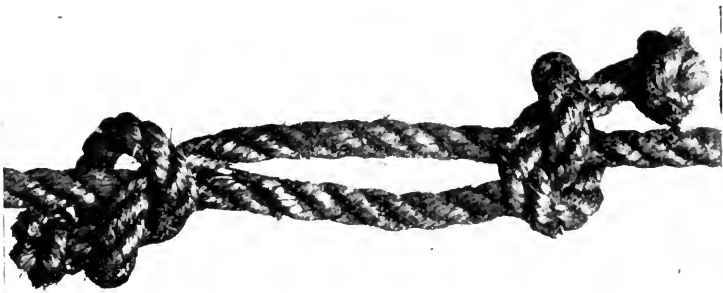


Fig. 15.—The Fisherman's Knot.



Fig. 16.—The Fisherman's Knot hauled taut.



Fig. 17 (a).—The Sheet Bend.

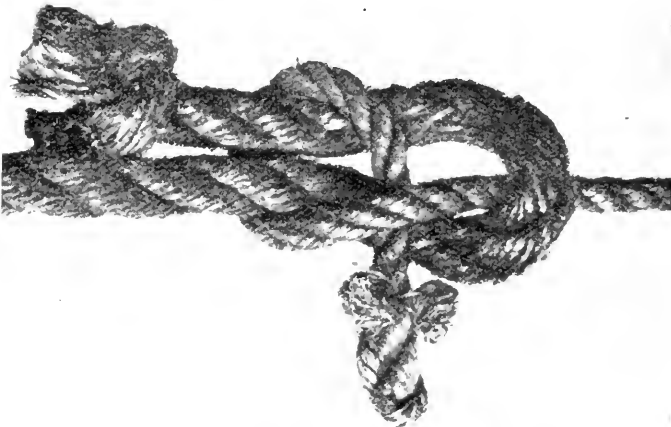


Fig. 17 (b).—Joining two ropes of uneven size with the Sheet Bend.

Knots.

There is such an array of knots that it is a difficult task to select just those that the farmer will find most useful. A few stand out prominently by virtue of their utility, but for the rest an endeavour will be made to describe types, and there should be little difficulty experienced in modifying or elaborating them according to requirements.

First and foremost are the methods of joining of two ropes together. The commonest and most inefficient knot to use is undoubtedly the "Grunny" (Fig. 13). If not tied tightly it will slip; and when once it catches it jams so tightly, and is so difficult to undo, that it is often a cause of grave danger. The "Reef" knot (Fig. 14), which should always be made in its place, is very similar, and may be confused with it. The first tie is the same in both cases, the difference in the knots being that, in the "Reef" knot, the end that comes over from on top, remains on top when crossed for the second tie, while in the "Grunny" it is crossed below for the second tie.

It may be worth noting here that a "Reef" knot is easily undone, by taking either end and giving it a sharp pull over in the opposite direction to which it is pointing. This will straighten it out if the material is pliable, and the end can then be easily drawn out. This is a good method to adopt with bandages or string, and when there is no knob on the end, but if there is a knob, or the material is fairly stiff, the easiest plan is to push one end back.

The "Reef" is easy to undo, and under ordinary conditions should never slip; but where a thin rope is to be tied to a thick one, the "Reef" will slip, and it is best then to use the "Sheet Bend" (Fig. 17*a* and *b*). The latter can be used when a small rope is heaved, say, over a limb of a tree, and a thicker rope pulled up after it. The "Sheet Bend" is not permanent, and will soon come undone if the rope gets slack or the strain is intermittent.

The safest way of tying two ropes together, whether of the same thickness or not, is by what is termed the "Fisherman's" knot (Fig. 15). It will take some practice to make this successfully, and the overhand knots should be made in such a way that they fit over one another when drawn tight as shown in Fig. 16. So sure is this knot, that the Alpine Club have recommended its exclusive use where ropes are to be tied together in mountain climbing.



Fig. 18.—The Figure-of-eight Knot.

The "Figure-of-eight" knot (Fig. 18) is hardly suitable for working in rope, but it is so readily made with wire, and holds so strongly, that it is very widely used for tying fencing wire. Its disadvantage lies in the two ends, which stand out at right-angles and prevent its passing through auger holes when

straining up the wires. Probably two or three trials will be necessary before this knot can be tied correctly. The illustration should be examined and carefully followed.

Both on sea and land, the "Bowline" (Fig. 19) is probably more in requisition by those who know it than any other knot. The heavier the strain the tighter the knot holds, while its most marked characteristic is the ease with which it is undone. This knot should invariably be made when horses are

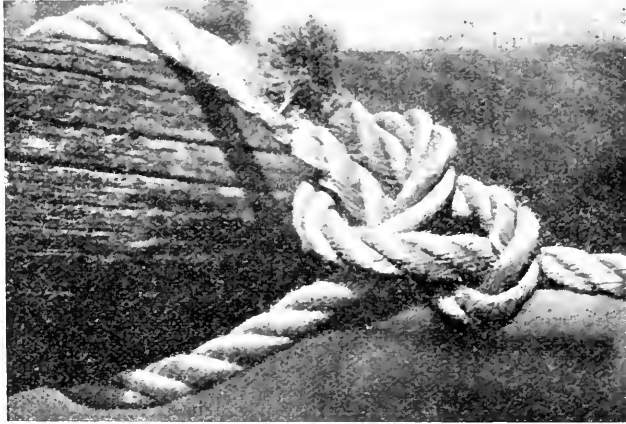


Fig. 19.—The Bowline.

tied up. If they pull back, it will not jam, a fault to which many knots are liable, frequently necessitating the rope being cut. Plough reins should be attached by the "Bowline," since once learnt, it is easily and rapidly made, and

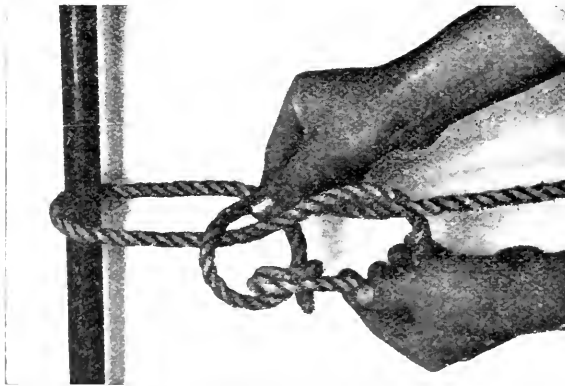


Fig. 20.—Making the Bowline.

as easily undone. To make it, first place the rope around the post, holding the short end in the left hand. Make a loop with the right, taking care that the long portion of the rope forms the bottom portion of the loop.

The short end in the left hand is then passed up through this loop, over and around the main rope, and back again downwards through the loop (Fig. 20),

so that the two ropes passing through will lie parallel. The rope in the right hand is then pulled tight to finish the knot.



Fig. 21.—Overhand Knot ready to be made into a Bowline on a Bight.

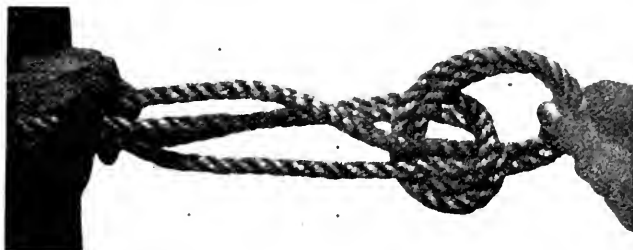


Fig. 22.—Showing the position of the loop in making the Bowline on a Bight, while it is being held down with the left hand.

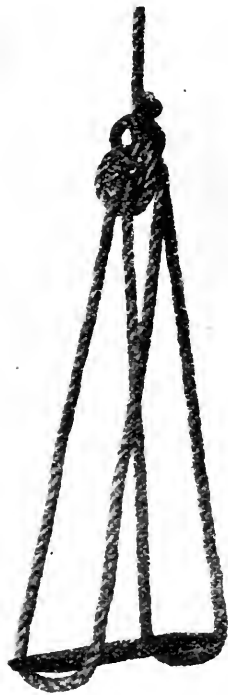


Fig. 23.—The Bosun's Chair.



Fig. 24.—The Bowline on a Bight used for throwing a horse.

A variation of the "Bowline," the "Bowline on a Bight," is best made by first tying an overhand knot in the doubled rope (Fig. 21). The loop is then placed above and held there with the left hand, while the right draws it down into position as shown in Fig. 22.

It makes an excellent cradle to sit in when drawing oneself up any height. As such it is called the "Bosun's Chair" (Fig. 23), and is useful in painting and other work when a ladder is not procurable or is inconvenient. The same knot is advocated by many for making the collar when throwing horses (Fig. 24). It makes a flat knot against the horse's chest, is doubled around the neck, and can readily be undone when a change in size is desired.

The "Timber Hitch" and the "Clove Hitch" are both well known (Figs. 25 and 26). The former is the safer, while the latter is quicker and easier to make. A slight alteration made in the "Clove Hitch," as shown in the lower part of Fig. 27, makes it surer and not so ready to slip.



Fig. 25.—The Hitch.



Fig. 26 —The Clove Hitch.

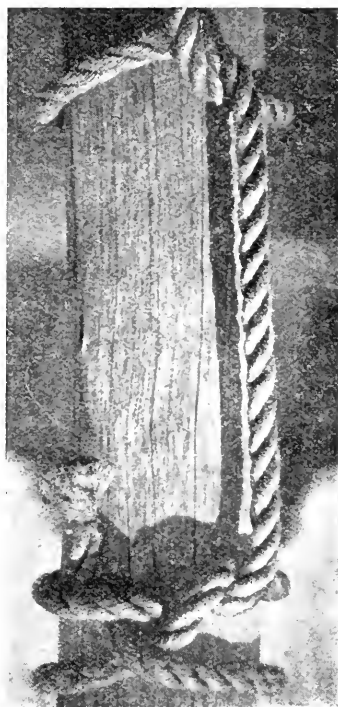


Fig. 27.—A Hitch adapted for lifting timber.

One of the safest of hitches is that shown in Fig. 28. The construction of such a hitch, or any other like it, prevents it from slipping sideways, making it extremely useful in tying horses to picket ropes, and in lifting and lowering round timber. One rope can also be attached to another by this means - as, for example, the guide rope of tackle used in lifting material for stacking.

To draw the lashing ropes of a load down tight, use is often made of the mechanical advantage derived from such a knot as that illustrated in Fig. 29. Make a loop in the rope as high as can conveniently be reached.

Double up a portion of the loose end in the right hand and pass a few inches of it through the loop (Fig. 30). To draw the knot tight, pull evenly on the lower loop and the loose end. This loose end is then passed round the guard irons of the dray and up through the lower of the two loops. Where the "Hay" knot, as it is often called, is to be made more or less permanent,



Fig. 28.—The Rolling Hitch. The safest hitch which will not slip in either direction.



29.—The Hay Knot.



Fig. 30.—Making the Hay Knot.

as in the case of railway trucks, &c., the top loop should take a half-hitch around the taut rope (Fig. 31). If this precaution is not observed, anyone stepping on the upper loop will cause it to slip. The knot will, of course, only hold while the rope is taut.

It is often necessary to temporarily shorten a rope, and for this purpose nothing is more satisfactory than the "Sheep-shank" (Fig. 32). If the strain slackens off, or becomes intermittent, there is danger of the knot



Fig. 31.—The Hay Knot made so as to prevent any chance of slipping.



Fig. 32.—The Sheep-shank.



Fig. 33.—Making the Military Tie.

slipping, especially if the rope is thin. The top of the "Sheep-shank" is the same as the "Hay" knot, and is therefore liable to the same danger of becoming undone. There are several ways of making it more permanent, one of the handiest being the same as is adopted in the "Hay" knot, but in this case taking a half-hitch with the loops both top and bottom.

The "Military Tie" (Figs. 33 and 34) is a handy and neat way of doing up a leading rope. The rope is placed around the horse's neck, with the loose end on the near side where the operator is standing. This loose end is doubled up, and the three ropes held in the left hand. The right hand then winds the loose end around the three held in the left hand, working downwards, till, when it is all used up, the end is passed through the small loop remaining, which is drawn tight to hold it in position. To facilitate undoing the knot, the end is best lashed, as its great disadvantage is the difficulty of drawing out the end, especially after it has become wet.

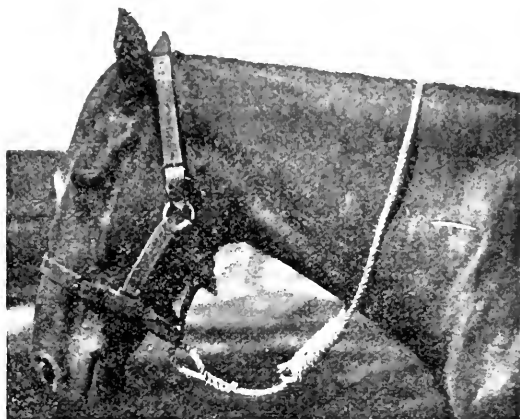
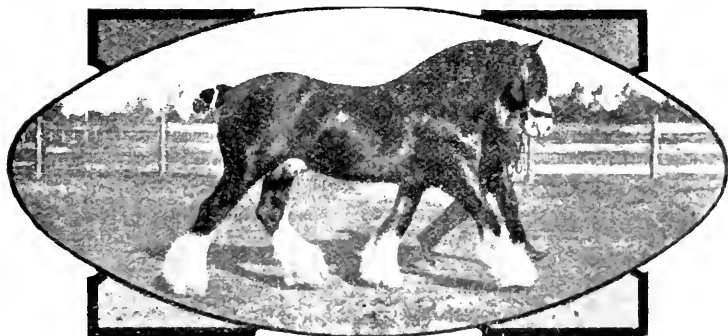


Fig. 34.—The Military Tie finished.



SECTION XV.

Book-keeping for Farmers.*

FARM accounts, to be really useful, are by no means easy to keep, inasmuch as many of the entries must necessarily be estimates rather than statements of actual transactions. The operations of each branch are so dovetailed into those of others that it requires keen discrimination to ascertain the percentage of profit or loss to be allocated to it.

But however difficult book-keeping may appear, it should be remembered that an actual knowledge of his financial standing is as important to the farmer as the state of his crops. The conditions of agriculture have changed; things are cut much finer, competition is keener, and details of leakages must be watched far more closely than was necessary in the so-called "good old days." This is an age when brain must supplement, if it does not replace, brawn, and success is far more likely to attend the steps of the farmer who does not neglect this important part of his operations.

Reasons for Keeping Accounts.

The following is a summary of the reasons for keeping accounts in a business-like fashion:—

1. It is our only way of knowing whether the farm is being run at a good profit, at a small profit, or at a loss.
2. It enables profit or loss to be traced to a certain department of the business. The expenses may be too high, the live stock may not be paying, a certain crop may be grown at a loss, or perhaps one section is paying well and another is not, and there is no indication where the leakage or the profit is. All these things would be told by a set of books.
3. It tends towards economy of expenditure by keeping the expense account continually in view, and may reveal to the farmer who is discouraged because his "farm doesn't pay," the fact that it is paying well, but the profits are all being consumed by extravagant management or living expenses.
4. It enables the elimination of the sources of loss by the abandonment or improvement of those branches which are being conducted without profit, and the development of those branches that show the greatest margin of profit.
5. It makes a handy compendium of particulars—a diary, a memorandum, a reference as to dates and crops, profits and transactions—which will be a source of much satisfaction and may become important evidence in case of litigation, or may even prevent it by furnishing indisputable proofs.

* This section has been revised by Mr. G. H. Johnston, Lecturer in Book-keeping Hawkesbury Agricultural College, who has added the portion headed "The Second Year." The figures quoted are not to be regarded as estimates of costs: they are only used as illustrations.

In addition, attention is directed to excessive expenses or to possible economies. Small items often amount to a considerable total and this attracts attention in a way that individual items would fail to do. In this connection it may be doubted whether many farmers, except those who keep regular books, have any definite knowledge in regard to the amount of their private expenses or cost of living. Their business and private moneys are rarely kept separate, and in many cases what is left over after the business and private expenses have been met is looked upon as representing the whole of the profits from farming. Undoubtedly many farmers are securing larger profits than they themselves realise, owing to their private expenses being in excess of what they estimate.

Preliminary Considerations.

It is first necessary to lay down a few definite rules before going into details. Many systems premise a clear line of demarcation between the farm proper and the house, practically on the basis that to ascertain the actual profits of a farmer, as compared with those of a merchant or a professional man, the two must be kept very distinct. Though this is only the logical outcome of any correct system, the constant analysis of all accounts makes it undesirable for at least the first few years of a beginner's career in book-keeping.

Again, one of two aspects of the profit assessment may be chosen. The first is to charge the business with the owner's estimated salary and treat the total net return as a direct interest on the capital invested—*e.g.*, if, after paying all expenses (including salary of say £200), a profit of £160 is made on a capital of £1,600, 10 per cent. per annum has been earned.

The second method is to charge the market rate of interest on the capital invested (*i.e.*, treat the owner's interest in the farm in exactly the same way as if it were a loan) and take the balance as net income for the year. Using the same figures as before in this case, 5 per cent. per annum on £1,600 would be £80, and the net profit is, therefore, £360 less £80 interest, or £280, which is the farmer's payment for time, trouble, and experience. In each case the total income is the same; but inasmuch as he would have received the 5 per cent. on his capital as a mere investment without labour, and as any allocation for salary can only be assumption, the second of the two systems is perhaps the more desirable.

In the case of a partnership, where the two or more parties are of unequal experience, or where one is not taking an active part in the business, the question assumes a different aspect and must be decided on its merits.

A popular suggestion for treating farm accounts is to take each of the paddocks separately, debit its proportion of rent, labour, seed, manure, &c., and credit the net returns. This, though possible to a skilled accountant, and perhaps comparatively easy where the crop occupies the ground the greater part of the year, should rather be discouraged, especially when dealing with mixed farming, as it involves so many mere approximations and estimates. Probably the only instances where it is directly beneficial are either in conjunction with experiment plots, when accuracy in the seed and manure used and in the yield obtained is imperative, or where a farm of only three or four paddocks is confined to one crop and each is dealt with at one time.

Simplifying the Work.

The following suggestions may assist in simplifying the work at the outset:—

1. The house, farm, buildings, &c., may be treated as one property, whether rented or owned by the farmer, unless the house (as in a few cases) is detached from the farm and forms a separate property.
2. No salary is drawn by the owner or his family for services rendered. All farm products used by the household need not be charged, but all definite expenses incurred debited to a house account.
3. Interest charged at 5 per cent. per annum on capital invested, and any further profit is his net return.
4. Inasmuch as few farmers have many cash or bank transactions, the cash book may be dispensed with to reduce the number of books required. All entries may then be made through the journal.

The First Essential—an Inventory.

The man who starts a system of book-keeping with his capital in cash, and then purchases the farm, stock, &c., has a much simpler task than the one who for years perhaps has been engaged on the land. The latter must, as a preliminary, "take stock,"—*i.e.*, discover what he is worth at any particular time. The season of the year for inaugurating the system needs some judgment. Other things being equal, January 1 or July 1 would be the best; but with certain classes of farming, this might be inconvenient. For instance the end of March might be most suitable for a wheat-grower, as in December he would have wheat unsold, or even unharvested. The end of September might be best adapted for a summer fruit and citrus orchardist, inasmuch as that would probably be the only time when there was no fruit for sale. A tenant farmer would probably find it better to take his inventory on the anniversary of the day he entered into occupation, and the holders of conditional purchases and homestead selections on one of the dates on which their payments became due. Low stocks and slackness of work may govern other cases. In general, however, as income is calculated for taxation purposes for the year commencing July 1, this may be regarded as the most suitable date on which to commence the work.

In making this valuation, much judgment must be exercised, and this in turn will tend to develop the business faculty. The memory will be called upon, old receipts and pass books looked up, and current values considered, to ensure some amount of accuracy. Over-sanguine estimates may in some cases be made, but a wide-awake farmer usually gathers from the prices obtained at local auction sales, &c., a very fair idea of values.

Numberless instances might be given of the problems which confront the farmer at such a time. For instance, with the financial year closing on June 30, he has several tons of seed potatoes intended for his own planting next season. To buy them would cost £6 per ton; whereas if sold they would realise but £4 or £4 10s. per ton. At what should they be valued? As an enhancement of the value in the "growing" year means a lowering of profit in the "sowing" year, the middle course would be wisest, with a strong leaning towards a low estimate.

The list must then be classified under separate headings, of which the following are the most important:—

1. Land (either with or without house, buildings, &c., which, with fences, dams, clearing, &c., may be placed under the heading of "improvements"). If the place has been bought as a going concern, with

the house built and fences erected, the one account will suffice; but if unimproved land is obtained, and the additions made subsequently, two or even more divisions would be preferable.

2. Live stock, including horses, cattle, sheep, pigs, and fowls, placed in separate accounts or together, according to importance. It is usually desirable to keep the horses separate, as, unless breeding is carried on, depreciation must be allowed for and loss incurred.
3. Plant, fixed and movable.—Where much heavy fixed plant is in use, the two classes may be kept distinct, as differing allowances for depreciation have to be made.
4. Farm products on hand (ready for sale or use).
5. Farm products growing.—If the inventory is made at the slackest period of the year, these may not be very extensive, and may even be neglected. To prevent an over-estimate, any such crops should only be priced at the cost of labour, seed, and manure, the benefit of any profit being carried to the year in which the harvesting is done.
6. Furniture and domestic effects.

This must be supplemented by a statement showing the cash in hand or in bank, debts owing to or by the farmer, promissory notes, mortgages, &c.

Possibly the most difficult task is the assigning of a value to the farm and buildings, and the tendency would be to overestimate it. Due consideration must be given to the original cost, and to the subsequent improvements, whether made by the farmer in the ordinary course, or carried out by tradesmen for a definite amount. In the case of a tenancy, an estimate must be made of the present worth of any additions or improvements, based upon the fact that the value of such must be spread over the term of the lease and will be considered as of no value at the end.

A Balance-sheet.

This will constitute his balance-sheet, showing his assets, or what he owns, on the one side, and his liabilities, or what he owes, on the other side, and the difference between these two will be his capital—provided, of course, that the assets exceed the liabilities.

All such balance-sheets inevitably include approximations to value, and not actual values (which can only be ascertained when a sale is effected), and, therefore, the merit of any system of book-keeping must depend, first and foremost, on the nearness to accuracy of the various valuations.

SPECIMEN BALANCE-SHEET.

£ s. d.						£ s. d.		
<i>Liabilities.</i>						<i>Assets.</i>		
Storekeeper ...	...	25 0 0	Land, Buildings, &c. ...	...	850 0 0	Stock ...	...	320 0 0
Interest unpaid ...	...	20 0 0	Plant ...	...	96 0 0	Crops ...	...	84 0 0
Loan from Bank ...	...	400 0 0	Sundry Debtors ...	...	105 0 0			
Capital ...	...	1,010 0 0						
		£1,455 0 0				£1,455 0 0		

It will be seen from this example that four out of the five divisions into which the assets are divided must of necessity be valuations on the part of the owner, and if in any way inflated will, when realisation takes place, reduce the stated capital to its correct figure.

The next Essential - a Diary.

The inventory, especially if taken on January 1, might well be copied on the opening-pages of a diary. These are cheap enough, and the foolscap sizes, with two or three days to a page, and sufficient space at the end for a financial summary, are eminently suitable. (If preferred, a well-bound book may be used, and columns ruled for the insertion of values for several years. An example of this is given later.)

All the transactions should be recorded in the diary as they occur; and in addition, it is wise to note the doings of every labourer (in a special book, if necessary), the date of service of the farm breeding stock, the plantings and harvestings, the rainfall, frosts, unusual winds, &c. Many an otherwise unaccountable variation in the yield of two similar crops sown at almost the same time may be understood by reference to some such record, and many of the innumerable problems which incessantly confront the agriculturist may by this means be solved.

At the end of each month a summary should be made of the receipts and expenditure, and in this some discrimination is needed. It is not enough to pay the storekeeper's bill of, say, 100s. Of this, 52s. may be for groceries, 20s. for seed, 10s. for plough-lines, harness oil, &c., 15s. for a new plough-share, and 3s. for an odd ball of binder twine. Similarly, the blacksmith's bill may include shoeing, to be charged to horses, repairs to ploughs, new tires, &c., to the implement account, and new gate-hinges to buildings and fences. In just the same way, the receipts must be classified, and credited to crops, cattle, sheep, pigs, fruit, &c.

From this summary of the month's transactions, the Journal (to be afterwards explained) may be made up. All receipts should be kept and numbered, and all account sales of produce, stock, &c., carefully preserved for future reference. The safest method for any farmer to adopt is the banking of all moneys received, and the payment of accounts by cheque as far as possible. His pass-book then becomes a very valuable aid in book-keeping. Small accounts may be paid from Petty Cash, a cheque for £5 or £10 being drawn for this purpose as required, and payments recorded on a special page of the diary. When the amount provided is exhausted, or nearly so, a cheque is drawn for the amount expended and the payments classified for entry in the Journal. The Journal entries will appear as under:—

Petty Cash—Dr	..	...	...	£5	0	0	
To Bank	..	...	...		£5	0	0
House Expenses	...	...	...	2	15	0	
Horse (shoeing)	...	...	...	1	2	6	
Plant (repairs)—Dr.	...	...	...	0	17	6	
				<hr/>			
To Petty Cash	...	...	...		4	15	0

It may not be out of place to suggest here that a page of the diary might well be used for a few particulars regarding the fire and life policies (giving No., amount and due date of premium, and where the policy is kept), details of any mortgages on the farm, and rough details (if actual copies are not on hand) of any agreements with labourers, clearers, &c. Such information may be required at a moment's notice, and may be of paramount importance when the owner is, through sickness or other cause, absent at the time when payments are due.

These are good grounds for the opinion that an accurately made inventory and a regularly kept diary conduce as much to a thorough knowledge of one's affairs as a journal or a ledger.

The Principles of Double-entry Book-keeping.

Having thus laid down the broad outlines upon which any system of book-keeping must be carried into effect, it is now necessary to briefly describe "Double Entry" as the most suitable for the farmer. It may entail a few more figures, but the ease with which its correctness may be proved and the balance-sheet compiled, makes it the system least open to criticism.

It is based upon the general principle that every transaction, whatever its nature, concerns two accounts, or has two aspects—that of a receiver and that of a giver. If money is paid into the bank as the result of a sale of stock, the bank account *receives*, while the stock account *gives*. If 100 corn bags are bought at 10d. each, and these are used to market the crops, the crop account *receives*, and the bank (or cash) account *gives*.

If, then, this principle is carried out in its entirety, and the same figures appear on both sides (though in different accounts) of whatever books are kept, a failure of the totals to correspond would certainly indicate an error, which must at once be looked for.

The two books which are needed to supplement the diary, or whatever means are used to make a rough record of daily happenings and transactions, are the Journal and the Ledger. The former is written up in order of date, and the latter according to the account to which the entry belongs.

Simple Rules.

The fundamental principles of correct book-keeping are:—

1. Debit the receiver, or that which is received; credit the giver, or that which is given.
2. Debit losses; credit gains.
3. Every debit must have a corresponding credit.
4. The sum of the debits must equal the sum of the credits.

If the first two rules are clearly grasped, the others may be neglected, as they are merely the logical outcome.

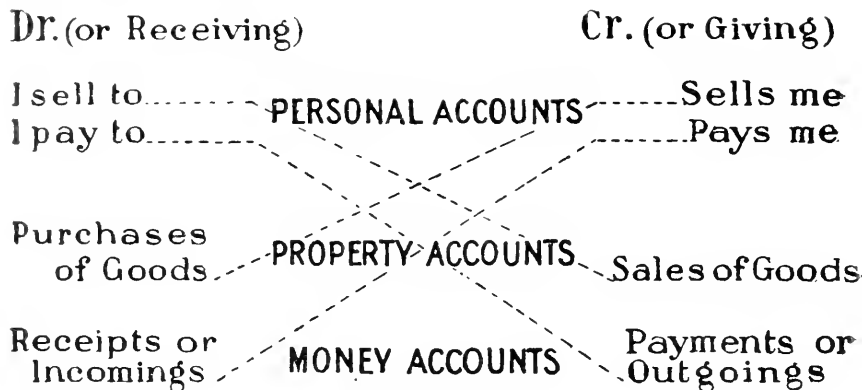
Custom has led to the placing of the debits on the left-hand side of the page and the credits on the right.

Classification of Accounts.

Some classification of the various accounts simplifies matters, and though two sections are occasionally advised, viz., real and personal, a more extended division into four classes has obvious merits. These classes are:—

- Personal, or accounts with persons.
- Property, or dealings in goods, live stock, &c.
- Money, or records of receipts and expenditure.
- Convenience, or nominal, such as expenses, interest, discount, wages, &c.

The following diagram may serve to illustrate the method of journalising the first three divisions:—



The Journal.

The Journal is ruled with the following columns:—"Date," "Name of account debited," "Name of account credited," "Ledger folio" (or page on which the corresponding entry is posted in the Ledger), "Amount of cash (or value) debited," "Amount of cash (or value) credited."

The method of writing up the Journal may be thus illustrated:—

Diary entries:—Jan. 1, 1920—Bought 700 corn bags at 10d. each, from T. Brown. Jan. 17, 1920—Paid for bags by cheque.

Being for crops, they are charged to that account.

Date.	Dr.	Cr.	Ledger Folio.	Dr.	Cr.
1920.				£ s. d.	£ s. d.
Jan. 1	Crops, Dr. ... ..	...	...	29 3 4	
	To T. Brown ... ..	...	...	...	29 3 4
" 17	T. Brown, Dr. ... ..	...	...	29 3 4	
	To Bank ... ..	...	...	...	29 3 4

In actual practice, as payment is made before the end of the month, the transaction can be treated as a cash one, and the entry would then be stated as "Crops Dr. to Bank," without involving the use of Brown's name.

Additional value may be given to the Journal by briefly describing the transaction:—

	£	s.	d.	£	s.	d.
Crops, Dr.	29	3	4			
To T. Brown				29	3	4
700 corn bags at 10d.						

Where the journal is compiled from rough memoranda, and not from a regularly-kept diary, this is distinctly advantageous.

Reference has already been made (see page 908) to the necessity for analysing the various receipts and expenses, to ascertain the accounts to which the amounts should be charged. The storekeeper's bill, if paid as soon as due, could be journalised thus:—

	DR.	CR.
	£ s. d.	£ s. d.
Household (groceries)	2 12 0	
Crops (seed and twine)	1 10 0	
Implement (shares, &c.), Dr.	0 18 0	
To Bank		5 0 0

The Ledger.

This is the most important of the books of reference, as it contains an abstract of every transaction recorded in business. It is ruled with columns for "Date," "Name of corresponding Cr. entry," "Journal folio" and "Amount" on the Dr. side, and a similar number of columns on the Cr. side.

Dr.					Cr.						
Date.	Name of corresponding Cr. entry.	Journal folio.	£	s.	d.	Date.	Name of corresponding Dr. entry.	Journal folio.	£	s.	d.

Every account mentioned in the Journal requires a Ledger account under its own heading. In actual practice, these would appear on various pages, allotting say ten to the bank, twenty to stock, two to horse, and so on, according to the number of likely transactions. An index is required, and it is desirable to classify them as already stated.

A FIRST YEAR'S OPERATIONS.

An elementary example of a year's business dealings is here given to explain the foregoing principles. The transactions are really a summary of a diary, and thus no dates are mentioned.

J. Bull starts in 1920 with a capital of £1,000, which is banked. He buys horses for £150, and stock for £400 cash, together with implements from the Sydney Plough Co., for £50 (not paid). He sells stock to James for £300 (not paid), crops for £100 cash, and butter for £10 cash. £120 is paid as wages, and £80 as rent. Valuations at the end of the year are:—Stock, £300; crops, £60; plant, £40; and horses, £140. Interest charged on capital at 5 per cent. per annum. These transactions would be journalised as follows:—

Date.	Dr.	Cr.	Ledger Folio.	Dr.	Cr.					
				£	s.	d.	£	s.	d.	
1920.	Bank, Dr.	...	...	2	1,000	0	0		
	To Capital	...	...	1			1,000	0	0
	Horses, Dr.	...	...	3	150	0	0		
	To Bank	...	...	2			150	0	0
	Stock, Dr.	...	...	4	400	0	0		
	To Bank	...	...	2			400	0	0
	Plant, Dr.	...	...	5	50	0	0		
	To Sydney Plough Co.	...	...	9			50	0	0
	James, Dr.	...	...	8	300	0	0		
	To Stock	...	...	4			300	0	0
	Bank, Dr.	...	...	2	100	0	0		
	To Crops	...	...	6			100	0	0
	Bank, Dr.	...	...	2	10	0	0		
	To Dairy	...	...	7			10	0	0
	Wages, Dr.	...	...	10	120	0	0		
	To Bank	...	...	2			120	0	0
	Rent, Dr.	...	...	11	80	0	0		
	To Bank	...	...	2			80	0	0
	Interest, Dr.	...	...	12	50	0	0		
	To Capital	...	...	1			50	0	0
					£2,260	0	0	£2,260	0	0

Entries need not be made of the valuations.

In the following ledger entries the accounts only are numbered, and date and Journal folio columns are omitted to facilitate working. The entries in *italics* will be explained later.

1. CAPITAL.

		£	s.	d.			£	s.	d.
<i>To Balance</i>	...	1,150	0	0	By Bank	...	1,000	0	0
					„ Interest	...	50	0	0
					„ Profit & Loss a/c	...	100	0	0
		<u>£1,150</u>	<u>0</u>	<u>0</u>			<u>£1,150</u>	<u>0</u>	<u>0</u>

2. BANK.

To Capital	...	1,000	0	0	By Horse	...	150	0	0
„ Crops	...	100	0	0	„ Stock	...	400	0	0
„ Dairy	...	10	0	0	„ Wages	...	120	0	0
					„ Rent	...	80	0	0
					„ Balance	...	360	0	0
		<u>£1,110</u>	<u>0</u>	<u>0</u>			<u>£1,110</u>	<u>0</u>	<u>0</u>

3. HORSE.

To Bank	...	150	0	0	By Balance (Valuation)	140	0	0
					„ Profit & Loss a/c	10	0	0
		<u>£150</u>	<u>0</u>	<u>0</u>			<u>£150</u>	<u>0</u>

4. STOCK.

To Bank	...	400	0	0	By James	...	300	0	0
„ Profit & Loss a/c	...	200	0	0	„ Balance (Valuation)	300	0	0	
		<u>£600</u>	<u>0</u>	<u>0</u>			<u>£600</u>	<u>0</u>	<u>0</u>

5. PLANT.

To Sydney Plough Co.	50	0	0	By Balance (Valuation)	40	0	0		
				„ Profit & Loss a/c	10	0	0		
		<u>£50</u>	<u>0</u>	<u>0</u>			<u>£50</u>	<u>0</u>	<u>0</u>

6. CROPS.

To Profit & Loss a/c	...	160	0	0	By Bank	...	100	0	0
					„ Balance (Valuation)	60	0	0	
		<u>£160</u>	<u>0</u>	<u>0</u>			<u>£160</u>	<u>0</u>	<u>0</u>

7. DAIRY.

To Profit & Loss a/c	...	10	0	0	By Bank	...	10	0	0
		<u>£10</u>	<u>0</u>	<u>0</u>			<u>£10</u>	<u>0</u>	<u>0</u>

8. JAMES.

To Stock	...	300	0	0	By Balance	...	300	0	0
		<u>£300</u>	<u>0</u>	<u>0</u>			<u>£300</u>	<u>0</u>	<u>0</u>

9. SYDNEY PLOUGH CO.

<i>To Balance</i>	...	...	50	0	0	By Plant	...	...	50	0	0
			<hr/>						<hr/>		
			£50	0	0				£50	0	0
			<hr/>						<hr/>		

10. WAGES.

To Bank	...	...	120	0	0	By Profit & Loss a/c	...	120	0	0
			<hr/>					<hr/>		
			£120	0	0			£120	0	0
			<hr/>					<hr/>		

11. RENT.

To Bank	...	...	80	0	0	By Profit & Loss a/c	...	80	0	0
			<hr/>					<hr/>		
			£80	0	0			£80	0	0
			<hr/>					<hr/>		

12. INTEREST

To Capital	...	...	50	0	0	By Profit & Loss a/c	...	50	0	0
			<hr/>					<hr/>		
			£50	0	0			£50	0	0
			<hr/>					<hr/>		

Trial Balance.

Neglecting the entries in *italics*, it is now possible to verify the correctness of the posting (*i.e.*, entering into the Ledger) by means of a trial balance. The totals of each side of every account are added, and the results should be equal to the totals of the Journal, and of course, to one another.

TRIAL BALANCE.

Dr.			Name of Account.	Cr.		
£	s.	d.		£	s.	d.
.....			Capital	1,050	0	0
1,110	0	0	Bank	750	0	0
150	0	0	Horse	.....	
400	0	0	Stock	300	0	0
50	0	0	Plant	.....	
.....			Crops	100	0	0
.....			Dairy	10	0	0
300	0	0	James	.....	
.....			Sydney Plough Co.	50	0	0
120	0	0	Wages	.....	
80	0	0	Rent	.....	
50	0	0	Interest	.....	
<hr/>				<hr/>		
£2,260	0	0		£2,260	0	0

It does not necessarily follow that, the Dr. and Cr. columns being equal, the postings must be correct, inasmuch as it does not disclose when there is an entry on the right side, but posted to the wrong account, or a posting to the wrong side, with its corresponding entry also on the wrong side.

The making up of a trial balance has so many distinct advantages that it must never be dispensed with. Any error must be at once looked for, because, if allowed to remain, the balancing entry will also be wrong, and it will be practically impossible to compile a correct balance-sheet and profit and loss account. It is convenient to remember that if one side is deficient by the same amount as the other side is in excess of the Journal total, an entry of that amount has usually been posted to the wrong side.

The trial balance is of great assistance in detecting mistakes in posting, such as taking 6 for 0, 7 for 1, 3 for 5, and *vice versa*. Another common error is to place the figures in the wrong money column, making 5s. 7d. appear as £5 7s.

In actual practice the Journal is not totalled, and the trial balance is made up by stating only the differences between the various accounts. This would then appear as follows, and the method can be recommended when a fair amount of proficiency has been gained.

TRIAL BALANCE BY DIFFERENCE.					
<i>Dr.</i>			<i>Cr.</i>		
£	s.	d.		£	s. d.
.....			Capital	1,050	0 0
360	0	0	Bank		
150	0	0	Horse		
100	0	0	Stock		
50	0	0	Plant		
.....			Crops	100	0 0
.....			Dairy	10	0 0
300	0	0	James... ..		
.....			Sydney Plough Co. ...	50	0 0
120	0	0	Wages		
80	0	0	Rent		
50	0	0	Interest		
£1,210				£1,210 0 0	

In the above example, very little time is saved, owing to its extreme simplicity, but where numerous accounts, many of which have been balanced off, are concerned, the economy in labour is considerable.

Closing the Accounts.

The posting into the ledger having been proved correct, we now proceed to close the accounts.

Leaving the Capital Account for the time being, we find that £1,110 has been received by the Bank Account, and £750 paid out, leaving a Cr. balance of £360. This is inserted, both sides totalled and ruled off, as seen from the entries in *italics*.

In the Horse Account, the valuation £140, or our estimate of what they are worth at the end of the year, is entered as a Cr. balance, and the difference between their original price and present value (£10) is carried to a Profit and Loss Account, as being the cost of using the horses throughout the year.

The Stock Account shows that £400 was paid for them. £300 worth has been sold, and £300 worth remains on hand; consequently a profit of £200 has been made, and to balance the account this amount is debited.

The other entries are treated in similar fashion, all cash, stock, crops, &c., on hand, and all amounts owing to or by the owner being carried to a Balance-sheet, and any differences to a Profit and Loss Account. In the case of wages, rent, and interest, it is clearly seen that they are losses in themselves, although contributing to the net gain.

Profit and Loss Account.

The Profit and Loss Account will now be prepared as under, the items being transferred to the side opposite to that on which they appear in the ordinary Ledger account (thus adhering to the essential principle of double entry, that every debit must have a corresponding credit):—

PROFIT AND LOSS ACCOUNT.							
<i>Dr. (Losses).</i>	£	s.	d.	<i>Cr. (Gains).</i>	£	s.	d.
To Horse	10	0	0	By Stock	200	0	0
.. Plant	10	0	0	.. Crops	160	0	0
.. Wages	120	0	0	.. Dairy... ..	10	0	0
.. Rent	80	0	0				
.. Interest	50	0	0				
.. Capital $\frac{a}{c}$ (net gain)	100	0	0				
	£370	0	0		£370	0	0

It will be noticed that this—like the wages, rent and interests accounts—carries out the second important rule referred to—“Debit losses; credit gains.”

The Americans, following the order in which these items appear, are slightly more accurate, and usually call this a loss and profit account.

The way in which the profits have been made is thus disclosed. If the horse-hire, wages, rent, &c., were charged to the crops, and the book-keeping carried out in further detail, the statement would have a different aspect, though the result would be the same.

The profit of £100 shown in this account represents an increase in the farmer's wealth, and is credited to, *i.e.*, transferred to the opposite side of, the Capital account, the business now representing £100 more than was originally put into it. A loss would be debited to the Capital account as in the transactions for 1921, which are shown hereunder. The Capital account is then balanced and ruled off.

Balance Sheet.

As the name suggests, this is not a true account, but a mere statement of liabilities (on the left) and assets (on the right). It has no debit or credit sides, the words “To” and “By” are not used, and the entries are not transferred from one side of an account to the opposite side of the balance-sheet. Instead, the various “Balance” and “Valuation” entries are brought straight down and entered on the same side of the balance-sheet, which should then balance, *i.e.*, the totals of the two sides should be equal.

The balance-sheet will appear as follows:—

BALANCE-SHEET.							
<i>Liabilities.</i>	£	s.	d.	<i>Assets.</i>	£	s.	d.
Sydney Plough Co.	50	0	0	Horse (as per valuation) ...	140	0	0
Capital	1,050	0	0	Stock	300	0	0
Difference, being profit ...	100	0	0	Plant	40	0	0
				Crops	60	0	0
				Bank (as per Ledger) ...	360	0	0
				James (book debt) ...	300	0	0
	£1,200	0	0		£1,200	0	0

It will be noticed that the actual return has been £50 for the use of the £1,000 capital and £100 as a general profit.

Opening Books for a Going Concern.

It may happen that, when a farmer takes over a property or commences keeping accounts, his capital does not consist exclusively of cash, but also of horses, plant, stock, crops on hand, &c., and he may have certain outstanding debts. These are known respectively as assets (things owned), and liabilities (things owed), and must be journalised according to the rule—Assets, Dr. to Liabilities (including Capital, which is a debt owed by the business to the proprietor). The words “assets” and “liabilities” are not employed in making the entries, the name of each asset or liability being used, as, for instance, in the following example, wherein Bull’s balance-sheet for 1920 is journalised :—

Horse.	£
Stock	140
Plant...	300
Crops	40
Bank	60
James— <i>Dr.</i>	360
	300
To Sydney Plough Co.	£50
To Capital	£1,150

THE SECOND YEAR.

To continue the work in the second year the balances in the Money, Property, and Personal accounts should be “carried forward” or “brought down” to the opposite side of each account, below the line which rules off the previous year’s entries, thus :—

		£	s.	d.			£	s.	d.		
CAPITAL ACCOUNT.											
1920	To Balance c/d	...	...	1,150	0	0	By Bank	...	1,000	0	0
							„ Interest	...	50	0	0
							„ Profit & Loss $\frac{1}{2}\%$	...	100	0	0
									£1,150	0	0
1921.							By Balance b/d (brought down).		1,150	0	0
HORSE.											
1920	To Bank	...	...	150	0	0	By Balance (Valuation) c/d	...	140	0	0
							„ Profit & Loss $\frac{1}{2}\%$	...	10	0	0
									£150	0	0
1921	To Balance b/d	...	...	140	0	0					
JAMES.											
1920	To Stock	...	...	300	0	0	By Balance c/d	...	300	0	0
									£300	0	0
1921	To Balance b/d	...	...	300	0	0					

The reason for transferring the balance, when brought down, to the opposite side will be apparent in the last example above. James not having paid for the stock, his account shows a debit balance of £300, and in opening the account for the new year’s transactions, the amount of his indebtedness must be shown as a debit, *i.e.*, in the same position as the original debit entry.

The following example will illustrate the method of dealing with the second year's transactions:—

During the following year, 1921, J. Bull sells horses for £60, and buys stock from James for £100. He pays the Sydney Plough Company £48, being allowed £2 discount, and accepts £195 from James in full settlement of his account. He buys seed for £5, sells hay for £75 and dairy produce for £30, and pays £100 for house expenses. Wages paid total £90. Interest is charged on capital at 5 per cent. per annum. At end of year he owes rent £40, that for the first half-year, £40, having been paid.

Valuations at the end of the year are, stock £560, crops £120, dairy produce on hand £5. Plant and horses are depreciated at rate of 10 per cent. per annum.

The journal and ledger will appear as under:—

Date.	Dr.	Cr.	Ledger Folio.	Dr.	Cr.
1921.				£ s. d.	£ s. d.
	Bank, Dr.		2	60 0 0	
	To Horse		3		60 0 0
	Stock, Dr.		4	100 0 0	
	To James		8		100 0 0
	Sydney Plough Co., Dr.		9	50 0 0	
	To Bank		2		48 0 0
	,, Discount		13		2 0 0
	Bank, Dr.		2	195 0 0	
	Discount, Dr.		13	5 0 0	
	To James		8		200 0 0
	Crops, Dr.		6	5 0 0	
	To Ban'k		2		5 0 0
	Bank, Dr.		2	75 0 0	
	To Crops		6		75 0 0
	Bank, Dr.		2	30 0 0	
	To Dairy		7		30 0 0
	House Expenses, Dr.		14	100 0 0	
	To Bank....		2		100 0 0
	Wages, Dr.		10	90 0 0	
	To Bank....		2		90 0 0
	Interest, Dr.		12	57 10 0	
	To Capital		1		57 10 0
	Rent, Dr.		11	80 0 0	
	To Bank....		2		40 0 0
	To Landlord		15		40 0 0
				£847 10 0	£847 10 0

I. CAPITAL.

1921.	£ s. d.		£ s. d.
To Profit and Loss ...	17 10 0	By Balance b/d ...	1,150 0 0
„ Balance c/d ...	1,190 0 0	„ Interest ...	57 10 0
	£1,207 10 0		£1,207 10 0
1922.		By Balance b/d ...	1,190 0 0

2. BANK.

1921.		By Sydney Plough Co. ...	45 0 0
To Balance b/d ...	330 0 0	„ Crops ...	5 0 0
„ Horses ...	60 0 0	„ House Expenses ...	100 0 0
„ James ...	195 0 0	„ Wages ...	90 0 0
„ Crops ...	75 0 0	„ Rent ...	40 0 0
„ Dairy ...	30 0 0	„ Balance c/d ...	437 0 0
	£720 0 0		£720 0 0
1922.			
To Balance b/d ...	437 0 0		

3. HORSE.

1921.		£	s.	d.			£	s.	d.
To Balance b/d		140	0	0	By Bank	...	60	0	0
					„ Depreciation	...	8	0	0
					„ Balance c/d	...	72	0	0
		<hr/>					<hr/>		
		£140	0	0			£140	0	0

1922.				
To Balance b/d	...	72	0	0

4. STOCK.

1921.		£	s.	d.			£	s.	d.
To Balance b/d	...	300	0	0	By Valuation	...	560	0	0
„ James	...	100	0	0					
„ Profit and Loss	...	160	0	0					
		<hr/>					<hr/>		
		£560	0	0			£560	0	0

1922.				
To Balance b/d	...	560	0	0

5. PLANT.

1921.		£	s.	d.			£	s.	d.
To Balance b/d	...	40	0	0	By Depreciation	...	4	0	0
					„ Balance c/d	...	36	0	0
		<hr/>					<hr/>		
		£40	0	0			£40	0	0

1922.				
To Balance b/d	...	36	0	0

6. CROPS.

1921.		£	s.	d.			£	s.	d.
To Balance b/d	...	60	0	0	By Bank	...	75	0	0
„ Bank	...	5	0	0	„ Valuation	...	120	0	0
„ Profit and Loss	...	130	0	0					
		<hr/>					<hr/>		
		£195	0	0			£195	0	0

1922.				
To Balance b/d	...	120	0	0

7. DAIRY.

1921.		£	s.	d.			£	s.	d.
To Profit and Loss	...	35	0	0	By Bank	...	30	0	0
					„ Valuation	...	5	0	0
		<hr/>					<hr/>		
		£35	0	0			£35	0	0

1922.				
To Balance b/d	...	5	0	0

8. JAMES.

1921.		£	s.	d.			£	s.	d.
To Balance b/d	...	300	0	0	By Stock	...	100	0	0
					„ Bank	...	195	0	0
					„ Discount	...	5	0	0
		<hr/>					<hr/>		
		£300	0	0			£300	0	0

9. SYDNEY PLOUGH COMPANY.

		£ s. d.			£ s. d.
1921.	To Bank	48 0 0	By Balance b.d.		50 0 0
	„ Discount	2 0 0			
		<u>£50 0 0</u>			<u>£50 0 0</u>

10. WAGES.

1921.	To Bank	90 0 0	By Profit and Loss		90 0 0
		<u>£90 0 0</u>			<u>£90 0 0</u>

11. RENT.

1921.	To Bank	40 0 0	By Profit and Loss		80 0 0
	„ Landlord	40 0 0			
		<u>£80 0 0</u>			<u>£80 0 0</u>

12. INTEREST.

1921.	To Capital	57 10 0	By Profit and Loss		57 10 0
		<u>£57 10 0</u>			<u>£57 10 0</u>

13. DISCOUNT.

1921.	To James	5 0 0	By Sydney Plough Co.		2 0 0
			„ Profit and Loss		3 0 0
		<u>£5 0 0</u>			<u>£5 0 0</u>

14. HOUSE EXPENSES.

1921.	To Bank	100 0 0	By Profit and Loss		100 0 0
		<u>£100 0 0</u>			<u>£100 0 0</u>

15. LANDLORD.

1921.	To Balance	40 0 0	By Rent		40 0 0
		<u>£40 0 0</u>			<u>£40 0 0</u>
1922.			By Balance b.d.		£40 0 0

The Profit and Loss Account and Balance-sheet would be as follows:—

PROFIT AND LOSS ACCOUNT.

<i>Dr.</i>	£ s. d.	<i>Cr.</i>	£ s. d.
To Horse	8 0 0	By Stock	160 0 0
„ Plant	4 0 0	„ Crops	130 0 0
„ Wages	90 0 0	„ Dairy	35 0 0
„ Rent	80 0 0	„ Capital (net loss)	17 10 0
„ Interest	57 10 0		
„ Discount	3 0 0		
„ House Expenses	100 0 0		
	<u>£342 10 0</u>		<u>£342 10 0</u>

BALANCE-SHEET.					
<i>Liabilities.</i>			<i>Assets.</i>		
	£	s. d.		£	s. d.
Landlord	40	0 0	Bank	437	0 0
Capital	1,190	0 0	Horse	72	0 0
			Stock	560	0 0
			Plant	38	0 0
			Crops	120	0 0
			Dairy	5	0 0
	£1,230	0 0		£1,230	0 0

Though the operations of the year 1921 show a small loss, it must be noted that £100 has been expended on housekeeping, the capital has been increased by £40 by the addition of interest charged upon the year's profits, and provision has been made for the payment of the amount of rent owing.

SOME FURTHER CONSIDERATIONS.

The system described herein furnishes the actual profit or loss on the whole of the farming operations for the year, and it will probably be best for the beginner to become thoroughly accustomed to this before attempting the more difficult process of analysing the gains or losses from the various branches.

This involves a careful dissection of—

1. The proportion of rent to be charged to each.
2. A strict appropriation of the labour, both of the farmer and his family, and of the wages men.
3. A close estimate, first of the cost of the upkeep of the horses, and then of the amount to charge per hour to the crops for teams, implements, &c.
4. An approximation of the value of the feed of the horses, stock, &c., to be credited to the Crop Account, and debited to the various Live Stock Accounts.

This involves such an amount of calculation, and so many transfers and adjustments, that it is likely to deter the beginner from continuing with his books, but to the man thoroughly interested in his work they present no difficulty. The principle is the same throughout, the object aimed at being to charge each branch of the business, for which an account is kept, with the whole of the direct and indirect expenses which it involves, or from which it benefits, and to credit it with its due proportion of the receipts, in order to ascertain the real profit or loss on that particular branch.

Valuations of Stock.

There is a decided difference of opinion as to whether the ordinary live stock on the farm should be valued in accordance with the fluctuations of the market or at a uniform figure consistent with age and quality. The former method shows the value that would be realised if the stock were sold; but even in a time of inflated prices they cannot be disposed of, as they are required for carrying on the farm operations. In such cases, the method may show profits which are not actually secured, while during a period of low prices, it may indicate losses that are not really sustained. Valuation at a regular, conservative price per head is on this account to be preferred, and on definite disposal the true loss or gain can be ascertained.

Repayments of Principal with Interest.

When land is obtained as a conditional purchase or a homestead selection, where repayments are being made under a loan from, say, the Rural Bank, and in fact whenever payments include interest with the principal, it should be noted that the principal is reduced by the total amount of the payment, less the interest.

For instance a payment of £15 on a C.P. might consist of £9 principal and £6 interest, and would be journalised thus,

	£	s.	d.	£	s.	d.
Land % (or Loan %)	9	0	0	.....	
Interest % _c , Dr.	6	0	0	.....	
To Bank	15	0	0			

The former reduces the total liability, whereas the latter is an expense for the current year.

Capital Cost.

Where a property is being constantly improved, a distinction should be made between permanent additions and current expenses. The former appear in the balance-sheet as assets, while the latter become part of the Profit and Loss Account. For instance, an orchardist who purchases unimproved land and gradually clears, fences, and plants the ground as circumstances permit, would probably utilise the space between the trees for the first few years for general crops and thus support himself. Under such conditions he might only charge to a Land or Orchard Account the actual outside costs

Assuming the purchase in 1919 of 27 acres at £10 per acre, clearing 12 acres at £8 per acre, fencing at £60, and wire-netting at £50 per mile, ploughing and subsoiling at £3 per acre, trees at £8 10s. per acre, and planting at £2 per acre.

In 1920 a further area of 10 acres was cleared and planted at the same rates. The cultivation, pruning, &c., of planted areas cost £2 per acre per annum.

The net cost to date of the orchard would then be as under:—

SPECIMEN ORCHARD ACCOUNT.

<i>Dr.</i>	£	s.	d.	<i>Cr.</i>	£	s.	d.
1919. To Purchase of Land ...	270	0	0	By Balance c/d (net cost to date) ...	612	10	0
„ Clearing	96	0	0				
„ Fencing	33	0	0				
„ Wire-netting	27	10	0				
„ Ploughing	36	0	0				
„ Trees	92	0	0				
„ Planting	24	0	0				
„ Cultivation	14	0	0				
	£612	10	0		£612	10	0
1920. To Balance b/d	612	10	0	By Sale of Timber	30	0	0
„ Clearing	80	0	0	„ Balance c/d (net cost to date)	876	10	0
„ Fencing (say)	20	0	0				
„ Wire-netting (say)	15	0	0				
„ Ploughing	30	0	0				
„ Trees	85	0	0				
„ Planting	10	0	0				
„ Cultivation (:2 acres)	44	0	0				
	903	10	0		£906	10	0

It will thus be seen that such an account gives a brief history of the owner's expenses in laying out his orchard; on the start of the third year, capital outlay will probably cease, and a return may be forthcoming after the fourth year. This, however, is best credited to a Fruit Account, and becomes one of the gross profits for the year. The question of making some small allowance for depreciation on such an orchard can only be left to the owner's judgment and knowledge of local conditions. Renewals and a gradual replacement of trees when needed can be charged as current expenses.

The Plant Book.

Where the implements in use are of a mixed character and have varying lengths of effective life, making a fixed depreciation is on the whole undesirable, and a special plant book may be used with decided benefit. This may be ruled according to circumstances and the insertion of other particulars may add to its value.

Name of Implement (and if necessary where procured).	Date of Purchase.	Cost.	Probable Life.	Amount of Depreciation.	Value at end of 1920.	Value at end of 1921.	Value at end of 1922.	Value at end of 1923.
		£	Years.		£ s. d.	£ s. d.	£ s. d.	£ s. d.
4-furrow plough ..	18-1-'20	40	4	25% or £10	30 0 0	20 0 0	10 0 0	.....
Spring cart ..	20-2-'20	30	10	10% or £3.	27 0 0	24 0 0	21 0 0	18 0 0
Reaper and binder..	20-2-'20	120	5	20% or £24	96 0 0	72 0 0	48 0 0	(Sold, £50)

The addition of all these items will give the valuation of the plant for the current year. Any period longer than six months may be taken as a year and all under that time neglected.

The plough may possibly have a nominal value at the end of the fourth year, and this can be put down in the column, if desired. The price, £50, for the binder will be credited to the Plant Account in the usual way, and it thus drops out of the valuations for the year.

Consignments Outwards.

This term is used to express the consignment of goods, stock, &c., to be sold on commission by an agent at a distance. In the majority of cases the account sales and cheque are received within a week or two, and they may well be treated as cash sales, the net return being journalised on receipt of the remittance. Where, as in the case of orchardists, consignments are being sent almost daily, and to different agents, it may be wise to enter them as sent in a book ruled as under, so that none may be overlooked:—

Date.	Goods Consigned.	Consignee or Agent.	* Expenses Prepaid	Account Sales.		† Amount Received.	Remarks.
				Date.	Net Amount.		
1921.							
Oct. 6	50 boxes peaches	Jones	5-	1921.	£ s. d.	£ s. d.	1 short delivered
.. 10	15 boxes grapes	Smith	3 6	Feb. 14	7 5 0	7 5 0	Claim on
.. 14	1 box peaches	Short delivered on 6th.	....	.. 20	4 10 0	4 10 0	Railway.
				Mar. 15	0 4 9	0 4 9	See below.

* Pay from Petty Cash.

† Enter in Journal, Bank Dr — To Fruit.

Sales on credit might also be entered in this book, if desired, pending settlement, and a glance through its pages will then show all supplies unpaid for.

In a few cases, such as sending cattle or sheep long distances by road, cold-storing fruit before sale, or shipments overseas, a considerable time might elapse before a settlement was made. Even in these cases, the above book would be suitable, avoiding the necessity for consignment accounts in the ledgers. When a balance-sheet is to be prepared, however, the outstanding items in the consignment book must be valued, and taken into account as produce on hand.

Conclusion.

Only a few of the salient points connected with book-keeping on the farm have been dealt with in this article. Other books for recording the receipts of cash, the doings of the labourers, transactions in bills, &c., may be used where the operations are extensive, or where further details are desired; but their use involves little difficulty after the elementary stages have been passed, and they can be ruled to suit varying conditions.

SECTION XVI.

Farmers' Calendar.

THE experience of every successful agriculturist is that it is only by timely and thorough preparation of the soil that cropping can be satisfactorily carried on. To provide a calendar giving specific details for each district in a handy form is manifestly impossible, and in the following pages the aim of the Department has been to provide the farmer, and more especially the newcomer, with a general indication of the practices that are proving successful as a result of many years of observation and experience in certain distinct localities.

By comparison of the altitude, average annual and monthly rainfall, and other conditions of their own districts with those for which specific details are given, farmers in districts other than those specified should be able to arrive at a fairly accurate estimate of the seasonal operations suitable for their own particular locality. In the descriptions of the specified districts, too, lists are set forth of districts that are considered to be of similar season.

No doubt, however, there still remains a large number of localities entirely unrepresented by the conditions obtaining in any of the districts described, and growers who are situated in such areas are invited to communicate with the Department for advice.

The various districts in the Calendar are:—

North Coast—Richmond-Tweed Section.

DIRECTIONS for the Richmond-Tweed section apply to practically all the districts embraced by the Big Scrub and as far as Lismore and a little beyond Murwillumbah. With slight modifications, the particulars will also apply, in the case of main crops for dairy fodder, to the districts surrounding Casino and Kyogle.

North Coast—Clarence Section.

DIRECTIONS for the Clarence section apply generally in that district with the exception of Dorrigo and other elevated plateaux, which, on account of cold nights are more akin to the tablelands in respect to cultural matters.

Central Coast.

COMPREHENDING the Nambucca, Macleay, Hastings, Manning and Hunter districts, and with slight modifications the directions apply to the whole area. Allowance must be made for the appearance of early and late frosts on the Hunter, and slightly earlier plantings must be made on the Nambucca and Macleay for spring crops.

Hawkesbury-Nepean.

DIRECTIONS for the Hawkesbury-Nepean district apply to Camden, Campbelltown, Liverpool, Penrith, Picton, Richmond, Sackville, St. Mary's, Windsor, Wiseman's Ferry.

South Coast.

THESE directions apply to Araluen, Bateman's Bay, Bega, Berry, Bodalla, Bulli, Candelo, Cobargo, Colombo, Eden, Gerringong, Kiama, Merimbula, Milton, Moinya, Nelligen, Nowra, Pambula, Picton, Shellharbour, Ulladulla, Wollongong, Wolumba.

Northern Tableland.

DIRECTIONS for Northern Tableland apply to districts adjacent to the Great Northern Railway from Woolbrook to Tenterfield, and to districts of somewhat similar elevation (from 2,000 feet) in the northern zone of the State.

Central Tableland.

THESE directions, with slight modifications, are applicable to Bathurst, Blayney, Orange, and other fairly elevated districts adjoining.

Southern Tableland.

THESE directions apply to Moss Vale, Goulburn, Crookwell, Braidwood, Queanbeyan, Cooma, Bombala, Delegate, and Dalgety districts.

North-western Slopes.

THE directions under this heading apply generally to the country west of a line from Singleton to Tenterfield, except such portions as have an elevation of 2,000 feet or more.

Central-western Slopes.

THESE directions, with slight modifications to meet differences in altitude and other natural conditions, apply to the following districts:—Canowindra, Cargo, Cowra, Dubbo, Eugowra, Forbes, Grenfell, Molong, Murrumburrah, Parkes, Temora, Wellington, Young. They would also apply, in a very large degree, to the slightly earlier districts of Condobolin, Narromine, and Trangie.

South-western Slopes and Riverina.

DIRECTIONS for Riverina apply to the majority of districts along the Southern line and branches from Junee to Albury, Junee to Jerilderie and Deniliquin; also Corowa and Berrigan.

Murrumbidgee Irrigation Areas.

DIRECTIONS apply to the areas watered by the Murrumbidgee irrigation works.

North-western Plains.

THE directions for North-western Slopes apply to the plains of the north-west, except that cropping is much more restricted in that district by reason of the difficulty of cultivating the soil at times, and by the fact that the soil is not sufficiently retentive of moisture by the present methods of cultivation to ensure successful cropping, except in years of good rainfall. The treeless plains are generally devoted to grazing. Water suitable for limited irrigation and good for stock may be obtained at varying depths on the plains.

JANUARY.

North Coast—Richmond-Tweed Section.

Crops to sow—

Maize—for green fodder; for grain blight-resistant varieties may be sown, but good yields cannot be expected.
Sorghum—for green fodder; may also provide grain for poultry and pigs.
Millet—for green fodder, cut before seeds ripen for hay for horse-feed; provides grain fairly useful for poultry.
Sweet potatoes—small planting.
Pumpkins—sow on small scale.
Marrows—sow on small scale.
Grass—after scrub fires paspalum grass-seed may be sown this month.

Vegetables—sow French beans, Swede and white turnips, red and silver beet, cabbage, lettuce, peas (a few), radish.

Get land ready for oats, barley, and rye for green feed.

Ensilage making commences.

Sugar-cane—keep down weeds by chipping and scuffling.

North Coast—Clarence Section.

Crops to sow—

Maize—for green fodder and silage. Early varieties may still be sown for grain to mature before frost, but good yields can never be expected from the late sowing of early varieties.
Sorghum—for green fodder and silage.
Millet (Manchurian and Hungarian)—for green fodder—useful as a cleaning crop for foul land.
Pumpkins, grammas, and marrows—sow on small scale.
Sweet potato—plant on small scale.
Cowpeas—sow for seed, fodder, or green manuring. For grain, sow 8 to 9 lb. seed in drills 30 inches apart. Broadcast for green manuring, using 20 to 30 lb. seed.

Vegetables—sow French beans, swedes, lettuce, cabbages, cauliflowers, silver beet, peas, (light sowing), cucumber, squashes, and marrows.

Potatoes—plant tubers, preferably uncut, and of medium size, so as to provide seed sufficiently shot to plant in July.

Get land ready for autumn cropping. It will generally prove profitable in this district to put a catch crop of (say) millet in land intended for autumn cropping. This will serve to clear it of weeds, as well as to provide some useful fodder.

Central Coast.

Crops to sow—

Maize—for green fodder and silage. Rather late for grain, although varieties such as Fitzroy and Learning may be tried—the former owing to its "blight" resistance.
Sorghum—sacaline and other varieties may be sown this month for winter use.
Millets—Manchurian and Hungarian may still be sown for green fodder.
Potatoes—small sowings for autumn crop, late in the month; use early maturing varieties.
Pumpkins—a small sowing early.
Cowpeas—in the maize or sorghum plots or alone.
Tomatoes—plant out for late crop.
Turnips—sow swedes late in month.
Grasses—after scrub fires, paspalum and Rhodes may be sown.

Vegetables—sow seed of French and other beans, beet, cabbage, cauliflower, cucumber, leek, lettuce, parsnip, radish, silver beet, sweet corn, turnips. Transplant tomato and other seedlings from previous sowing, choosing cool weather.

Muleh, hoe and water freely.

Get land ready for barley, oats, rye, field peas, turnips, lucerne, mangolds, grasses, and clovers. Aim at the destruction of weeds and the conservation of moisture. Ensilage making commences this month.

Hawkesbury-Nepean.

Crops to sow—

Maize—for green fodder and silage. In sheltered situations a quick-maturing variety might mature grain, but risky, and areas should be small.
Sorghum—for green fodder and silage.
Millet—when hay is scarce, the rapid growth of millet affords a ready means of replenishing the supply. Hungarian is best for this purpose.

Vegetables—sow French and butter beans, silver beet, cauliflower, cabbage, leeks and green bush marrows for late crop; plant out celery and tomatoes.

Get land ready for autumn sowings of cereals, legumes, rape, lucerne, and for autumn crop of potatoes. The land should be left open to catch any rain, and cultivated whenever a crust forms, in order to conserve soil-moisture.

*South Coast.***Crops to sow—**

Maize, sorghum, and Japanese millet for green fodder.
Red clover.

Vegetables—sow seed of French beans, beet, cabbage, cauliflower, cucumber, leek, lettuce, parsnip, radish, silver beet, squash and (for late planting) some tomato seed.

Transplant celery and tomato plants.

Get land ready—by ploughing for winter fodder crops. Keep cultivator going among row crops where it is possible.

*Northern Tableland.***Crops to sow—**

Maize, sorghum, millet—can still be sown on a small scale for autumn green feed or for silage.

Barley—an early sowing could be made for cutting, and then be allowed to make a second growth.

Potatoes—only very quick maturing varieties.

Peas—may be sown this month in the milder portion of the district.

Vegetables—sow beans, cabbage, cauliflower, celery, leek, lettuce, parsnip, radish, silver beet, and Swede turnip. Transplant cabbage, cauliflower, leek.

Harvesting of the grain crops will be proceeding, as there are generally late crops in this district. As the paddocks are cleared of crop, sheep should be turned in to clean up all weeds, &c.

During the busy harvest, the summer crops, such as maize, potatoes, &c., are apt to be neglected; but all available time should be given to them in the way of cultivation, stirring up the soil after rain to conserve the moisture and to keep down the weeds.

*Central Tableland.***Crops to sow—**

Maize—early varieties for green fodder for autumn use.

Sorghum—early varieties for green fodder for autumn use.

Millet—for green fodder for autumn use.

Swedes—main crop may be sown.

Barley } small sowings of any of these
Rye } crops may be made towards end
Wheat } of month for early winter green
Oats } fodder.

Vegetables—sow swedes, French and butter beans, parsnip, radish. Peas for late crop. Sow in seed-beds cabbage, Brussels sprouts, broccoli, leeks, celery, lettuce, silver beet
Transplant cabbage, cauliflower, and celery.

Get ready land for autumn cropping. All land from which cereal crops have been harvested should be ploughed lightly, or cultivated as early in this month as possible; moisture is thereby conserved, weeds destroyed, and shed grain given a chance to germinate.

*Southern Tableland.***Crops to sow—**

Maize, Japanese millet—for green fodder.
Turnips and mustard—for sheep feed.
Clovers.

Other work—give close attention to the potato crops, check weed growth, watch for the potato moth and hill if necessary to check the trouble. Plough ground for autumn sown crops. Get ready any areas to be sown with lucerne—it is necessary that the weed seed be worked out. See to the wheat drill, that it is in working order.

Vegetables—sow seed of beans (French and broad), cucumber, lettuce, parsnip, radish, cabbage, silver beet, squash, and Swede turnip.

Transplant celery, cabbage, cauliflower, and leek plants.

If weather is dry, keep the surface soil well worked and give plants an occasional good watering.

See that drains are in good order, so that in event of heavy rain the surplus water can get away easily.

*North-western Slopes.***Crops to sow—**

Maize and sorghum—early maturing varieties for green feed and silage.

Millets and Sudan grass—for grazing and hay.

Potatoes—often a successful crop can be obtained if early maturing varieties, such as Factor and Early Manhattan, are grown.

Vegetables—sow French beans, marrow, squashes.

Prepare land for winter fodder crops, such as rape, and for the cereals, wheat, oats, barley.

*Central-western Slopes.***Crops to sow—**

Maize—early maturing varieties for greenstuff and silage.

Sorghum and millet—early maturing varieties for greenstuff and silage.

Potatoes—the second, or autumn crop, for household use, should be planted in well-worked, fallowed land. For this crop use small whole tubers rather than pieces of large ones. When planted at this season cut sets rot quickly.

Vegetables—sow French beans, marrows, squashes, pumpkins, turnips, peas, beet, radish.

Get land ready for autumn crops. Keep the fallowed land clean by feeding off and cultivation.

South-western Slopes and Riverina.

Crops to sow—

There are few, if any, crops which can be safely sown this month. All the attention possible should be devoted to keeping soil in a condition to conserve moisture.

Get land ready for early sowings of rape and swedes for sheep, and break up or scarify land intended for cereal in autumn.

Murrumbidgee Irrigation Areas.

Crops to sow—

Maize—for green feed only; for grain small areas may still be chanced, but risky.

Millet—for green feed only.

Vegetables—sow carrots, turnips (white), cabbages, cauliflowers, peas, beet-roots, French beans, radishes, lettuce, potatoes (end of month).

Get land ready for next cereal crops. Even a short fallow is better than none. The same applies to land intended for lucerne.

North-western Plains.

Crops to sow—

Conditions are generally unfavourable this month for sowing any main crops. Special attention in the way of cultivation should be paid to all growing crops to destroy weeds and conserve soil moisture.

FEBRUARY.

North Coast—Richmond-Tweed Section.

Crops to sow—

Japanese millet—sow for green fodder (on high ground).

Maize—sow for green fodder and ensilage.

Rye— do do

Planter's Friend do do

To balance these, add a leguminous crop, (say) cowpeas.

Swede turnips—for winter food for dry cows and milkers; also for pigs.

Mangolds— do

Carrots— do

Field cabbage— do

Thousand-headed kale— do

After fires, paspalum seed may be planted. Rye and prairie grass seed may be sown.

Vegetables—sow seed and plant out cabbage, cauliflower, lettuce, celery. Sow beans, peas (a few), beet, carrot, cucumber, leek, parsnip, potato, radish, silver beet, turnip. Transplant tomato, silver beet.

Get land ready for lucerne: choose good spot where soil is deep and drainage is good.

Ensilage-making continues.

North Coast—Clarence Section.

Crops to sow—

Oats, barley, and rye—sow for green fodder, combine either peas or vetches. Rape—sow for green fodder.

Swede turnips—for winter food for pigs and cows.

Sorghum—for green feed.

Thousand-headed kale and field cabbage (in drills)—for winter food for pigs and cows.

Hungarian and Manchurian millet—for green feed or hay.

Paspalum—the best month for sowing seed.

Potatoes—plant, but not on a large scale, uncut sets.

Vegetables—sow swedes, white turnips, French and butter beans, peas, beet, carrot, cucumber, leek, parsnip, radish, lettuce, silver beet, cabbage, cauliflower, celery.

Transplant cabbage, cauliflower, celery.

Central Coast.

Crops to sow—

Maize—for green fodder and silage.

Sorghum—Saccaline and other varieties for winter and early spring use.

Oats—Algerian, for grazing.

Barley, rye, rape—for green fodder.

Potatoes—autumn crop—sow early and use early varieties.

Turnips—sow extensively.

Mangolds—small lot latter end of month.

Field peas and vetches—for green fodder and green manure.

Winter grasses and clovers—autumn sowing.

Vegetables—sow broad beans, beans of other varieties, beet, cabbage, cauliflower, carrot, celery, cucumber, leek, lettuce, onion, parsnip, peas, potatoes, radish, silver beet, turnip, kohlrabi.

Transplant cabbage, cauliflower, celery, eschalot, silver beet, tomato.

Keep water going freely, mulch and hoe.

Get land ready for lucerne and other autumn sown crops. Ensilage making.

Hawkesbury-Nepcan.

Crops to sow—

Maize—for green feed and silage.

Sorghum—for green feed and silage.

Millet—for green feed, hay, and silage.

Barley—latter end of month sow either Cape or Skinless for green fodder, preferably with vetches or Grey field peas for complete ration. Rape and barley forms an excellent mixture for sheep and pigs.

Potatoes—plant autumn crop for market and home use.

Rape—sow largely for pig feed and green manure.

Turnips and swedes—sow towards end of month for market and stock purposes.

Cabbage and kale—sow for field culture.

Vegetables—sow French and butter beans, beet, cabbage, cauliflower, celery, leeks, lettuce, onions, radish, carrots, and parsnips (end of month). Plant out cabbage, cauliflower, and celery if weather is favourable.

Get land ready for main cereals, lucerne and autumn sowings of grass seeds; also break up ground where shade or shelter trees are to be planted.

South Coast.

Crops to sow—

Japanese millet, sorghum, and mangolds—for fodder for dairy cattle.

Red clover—it is a wonder plant on cold soils.

† 54797—24.

Vegetable—sow seed of beans (French and broad), beet, cabbage, carrot, cauliflower, celery, cucumber, leek, lettuce, onion, parsnips, peas, radish, silver beet, white and Swede turnips.

Transplant—cabbage, cauliflower, celery, eschalots, silver beet, and tomato.

Plant potatoes.

Get silo ready for filling—if there is not one on the farm, no time should be lost in its erection.

Northern Tableland.

Crops to sow—

Barley—a sowing of either Cape or Skinless barley for green feed should be made; the latter should be sown more thickly than the former, as it does not stool well.

Rape, tares (or vetches)—for winter feed.

Rye—this may be sown for green feed.

Turnips—a sowing of swedes and white turnips may be made for a general crop this month.

Vegetables—sow broad beans, beet, cabbage, carrot, leek, lettuce, parsnip, radish, silver beet, spinach.

Transplant eschalot, leek, silver beet. If any seedlings of cabbage or cauliflower have been raised they should now be planted out in rich, well-worked land. Onion seed may be sown on carefully-prepared land. Sow thinly in drills; keep free from weeds, and thin out later.

Get land ready for grasses, lucerne, and clovers.

Central Tableland.

Crops to sow—

Barley, rye, wheat, or oats (the first two for preference)—as the main winter green fodder.

Rape—should be sown largely. A mixture of rape and barley, rape and oats, or rape and rye in alternate drills is preferable to rape alone.

Swedes may still be sown.

Sow kale, lucerne, and black tares in well prepared land towards end of month.

Vegetables—sow in seed-beds onions for main crop. Sow cabbage, Brussels sprouts, broccoli, leeks, beet, lettuce, radish, turnip, silver beet, and celery. Transplant cabbage, broccoli, leeks, celery, and eschalots. Make a small sowing of carrots.

Southern Tableland.

Crops to sow—

Rye and field peas—for green fodder.
Barley and field peas or wheat (Firbank or Thew) and field peas may be sown on small areas if the season is favourable where early green winter fodder for dairy stock is required.
Lucerne—this is a good month to sow lucerne seed providing the weed seed has been worked out of the ground, and there is sufficient soil moisture. Get the crop up and doing before the ground becomes cold.

Vegetables—sow seed of broad beans, beet, cabbage, carrot, celery, leek, lettuce, onion, parsnip, radish, silver beet, spinach, white and Swede turnip. Transplant cabbage, cauliflower, celery, eschalot, leek and silver beet plants.
Hot weather conditions have to be met. Keep ground well worked and weed growth down. See that plants do not lack soil moisture.

North-western Slopes.

Crops to sow—

Millets and Sudan grass—for feeding off.
Rape, barley, wheat and oats—in the latter part of the month for grazing.

Vegetables—sow French beans (early in month), and cabbage, cauliflower, peas, Swede and white turnip later in the month.

Get land ready for wheat, oats, barley, and rape.

Central-western Slopes.

Crops to sow—

Rape—for early grazing and greenstuff.
Mustard— do
Barley— do
Rye— do
Tares (or vetches) do

Early sown crops of rape are likely to be attacked by aphid; to keep the pest in check the crop should be kept fed off until cool weather sets in. Barley or mustard, sown with rape, tends to reduce the danger of "bloating" when stock are first put upon the crop.

Vegetables—sow French beans, beet, turnip, radish, lettuce, silver beet, swedes, cabbage, cauliflower.

Get land ready for autumn crops by breaking up stubble or new land, and by working the fallows to check weeds and evaporation.

South-western Slopes and Riverina.

Vegetables—sow cabbages and cauliflower in seed-beds for transplanting later on. If soil is sufficiently moist, sow white turnips and swedes. Growing crops will need especial attention, and if weather is dry, an occasional watering. In applying the water, stir up the soil beforehand, and then cover the moist ground with a mulch of old straw, leaves, or anything that will help to conserve the moisture.

Other work—It is rather early for sowing any of the main crops yet. All the time possible should be devoted to preparing land for—

Rape—for green feed, which may be sown in fallowed land or after showers.

Oats—for green feed.

Wheat—for green feed.

Swedes and turnips—sow if weather be favourable.

Murrumbidgee Irrigation Areas.

Crops to sow—

This is a bad time to sow crops, though towards the end of the month Cape or Skinless barley may be sown for green feed.

Vegetables—sow cabbage, cauliflower, carrots, beetroot, parsnips, turnips (white and Swede), lettuce, potatoes.

Get land ready for all classes of autumn sown crops.

North-western Plains.

Vegetables—cabbage and cauliflower seed may be sown to provide young plants for setting out towards the end of March.

Other work—should the weather permit, ploughing may still be done for crops that are to be put in late in May or in June, but this is usually a very wet month, and work on the land is impossible.

MARCH.

North Coast—Richmond-Tweed Section.

Crops to sow—

- Sorghum—sow a little for green fodder.
- Oats—sow as much as desired for green fodder.
- Barley—sow as much as desired for green fodder.
- Maize—sow for green fodder.
- Rye—sow for green fodder.
- Rape—sow for green fodder for pigs and dry cows.
- Field peas } sow alone, or in combina-
- Vetches } tion with oats, rye, or
- } barley, as winter food
- } for milch cows.
- Potatoes—plant largely as desired.
- Grasses—sow cocksfoot, rye grasses, and prairie.
- Clover—sow White or Dutch, and Red.

Vegetables—sow cabbage, onions, leek, lettuce, peas, globe artichokes, French bean, beet, carrot, celery, herbs, parsnips, radish, silver beet.
Transplant available seedlings.

Get land ready for lucerne.
Plant evergreen trees for shade.

North Coast—Clarence Section.

Crops to sow—

- Oats—sow for green fodder.
- Barley— do
- Wheat— do
- Rye—sow a small area for green feed.
- Field peas—sow to raise seed supply for future combination cereal crops for fodder.
- Vetches and field peas should also be sown in combination with cereals.
- Rape—for pigs.
- Potatoes may still be planted, but on very small scale.
- Lucerne.
- Grasses—the best month to sow grasses of all kinds.

Vegetables—sow cabbage, onions, peas, globe artichokes, French and broad beans, beet, carrot, celery, herbs, lettuce, parsnips, silver beet, spinach, turnips (white and Swede).
Transplant cabbage, cauliflower, celery, lettuce, silver beet

Central Coast.

Crops to sow—

- Maize—for green fodder only. Leaming and Hickory King.

Sorghum—Saccaline can be sown in northern portion of district for winter and spring use early in the month.

- Oats
 - Barley
 - Wheat
 - Rape
 - Rye
- } for green fodder.

Field peas and vetches alone or with the above mentioned cereals for fodder.
Tiek beans, clovers, and winter grasses.
Onion—plant seed, late in month in seed-beds.

Vegetables—sow broad beans, French and other varieties (northern districts), beet, cabbage, cauliflower, carrot, celery, herbs, leeks, lettuce, onion, parsnips, peas, potato, radish, silver beet, Spanish turnip, kohlrabi.

Transplant cabbage, cauliflower, celery, eschalots, lettuce, silver beet.

Keep ground well manured. For winter elevate bed rows so that water will drain off.

Get land ready for lucerne, clovers, and winter fodders, mangolds, &c.

Hawkesbury-Nepean.

Crops to sow—

- Hungarian millet may be sown for green feed or silage early in the month.
- Wheat—sow for green forage.
- Oats—sow for green feed, in conjunction with vetches or field peas.
- Barley—sow for green feed alone or with rape.
- Rye—on poorer soils where other cereals fail to flourish rye may be grown for stock feed, provided it is cut before the seed is ripe.
- Lucerne—may be grown this month.
- Rape—sow largely for pig feed and green manure.
- Turnips, swedes, kohlrabi, tree-kale, and thousand-headed kale may be sown.

Vegetables—sow French beans (sparingly), broad beans, beet, cabbage, cauliflower, celery, lettuce, leeks, peas, radish, carrot, herbs, parsnips, silver beet, spinach, turnips.
Transplant cabbage, cauliflower, celery, lettuce, silver beet.

Get land ready for sowing grasses and make final preparations of land for lucerne, and for planting out shelter trees.

*South Coast.***Crops to sow—**

Wheat, oats, barley and rye for green fodder. Field peas sown with any of these crops increase the feeding value, and superphosphate will be found a very useful help to the growing plants.

Lucerne—now is a good time to sow lucerne, so that the plants may become firmly established before the ground becomes cold. Have the ground clean and weeds in check.

Winter pasture grasses.

Vegetables—sow seed of beans (French and broad), beet, cabbage, carrot, cauliflower, celery, cucumber, leek, lettuce, onion, parsnip, peas, radish, silver beet, white and Swede turnip.

Transplant cabbage, cauliflower, celery, eschalot, silver beet, and to nato.

*Northern Tableland.***Crops to sow—**

Rape may be sown for feeding stock in winter.

Wheat, oats, barley, and rape may be sown for green feed. Cape or skinless barley, two of the best, may be sown with tares or vetches if required.

Rye may also be sown with tares for green food or for hay, if cut early.

Clovers for feed or hay may be planted end of the month.

Field peas may be sown alone or in conjunction with wheat, oats, barley, or rye for green feed.

Lucerne—the latter part of March is a good time to sow lucerne to enable roots to establish themselves well in the soil before cold weather sets in.

Vegetables—sow broad beans, beet, cabbage, carrot, leek, lettuce, onion, parsnip, radish, silver beet, spinach, white and Swede turnip.

Transplant cabbage, cauliflower, eschalot, leek, onion, silver beet.

Plough land for spring cropping, the earlier the ploughing the deeper it should be, except that too much clay subsoil should not be brought to the surface.

*Central Tableland.***Crops to sow—**

Wheat—the earliest sowing of this cereal for the main crop may be made about the end of the month, if it is intended to graze sheep upon it during winter. The lighter portions of the farm should be chosen for this purpose. Late-maturing varieties should be used.

Barley, oats rye, and rape should still be sown early in the month for green fodder.

Kale, white mustard, clovers, Black tares, field peas, grasses, and sheep's burnet.

Lucerne—the main crop, may be sown this month upon well prepared land.

Onions—for main crop.

Vegetables—sow onions, radish, spinach, leeks, eschalots, Savoy cabbage, broccoli, and white turnips. Make a small sowing of carrots and lettuce.

Transplant Savoy cabbage, broccoli, onions, leeks, eschalots, and silver beet.

*Southern Tableland.***Crops to sow—**

Wheat—for hay, green feed, or grain.

Barley and rye—for green feed.

Field peas—for green feed, sown with wheat, barley, or rye.

Sunrise oats—for early green fodder might be sown.

Lucerne, clovers, mustard, rape, and turnips, rye grass, cocksfoot, prairie grass—may be sown now; and some clover should be added to the mixture.

Vegetables—sow seed of broad beans, beet, cabbage, carrot, leek, lettuce, onion, radish, silver beet, spinach, white and Swede turnip.

Transplant cabbage, cauliflower, celery, aschalot, leek, and silver beet plants.

Other work—keep the cultivator going among row crops and the harrow where it can be used on any broadcast or drilled crops to check evaporation by stirring the surface soil. See that on established lucerne patches the harrow is used after every cut. Pasture improvement can be attended to. Keep plants moving. Watch potato crops for sign of the moth—the grub causes big loss. See to the planting of suitable trees or shrubs for shelter and shade for stock. Select native plants, if possible.

*North-western Slopes.***Crops to sow—**

Wheat, barley, and oats—for grazing and green feed, and subsequently for hay crops.

Rape, clovers, swedes, vetches, and grasses—for grazing and green fodder.

Vegetables—sow beet cabbage, carrot, cauliflower, leek, lettuce, onions, parsnip, radish, silver spinach beet, turnip.

Prepare land—for cereals and lucerne.

*Central-western Slopes.***Crops to sow—**

Rape
Kale
Mustard } for grazing and greenstuff.
Oats
Barley } with tares or vetches.

Crimson clover for grazing and greenstuff.

Wheat—for green fodder and silage.

Rape—early in March is the most favourable time for the main crops of rape.

Vegetables—sow beet, cabbages, cauliflowers, onions, carrots, parsnips, turnips, swedes, radish, lettuce, silver beet.

Transplant cabbage, cauliflower, celery, leek, eschalot, silver beet.

Get land ready—for lucerne, and finish the preparation of the land intended for wheat, oats, and barley.

*South-western Slopes and Riverina.***Crops to sow—**

Rape—sow as largely as desired.

Oats—for greenstuff, hay, and grain.

Barley—for green fodder, with or without peas or vetches.

Sow lucerne on land which has been fallowed and kept free from weeds.

Vegetables—sow cabbage, cauliflower, carrots, parsnips, beet, turnips, swedes, onions, and a few rows of peas.

*Murrumbidgee Irrigation Areas.***Crops to sow—**

Barley for green feed.

Oats—for green feed and hay.

Clovers, cocksfoot, prairie, rye grasses

Wheat—for green feed.

Tick beans—for green manure crop.

Vetches—with cereal for green feed.

Turnips—broadcast for a field crop.

Rape can still be sown.

Vegetables—sow carrots, parsnips, beet-root, broad beans, turnips (white and Swede), lettuce, cabbage, silver beet, radish, herbs, leek.

Transplant eschalots, tree onions, garlic, cabbage, cauliflower.

*North-western Plains.***Crops to sow—**

Barley, oats, and wheat for winter feed.

Grass, lucerne, and field peas.

Vegetables—cabbage and cauliflowers sown last month may be planted out if the weather is not too hot, otherwise they had better be left in the seed-bed, where they can be shaded until the weather begins to cool off; sow seeds for succession.

Get land ready for sowing wheat, oats, barley, rye, and lucerne. By working the surface at this stage, the soil will be got into good condition by April, and weeds, which at this stage commence to grow luxuriantly, will be checked, and the majority got rid of by scarifying.

APRIL.*North Coast—Richmond-Tweed Section.***Crops to sow—**

Wheat, oats, and barley—sow for greenstuff and also wheat and oats for hay.

Rye—sow for greenstuff.

Lucerne—make main sowing.

Rape—sow for winter feed for pigs.

Field peas—sow for cattle feed, and seed for pigs.

Vegetables—sow broad beans, peas, onions, turnips, beet, carrot, herbs, leek, lettuce, radish, silver beet, spinach, and, in frost-free situations, French beans.

Plant out rhubarb, cabbage, cauliflower, celery, leek, silver beet, onion, lettuce.

*North Coast—Clarence Section.***Crops to sow—**

Wheat and oats—for greenstuff, and also for hay.

Barley and rye—for greenstuff.

Wheat—for grain (poultry feed only).

Vetches and field peas should be sown in combination with cereals for greenstuff.

Field peas—sow for pig feed.

Lucerne—sow largely. This is the best month for this crop.

Rape—sow for winter feed for pigs.

Thousand-headed kale and cattle cabbage—in drills 3 feet apart, for pig and cow feed.

Swedes—sow for market and stock.

Grasses and clovers may be sown.

Vegetables—sow French beans (in frost-free situations), cabbage, carrot, onions, peas, herbs, beet, radish, leek, lettuce, silver beet, spinach, turnips.

Transplant cabbage, cauliflower, celery, leek, onion, silver beet.

*Central Coast.***Crops to sow—**

Oats } for green fodder and hay.
 Wheat }
 Barley }

Rye } for green fodder.
 Rape }

Field peas and vetches—for fodder alone, or with cereals.

Tick beans—for fodder and green manure.

Mangolds.

Lucerne—probably best month for sowing on the lower rivers. Little early for the Macleay.

Clovers and winter grasses—good month for sowing.

Onions—plant seed in seed-bed.

Vegetables—sow broad beans, French beans (in frost-free situations), beet, carrot, cabbage, kohlrabi, turnip, herbs, leek, lettuce, onions, parsnip, peas, radish, silver beet, spinach, turnips, rhubarb (also divide latter).

Transplant cabbage, cauliflower, celery, eschalots, leek, lettuce, onion, silver beet.

Other work—plough under all stalks, &c., and cowpea crops sown during summer. Let them decompose by leaving the land under fallow for spring crops.

*Hawkesbury-Nepean.***Crops to sow—**

Wheat—sow late varieties for green feed and hay.

Oats—sow largely for hay, and with peas and vetches for green feed. Too early for river flats.

Barley—for grain for pigs and poultry, and for green feed, either alone or with rape.

Rye—for green feed and grain.

Turnips, swedes, rape, and kale—may still be sown.

Mangolds may be sown on rich ground for stock feeding.

Lucerne—make main sowing in well prepared soil.

English grasses and clovers—sow either in well cultivated land or in roughly scratched-over pasture, if weather be favourable.

Field peas and vetches—may be sown for pig feed or green manure.

Tree planting—for shade, shelter, and ornament—should receive attention this month. Non-deciduous trees, such as peppers (very early in month), pines (various), kurrajong, silky oak, camphor laurel, river oak, juniper, carob bean, and bunya bunya may be planted out. Hedges should also be planted out. The seeds of such trees as pines, cedars, oaks, walnuts, and

chestnuts should be sown as soon as possible after ripening, but not later than April.

Vegetables—sow broad beans, carrots, parsnips, leeks, onions, lettuce, parsley, peas, eschalots, beet, radish, silver beet, spinach, and herbs. Winter rhubarb may be planted out, also cabbage, cauliflower, celery, leek, onion, silver beet, herbs.

*South Coast.***Crops to Sow—**

Wheat, oats, barley, and rye, with field peas—for green winter fodder for stock.

Clovers and pasture grasses.

Lucerne.

Vegetables—sow seed of beans (broad), beet, cabbage, carrot, cauliflower, celery, leek, lettuce, onion, parsnip, peas, radish, silver beet, white and Swede turnip.

Transplant cabbage, cauliflower, celery, eschalots, silver beet, and tomato.

Other work—harrow the pastures—it helps to freshen the grass, it breaks up the cowpats, and disturbs insects which might be harbouring in the grasses. See that the pastures contain a percentage of clovers. Harrow the lucerne patches after every cut. See to the maize-sheller.

*Northern Tableland.***Crops to sow—**

Wheat—the end of the month is a good time to sow wheat, especially sorts that take a long time to mature.

Barley, rye, or oats may be sown for green fodder.

Lucerne may also be sown, although it is getting late.

Tares, vetches, &c., may be sown in combination with rye or barley. The former are good for ploughing in in orchards during the winter months.

Vegetables—sow broad bean, beet, cabbage, herbs, leek, lettuce, onion, radish, silver beet, spinach, and white turnip. Transplant cabbage, eschalot, leek, lettuce, onion, and silver beet.

Get land ready for main crops of cereals and hay, and spring crops.

*Central Tableland.***Crops to sow—**

Wheat—as much as possible of the main crops should be sown. Sow the late-maturing varieties first upon the poorer portions of the farm.

Barleys can be advantageously sown towards the end of the month for the main crops.

Oats can be sown freely this month; comparatively early sowing frequently ensures good plump grain.

Rye may be sown for the main crop; it thrives upon very light soils.

Lucerne may be sown for the main crop. Kale, Searlet clover, Black tares, field peas and grasses may be sown.

Vegetables—sow white turnips, Savoy cabbage, broad bean, leek, onion, radish, and herbs. Make small sowings of spinach and lettuce.

Transplant onions, leek, Savoy cabbage, broccoli, and eschalots.

South-rn Tableland.

Crops to sow—

Wheat and oats—for hay, green fodder, or grain.

Barley and rye—for green fodder.

Field peas—for growing in with other green fodder.

Rape, mustard, turnips, lucerne.

Vegetables—sow broad beans, beet, cabbage, carrot, leek, lettuce, onion, radish, silver beet, spinach, white and Swede turnip.

Transplant cabbage, cauliflower, eschalot, herbs, leek, and silver beet plants.

Clear the garden of any spent plants.

Other work—Cultivate where possible to conserve soil moisture, especially for lucerne. Prepare to meet winter weather conditions; see to pastures, &c.

North-western Slopes.

Crops to sow—

Wheat, oats, and barley—for hay and grain crops.

Clovers, grasses, rape, vetches, and swedes—for grazing, &c.

Vegetables—sow beet, cabbage, carrot, cauliflower, herbs, leek, lettuce, onions, parsnips, radish, silver beet.

Prepare land for cereals (wheat, oats, barley) and for spring sowings. If the season has been favourable the earlier sown grazing crops—rape, wheat, barley, &c.—may now be fed off. It is wise after each feeding of such crops to give the land a thorough harrowing. This induces more vigorous growth and helps to check weeds.

Central-western Slopes.

Crops to sow—

Lucerne—in a well prepared seed-bed.

Wheat and oats—for hay and grain.

Barley and rye—for greenstuff, hay, and grain.

Rape, tares or vetches, and Crimson clover—for grazing.

Vegetables—sow silver beet, radish, lettuce, leek, beet, peas, onions, carrots, parsnips, turnips, swedes, cabbages, and cauliflowers; and transplant any seedlings available.

Get land ready for the final sowings of wheat. Keep the ground between the drills of rape and other growing crops loose to conserve moisture, kill weeds, and stimulate growth of crop.

South-western Slopes and Riverina.

Crops to sow—

Wheat—for hay and grain.

Rape may still be sown on a small scale.

Barley—for grain, and in combination with tares and greenstuff for silage.

Lucerne—sow as much as land is well prepared for.

Clover and trefoil can be sown this month.

Vegetables—sow a moderate area of peas and broad beans, also cabbages and cauliflowers for future transplanting.

Transplant cabbages and cauliflowers as they become fit. Sow onions, carrots, parsnips, and white turnips.

Get land ready for the further sowing of wheat, which it is desirable should be completed during next month.

Murrumbidgee Irrigation Areas.

Crops to sow—

Barley—for green feed.

Oats and wheat—for green feed, grain, and hay.

Lucerne—the best month for autumn sowing.

Field peas—for pig feed or green manuring.

Either field peas or tares in combination with cereals for green feed.

Cocksfoot, rye, and prairie grasses, provided the season is favourable.

Vegetables—sow turnips, carrots, beetroot, parsnips, radish, lettuce, broad beans, onions, silver beet, herbs, leek.

Transplant cabbage, cauliflower, lettuce, silver beet.

North-western Plains.

Crops to sow—

Wheat, oats, barley, lucerne, grass—in fact, any of the hardy winter crops.

Vegetables—plant out cabbage and cauliflowers and sow seed for later plantings; sow broad beans.

MAY.

*North Coast—Richmond-Tweed Section.***Crops to sow—**

- Barley—sow for green feed, also some for poultry and pig grain.
 Oats—sow for hay and with field peas or vetches for green feed.
 Rye—sow for green feed, also some for poultry grain.
 Grasses and clover—sow, but it is getting late.
 Vetches and field peas.

Vegetables—sow broad beans, peas, lettuce, cabbage, turnips, beet, radish, herbs, leek, onion, parsnip, silver beet, spinach, turnips, and carrots. Plant out a few rhubarb roots.

Transplant cabbage, celery, herbs, leek, lettuce, onion, silver beet.

Get a small plot trenched and well prepared for asparagus.

*North Coast—Clarence Section.***Crops to sow—**

- Wheat and oats—for hay and green feed.
 Barley and rye—for green feed.
 Vetches and field peas—sow in combination with cereals for green feed.
 Rape—for green feed for pigs and sheep.
 Lucerne—if weather is favourable.

Vegetables—plant out rhubarb roots, top-dress asparagus beds with stable manure. Sow peas, cabbage, turnips, lettuce, carrots, beet, radish, leek, onion, parsnip, silver beet, spinach.
 Transplant cabbage, celery, herbs, leek, lettuce, onion, silver beet.

*Central Coast.***Crops to sow—**

- Wheat and oats—for green feed and hay.
 Barley and rye—for green feed.
 Field peas and vetches alone or in combination with cereals.
 Rape, lucerne, clovers, tick beans.

Vegetables—sow broad beans, beet, cabbage, carrot, lettuce, peas, radish, silver beet, spinach, turnip, potato, onions.

Transplant cabbage, celery, eschaloit, herbs, leek, lettuce, onion, rhubarb, and silver beet.

Dig up and manure land for spring sowings.

Other work plough up all idle land and fallow.

*Hawkesbury-Nepean.***Crops to sow—**

- Wheat—sow quick-maturing varieties for green feed, hay, and grain.
 Oats—main crop for hay.
 Barley—green feed, and for pig and poultry grain.
 Rape—when weather conditions have been unfavourable for previous sowing, this may be done now. Somewhat too late for turnips and swedes, as they go to head in August before making much growth.

Vegetables—sow broad beans, carrots, leeks, lettuce, onions (for pricking out), parsley, herbs, peas, and eschalots. Plant out asparagus roots, though June is preferable, also cabbage, celery, herbs, leek, lettuce, onion, silver beet.

Get land ready for late sowings of wheat and rye for winter green feed.

*South Coast.***Crops to sow—**

Wheat, oats, barley, rye, and field peas may be sown, but they will not run up to any height until October.

Vegetables—sow seed of broad beans, beet, cabbage, carrot, celery, leek, lettuce, onion, parsnip, peas, radish, silver beet, white and Swede turnip.

Transplant cabbage, celery, eschalots, and silver beet.

Clean up the garden of all old plants: squash, pumpkin, melon, and tomato vines if left harbour spores of disease, and should be burnt along with old bean plants. Dig up old beds to sweeten the soil.

Other work—the ground, as a rule, is cold from now and until August, and unless a plant is well established, there will be little growth. Plough up ground after ensilage and green fodder crops have been removed, particularly after sorghum, for the stubble holds the red stain disease. Maize-pulling will occupy a lot of time this month.

*Northern Tableland.***Crops to sow—**

- Wheat—late maturing varieties may be sown early in the month.
 Barley } for green fodder.
 Rye }
 Vetches may be sown in combination with the cereals for green fodder.

In view of the severity of the winter in this district, no effort should be spared to provide abundance of winter fodder, and especially in the form of silage, as the most nutritious and succulent substitute for grass.

Vegetables—sow broad beans, beet, cabbage, herbs, lettuce, onion, radish, spinach, and white turnip.

Transplant cabbage, eschalot, leek, lettuce, onion, rhubarb, and silver beet.

Get land ready for the sowing of cereal crops and spring crops.

Central Tableland.

Crops to sow—

Wheat—the sowing, if possible, should be completed this month.

Barleys—the main crops for grain for malting and other purposes should be sown.

Oats and rye may be sown to advantage.

Lucerne may still be sown, preferably early in the month.

Clovers, tares, field peas, sheep's burnet, and many grasses may be sown.

Vegetables—transplant onions, Savoy cabbage, broccoli, eschalots, and leek. Plant tree onions, potatoes, onion and garlic. Make sowings of broad beans, cabbage, lettuce, onion, radish, spinach.

Southern Tableland.

Crops to sow—

Wheat and oats for hay, grain and green fodder.

Barley, rye and field peas for green fodder.

Rape, turnips, and mustard for sheep-feeding.

Vegetables—sow broad beans, beet, cabbage, leek, lettuce, onion, radish, silver beet, spinach, white and Swede turnip.

Transplant cabbage, eschalot, herbs, leek, rhubarb, and silver beet.

Clean up the garden of all trash—it harbours pests.

North-western Slopes.

Crops to sow—

Wheat, oats and barley—main sowing.

Lucerne and clovers—most suitable month to sow.

Rape and swedes.

Vegetables—sow broad beans, beet, cabbage carrot, cauliflower, herbs, leek, lettuce, onion, parsnip, radish, silver beet, spinach, and white turnip.

Transplant rhubarb.

Prepare land for the sowing of cereals and for spring crops.

Central-western Slopes.

Crops to sow—

Lucerne—in a well prepared seed-bed.

Wheat and oats— for hay and grain.

Barley—for greenstuff, hay, and grain.

Rye—for greenstuff and grain.

Rape and tares—for grazing.

Vegetables—sow peas, onions, parsnips, carrots, swedes, cabbages, broad beans, radish, lettuce, beet, spinach, silver beet. Plant out any seedlings available.

South-western Slopes and Riverina.

Crops to sow—

Wheat—this is the best month for main sowings of grain crops.

Barley—for grain.

Field peas—for green feed or seed.

Vetches or tares—for green feed.

Rape—for green feed.

Vegetables—plant tree onions, potato onions, and eschalots. Make a final transplanting of cabbage and cauliflower. Sow peas and broad beans as largely as required.

Murrumbidgee Irrigation Areas.

Crops to sow—

Wheat—early varieties for grain and green feed.

Oats—main crops.

Barley—for malting.

Tares and field peas may be sown with the cereals for green feed.

Vegetables—sow carrot, beetroot, lettuce, peas, onion, broad beans, cabbage, leek, radish, silver beet, spinach, turnip.

Transplant cabbage, lettuce, leek, onion, silver beet.

North-western Plains.

Crops to sow—

Wheat and oats—for hay and grain.

Barley—for green feed or grain.

Vegetables—plant out and sow seed for a succession of cabbage and cauliflower; sow broad beans, radish, lettuce, carrot, spinach.

Get land ready for spring sowing of maize, sorghum, and other green fodder and silage crops. At this stage the area should be ploughed and left in the rough to take the greatest advantage of the mellowing influences of the weather during the winter months.

JUNE.

North Coast—Richmond-Tweed Section.

Crops to sow—

Oats—sow for green fodder: not too late for a hay crop.

Rye—sow for green fodder.

Vegetables—sow broad beans, peas, parsnip, beet, carrot, silver beet, spinach, tomato (under cover), cabbage, endive, lettuce, radish. Plant chokos, asparagus, winter rhubarb, cabbage, herbs, leek, lettuce, onion, silver beet.

Get land ready for potatoes and for artichokes for domestic use and fodder. The latter crop is a useful one to be harvested by pigs.

North Coast—Clarence Section.

Crops to sow—

Oats—sow for hay and green feed.

Rye—for green feed.

Wheat—for green feed and grain.

Vegetables—sow peas, broad beans, cabbage, endive, parsnip, beet, carrot, silver beet, spinach, tomato (under cover), leek, lettuce, onion, herbs.

Transplant rhubarb, asparagus, cabbage, herbs, leek, lettuce, onion, silver beet.

Get land ready for main crop of potatoes and early maize.

Paspalum paddocks should be broken up now, if showing signs of deterioration.

Central Coast.

Crops to sow—

Wheat, oats—for green feed and hay.

Barley, rye.

Lucerne—along upper rivers.

Clovers.

Onions—transplant plants into permanent bed.

Tomatoes.

Vegetables—sow broad beans, beet, cabbage, carrot, lettuce, peas, onion, radish, silver beet, tomato, turnip.

Transplant cabbage, eschlot, lettuce, onion, silver beet, also rhubarb and asparagus roots.

Dig up and manure land for spring sowings.

Other work—plough over weedy fallowed land.

Hawkesbury-Neyran.

Crops to sow—

Wheat—sow only quick-maturing varieties.

Oats—for hay and green feed.

Barley—for greenstuff may still be sown for succession.

Rye—late crops are worth a trial on the poorer classes of soil.

Onions should be transplanted.

Artichokes may be planted from now on.

Vegetables—sow broad beans, cabbage, leek, parsnip, peas, herbs, silver beet, endive, carrot, spinach.

Transplant rhubarb, asparagus, cabbage, herbs, leek, lettuce, onion, silver beet.

Get land ready for potato (main crop) and maize. Spread all available farmyard manure on the ground and plough in to mellow.

South Coast.

Crops to sow—

Oats and rye may be sown where a late sowing is necessary for green fodder.

Vegetables—trials may be made with seed of cabbage, lettuce, peas, radish, and turnip.

Transplant asparagus, cabbage, eschlot, herbs, leek, onion, rhubarb, and silver beet.

Other work—from this month on to the end of October the worst time of the year has to be faced. Ensilage is a great factor in keeping stock in condition; feeding stalls effect a great saving of fodders when feeding stock; good shelter from useful trees is a comfort to stock.

Get land ploughed for corn and conserve all the soil moisture possible. On the average dry windy weather prevails in the spring, and early preparations should be made.

*Northern Tableland.***Crops to sow—**

Wheat—sowings may be made this month.

Oats may be sown for hay or grain.

Vegetables—sow broad beans, cabbage, lettuce, radish, and onion.

Transplant cabbage, eschalot, herbs, leek, lettuce, onion, and rhubarb.

*Central Tableland.***Crops to sow—**

Wheat may still be sown, although somewhat late to give best results.

Oats, barley, and rye may be sown.

All land for summer crops should be ploughed as soon as possible.

Vegetables—sow peas and broad beans for main crop. Sow cabbage in seed-beds.

Transplant cabbage and herbs. Plant out tree onion, potato onion, garlic, eschalot, and rhubarb.

*Southern Tableland.***Crops to sow—**

Oats for hay, green fodder, or grain.

Get ground ploughed for sowing of spring crops, especially potatoes.

Vegetables—sow seed of broad beans, cabbage, lettuce, radish.

Transplant cabbage, eschalot, herbs, leek, and rhubarb.

Get ground ready for spring crops.

*North-western Slopes.***Crops to sow—**

Wheat, oats and barley.

Vegetables—sow broad beans, beet, cabbage, carrot, cauliflower, leek, onion, parsnip, radish, silver beet, and white turnip.

Transplant rhubarb.

Prepare land for spring sowings. The feeding off of cereals for hay should cease early in this month.

*Central-western Slopes.***Crops to sow—**

Wheat—late plantings of early maturing wheats may be made on well-prepared land up to the end of the month with a prospect of getting profitable, though not maximum, returns.

Vegetables—sow cabbage, broad beans, radish, beet, spinach, silver beet, lettuce, endive, leek, carrot, parsnip, turnip, and peas.

Transplant cabbage, cauliflower, onion, rhubarb, asparagus, silver beet, and leek.

Get land ready for planting out shade and shelter trees where necessary.

*South-western Slopes and Riverina.***Crops to sow—**

Wheat—it is now late for wheat, and sowing of ordinary varieties cannot be safely extended beyond first week of this month except in favourable localities. Where delay has occurred early varieties only should be sown.

Vegetables—sow carrot, parsnip, lettuce, broad beans, white turnip, peas, and onion in limited quantities only where water will be available.

Get land ready for sweet potatoes, lucerne, sheep's burnet, and for final sowing of barley for fodder.

Fallowing should commence this month.

*Murrumbidgee Irrigation Areas.***Crops to sow—**

Wheat—season is getting too late, but quickly maturing varieties may be sown if conditions are favourable.

Oats—may yet be sown for green feed or hay.

Barley—for malting.

Vegetables—sow beetroot, carrot, peas, lettuce, cabbage, radish, silver beet, spinach, turnip, tomato (under shelter). Plant out asparagus and rhubarb.

Transplant cabbage, lettuce, leek, onion, silver beet.

Plough land for spring sown crops.

*North-western Plains.***Crops to sow—**

All sowings should be completed, but late sowings of early varieties should be made.

Vegetables—plant cabbage and sow carrot, broad beans, lettuce, radish, peas, and spinach.

Other work—continue to plough land that is to be sown in the spring; the frost will kill most of the couch grass that is ploughed up now.

JULY.

North Coast—Richmond-Tweed Section.

Crops to sow—

Potatoes—sow main crop towards end of month.

Onions—sow on small scale.

Vegetables—sow broad beans, beet, peas,

French beans (in frost-free situations), Jerusalem artichoke, carrot, cucumber (under cover), radish, silver beet, spinach, white turnip; tomato for early planting (under cover); plant out cabbage, endive, lettuce.

Transplant asparagus, cabbage, choko, eschalot, herbs, leek, onion, lettuce, rhubarb, silver beet; bed sweet potato tubers to secure rooted cuttings.

Get land ready for early spring sowing of maize, sorghum, and millet.

North Coast—Clarence Section.

Crops to sow—

Potatoes—sow main crop towards the end of this month; earlier in sheltered situations free from frost.

Vegetables—sow Jerusalem artichoke,

French beans (in frost-free situations), beet, cabbage, carrot, cucumber (in frost-free situations), lettuce, peas, potato, radish, silver beet, spinach, white turnip.

Transplant asparagus, cabbage, choko, eschalot, herbs, leek, lettuce, onion, rhubarb, silver beet; bed sweet potato tubers to secure rooted cuttings.

Get land ready for spring cropping. Turn in any stable manure or other coarse manure, so that by the time the crops are planted, it may be incorporated with the soil.

Central Coast.

Crops to sow—

Wheat } for green fodder and hay.
Oats } Early-maturing varieties.

Potatoes—main crop upper rivers; early lots lower down.

Tomatoes—also plant out early plants under cover.

Vegetables—sow Jerusalem artichoke, French beans (sheltered situations), broad beans, beet, carrot, cucumber (in boxes), kohlrabi, lettuce, peas, parsnip, potato, radish, spinach, tomato, turnip.

Transplant cabbage, choko, eschalot, herbs, leek, lettuce, onion, silver beet, and roots of asparagus and rhubarb. Dig and manure land for spring crops.

Other work—Renovate lucerne beds by top dressing. Prepare land for potato plots and spring crops.

Hawkesbury-Nepean.

Crops to sow—

Limited areas only of oats and rye, for green feed.

Onions—as a field crop, if sown where they are to grow, should be sown this month on ground brought to an extremely fine tilth. If transplanted, they should be sown much earlier (May or June).

Vegetables—sow tomato, cucumber, and melon under good shelter, and set out sweet potato tubers under frames or glass to secure stocks of rooted cuttings for early planting. Sow a few carrot, lettuce, radish, onion, and peas. Plant out Jerusalem artichokes, asparagus, summer rhubarb, cabbage leek, lettuce, onion, silver beet.

Tree planting of deciduous kinds for shade should be completed.

Get land ready for potatoes. Plough in any fresh stable manure so that it will be mellowed before planting time. It will be well to break up and expose to atmospheric influence land intended for early maize crops.

Prepare new ground for cropping by deep ploughing, so that frosts may act beneficially upon the soil, and couch and other tenacious perennial growths may be destroyed.

South Coast.

Crops to sow—

A small sowing of oats may be made, though it is rather late for winter crops.

Vegetables—sow seed of French beans (where frost free), beet, carrot, lettuce, peas, silver beet, turnip. Plant potatoes and artichokes in frost free situations.

Transplant asparagus, cabbage, eschalot, herbs, leek, onion, and silver beet plants.

Get land ready for spring sowing. Crops sown in March should be fit to cut now if the season has been fair. Top-dress and harrow the lucerne paddock.

*Northern Tableland.***Crops to sow—**

Oats may be sown this month either for grain or hay; they do well on the heavier moister land of the district, which is not so good for wheat and barley.

Wheat—may still be sown, but sow more thickly than earlier in the season

Rye—this may still be sown for green fodder or grain

Vegetables—sow broad bean, cabbage, lettuce, onion, peas, and radish.

Transplant asparagus, cabbage, eschalot, herbs, leek, lettuce, onion, and rhubarb.

Get land ready for spring crops by ploughing and cultivating.

*Central Tableland.***Crops to sow—**

Oats and rye—may be sown, but, generally speaking, they should be in.

Vegetables—sow peas and broad beans.

Sow in seed beds cabbage and early cauliflower; transplant cabbage, herbs, rhubarb, eschalots, asparagus.

Get land ready for spring cropping. Plough deeply and work in any available crude farmyard or stable manure.

*Southern Tableland.***Crops to sow—**

Oats may be still sown as required.

Other work—see to the pastures—from this month to the end of September is about the worst time for stock, as a rule. Where clover will grow it is a great help at this season. Westerly winds “tuck” stock up, and the question of shelter for the stock should be considered. Shelter makes a big difference, especially to lambing ewes. If dairy cattle are stall fed, especially at this season, it means added profits—good ensilage is worth considering

Vegetables—sow broad beans, cabbage, lettuce, and radish.

Transplant asparagus, cabbage, eschalot, herbs, leek, and rhubarb.

*North-western Slopes.***Crops to sow—**

Wheat and oats—though it is wise to have cereals sown before this month, for, as a rule, lighter yields result from sowing later than May.

Lucerne—may be sown, but is better sown in autumn.

Vegetables—sow broad beans, beet, carrot, leek, lettuce, onion, peas, radish, silver beet, white turnip, and, protected from frost, tomato.

Transplant cabbage, rhubarb.

Prepare land for spring sowing. Feeding off of cereal crops for grain should cease this month. Harrowing of cereal crops will generally be inadvisable after this month. The time to cease this operation is indicated by the spindling of the plants, *i.e.*, the definite development of stems containing immature ears, for these ears may be damaged.

*Central-western Slopes.***Crops to sow—**

This is a risky month for sowing any farm crops.

Vegetables—sow beet, spinach, silver beet, turnip (white), broad beans, peas, radish, leek, cabbage, lettuce, onion, endive: sow tomato seed and plant sweet potatoes in cold frames or under cover.

Transplant cabbage and cauliflower.

Get ready for spring crops of lucerne and potatoes, land ploughed in the autumn. For potatoes an application of stable manure will be of great benefit to enable this crop to withstand drought. Commence to break up the stubble land for summer and autumn crops.

Fallowing should be commenced.

South-western Slopes and Riverina.

Vegetables—sow tomato seed and plant sweet potatoes under cover for early plants.

Transplant cabbage and cauliflower, and sow seed for later use.

Plough land to lie fallow for wheat, barley, oats, &c., to be sown in autumn.

Murrumbidgee Irrigation Areas.

Vegetables—sow peas, lettuce, tomato (under cover), herbs, cabbage, beet, radish, silver beet, spinach, turnips.

Plant out asparagus and rhubarb, cabbage, leek, lettuce, onion, silver beet.

Work land—for spring sown crops.

North-western Plains.

Vegetables—sow and plant cabbage, broad beans, carrot, radish, lettuce, peas, and spinach.

Other work—finish ploughing land that is to be sown in the spring.

AUGUST.

*North Coast—Richmond-Tweed Section.***Crops to sow—**

Potatoes—plant largely if not already done in July.

Mangolds—sow in deeply-worked soil.

Maize—large areas should not be attempted this month, but small sowings of early varieties may be made. Planting should not be too thick, nor the depth of sowing more than sufficient to avoid the grain drying out before the first roots take hold. Usually 2 inches at most is ample depth.

Grass-seed—sow all kinds except prairie, which does better in autumn.

Sweet potatoes—rooted cuttings may be set out.

Artichokes—tubers may be set out.

Vegetables—sow cabbage, endive, kohlrabi, lettuce, parsley, garden swedes, turnip, beet, carrot, French beans, leek, onion, parsnip, peas, radish, rhubarb (seed), silver beet, tomato, capsicum, egg plant. Where situation is warm and sheltered, tomatoes may be set out; also French beans. Cucumber seedlings should be raised under shelter for setting out at first opportunity. Chokos may be planted near a fence or other support.

Transplant asparagus, rhubarb, cabbage, herbs, lettuce, onion, silver beet.

Get land ready for maize, sorghum, broom millet, cucumbers, pumpkins.

*North Coast—Clarence Section.***Crops to sow—**

Maize—sow early varieties towards end of month under conditions similar to Richmond-Tweed section.

Potatoes—sow main crop if not sown in July.

Lucerne—sow in well prepared land, but April is the best month for conditions of this district.

Grasses—sow all grasses with the exception of prairie and paspalum, which do better in February.

Sweet potatoes—shoots may be planted out in drills 3 feet apart. Use small tubers if conditions are dry.

Artichokes—plant tubers in drills 4 feet apart; the white variety is the most prolific.

Canadian Wonder beans—sow largely for market and seed.

Vegetables—sow cabbage, endive, kohlrabi, lettuce, parsley, swedes, turnips, beet, carrots, parsnip, leek, onion, capsicum, egg plant, parsnip, peas, radish, rhubarb (seed), silver beet; cucumber and tomato seedlings should be raised under shelter for setting out later. Tomatoes may be set out, also asparagus, rhubarb, cabbage, herbs, lettuce, onion, silver beet.

Get land ready for maize. Plough deeply, and as soon as weeds show up cultivate to destroy them. The same applies to land intended for millet, sorghum, pumpkins, and other spring crops. It is better to work any available stable manure into the soil now than put it in at time of seedling.

*Central Coast.***Crops to sow—**

Potatoes—continue sowing.

Maize—early varieties, early sowing along Macleay

Lucerne—spring-sown crops this month.

Artichokes—dig and resow.

Sweet potatoes—early sowings.

Tomatoes—plant out.

Onions—sow seed in permanent bed.

Vegetables—sow artichoke, asparagus, beans, beet, cabbage, carrot, celery, cucumber, herbs, kohlrabi, leek, lettuce, onion, parsnip, peas, potato, pumpkin, radish, rhubarb, silver beet, spinach, squash, tomato, turnip.

Transplant asparagus, cabbage, choko, eschalot, herbs, lettuce, onion, rhubarb, silver beet, and tomato.

Prepare beds for further sowings.

Other work—prepare land for spring crops.

Renovate and top-dress lucerne paddocks. Plough under green manure crops.

*Hawkesbury—Nepean.***Crops to sow—**

Potatoes—main crop latter end of month.

Mangolds and sugar beets—where frosts are not likely to be severe.

Vegetables—sow French beans in frost-free positions, beet, carrots, lettuce, parsnip, onion, leek, capsicum, egg plant, peas, radish, silver beet, spinach; and under

shelter, tomatoes, bush marrows, and cucumbers. Set out tomatoes in warm situations; plant out Jerusalem artichokes, summer rhubarb, cabbage, herbs, lettuce, onion, silver beet.

Get land ready for maize, sorghum, pumpkins, &c.; land intended for laying down to lucerne should receive a final ploughing and be left rough till end of month.

South Coast.

Vegetables—sow seed of beans (French), beet, carrots, cucumber, leek, lettuce, parsnips, peas, radish, silver beet, squash, tomato, turnip. Plant potatoes.

Transplant asparagus, cabbage, choko, eschalot, lettuce, silver beet.

Other work—It is too early yet for maize or sorghum. Keep the ground stirred after every shower to conserve the soil moisture—windy weather sucks a lot out of the ground if a crust is left on top. Where green fodder is being cut the land should be ploughed up as soon afterwards as possible, for rain soaks in better where the land is worked.

Northern Tableland.

Crops to sow—

Barley and rye—may be sown for green feed.

Wheat—early maturing varieties may still be sown for grain or hay.

Oats—long season varieties may be sown on the New England tableland with advantage this month or even later; but, as with other cereals, the sowing should be thicker as the season advances.

Vegetables—sow broad bean, beet, cabbage, carrot, herbs, lettuce, onion, parsnip, peas, radish, silver beet, white turnip.

Transplant asparagus, cabbage, eschalot, herbs, lettuce, onion, rhubarb.

Get land ready for all spring crops such as maize, sorghum, millet, cowpeas, pumpkins, melons, cucumbers, &c., and other spring vegetables.

Central Tableland.

Crops to sow—

Lucerne—may be sown upon well prepared land if moisture has been conserved. Upon soil not properly fitted spring sowing of lucerne is risky. It is preferable to sow during the autumn. Stock should be taken off all lucerne paddocks. The surface should be loosened by spiked roller or other implement.

Tobacco—sow at end of month in seed-beds which can be covered from frosts.

Vegetables—sow carrots, parsnips, turnips, broad beans, peas, lettuce, beet, and radish. Sow in seed-beds cabbage, Brussels sprouts, early cauliflower, tomatoes, capsicums, Cape gooseberries, and egg plants.

Transplant asparagus, rhubarb, cabbage, lettuce, early cauliflower, eschalots, herbs.

Southern Tableland.

Crops to sow—

Oats may be sown as required.

Vegetables—sow seed of broad beans, beet, cabbage, carrot, lettuce, parsnip, peas, radish, silver beet, and white turnip.

Transplant asparagus, cabbage, eschalot, herbs, lettuce, onion, and rhubarb.

Other work—green fodder crops sown early should be now a nice height for cutting for dairy stock. Land should be got ready for spring planting. Conserve soil moisture by harrowing—westerly winds evaporate a lot of moisture this month. Harrow the pastures—it distributes the manure, especially about the camping grounds of stock. It also kills and disturbs insects which might be sheltering in the plants. Top-dress lucerne with superphosphate.

North-western Slopes.

Crops to sow—

Lucerne—small sections may be sown.

Vegetables—sow beet, carrot, herbs, leek, lettuce, onion, peas, silver beet, tomato, and white turnip.

Transplant cabbage and, under protection, tomatoes. Bed sweet potatoes for raising plants.

Get land ready by ploughing and working for spring sowing. Plough stubble or new land for long fallow for cereal growing next year.

*Central-western Slopes.***Crops to sow—**

Lucerne—sow early on well prepared land.

Potatoes—plant after the middle of the month, and cover lightly with straw if possible.

Vegetables—sow broad beans, beet, cabbage, leek, lettuce, carrot, parsnip, turnip (white), peas, radish. Plant tomatoes, capsicum, egg plants, in seed boxes or beds, under cover.

Transplant cabbage and cauliflowers.

Cultivation—continue the preparation of land for summer crops, and for fallowing. Get land ready for maize.

*South-western Slopes and Riverina.***Crops to sow—**

Lucerne—sow early in month in well prepared land.

Potatoes—commence planting.

Vegetables—sow peas on small scale, and tomato seed; cucumbers.

Get land ready for millets, sorghum, maize, pumpkins, melons, and other summer crops. Plough land to lie fallow for wheat, barley, oats, &c., to be sown in the autumn.

*Murrumbidgee Irrigation Areas.***Crops to sow—**

Lucerne—if the season is favourable.

Paspalum and Rhodes grass may be sown, but risky, as frosts may kill off the young shoots.

Vegetables—sow celery, leek, potatoes, sweet potatoes (in hot beds), beet, carrots, herbs, lettuce, peas, radish, silver beet, and, with protection, tomatoes, cucumbers, melons, marrows, pumpkins, and squashes.

Transplant herbs, lettuce, silver beet, cabbage.

Get land ready for maize, sorghum, millet, beet, mangolds.

*North-western Plains.***Crops to sow—nil.**

Vegetables—sow carrots, lettuce, radish, peas, spinach; also, tomatoes, marrows, squash, cucumbers, pumpkins, and Cape gooseberries if they can be sheltered at night from the frost.

Get land ready for planting next month by harrowing to reduce soil to fine tilth.

SEPTEMBER.*North Coast—Richmond-Tweed Section.***Crops to sow—**

Maize for grain—further sowings of early or main crop varieties may be made.

Sorghum—for green fodder and grain.

Millet—for green fodder, hay, and grain for pig and poultry feed.

Broom millet—may be sown this month.

Mangolds—for summer feed for dairy cattle.

Pumpkins, squashes, grammas, pie melons—sow in odd corners and in special plots.

Peanuts—for pig and poultry food.

Cowpeas—for fodder and pigs (grazing), also for mixing with maize in silage, and for hay. Useful to renovate soil of worn-out maize paddocks.

Buckwheat—for green fodder, and for grain for poultry and pigs.

Sunflowers—sow in odd corners and around sunny edges of maize crops, &c., for poultry feed and for mixing with cattle rations.

Vegetables—sow all kinds of beans, Jerusalem artichoke, beet, lettuce, tomatoes, cucumbers, melons, asparagus (seed), carrot, herbs, leek, parsnip, peas, radish, rhubarb (seed), silver beet, turnip.

Transplant herbs, lettuce, silver beet, sweet potato, tomato, capsicum, egg-plant.

Get land ready for further sowings of maize, sorghum, millet, and cowpeas.

*North Coast—Clarence Section.***Crops to sow—**

Maize—further small sowings of early varieties of main crop may be made.

Sorghum—for green fodder and grain.

Millet—for green fodder, hay, brooms, and grain for pig and poultry feed.

Mangolds—for pig feed.

Pumpkins, squashes, grammas, and pie melons—sow apart in special plots.

Cowpeas—sow for fodder, pig feed and grain.

Sunflowers—sow for grain for poultry and pigs.

Lucerne may be sown if season be favourable.

Vegetables—sow French and butter beans, leek, spinach, silver beet, lettuce, Jerusalem artichoke, cucumber, egg plant, capsicum, rhubarb, melons, beet, radish, carrot, parsnip, tomatoes; small sowing of peas, turnips, swedes, and rock melon may be made now.

Transplant herbs, lettuce, silver beet, sweet potato, tomato, capsicum, egg plant.

Central Coast.

Crops to sow—

Maize—for grain and fodder, main crop varieties.

Sorghum—Saccaline and other varieties.

Millet—sow for fodder.

Sudan grass, broom millet.

Potatoes—though getting rather late.

Pumpkin, marrow, peanuts.

Cowpeas—with maize or sorghum or alone.

Soy beans, buckwheat, sunflower, artichokes.

Sweet potatoes—plant out cuttings.

Melons, lucerne, summer grasses.

Vegetables—sow artichokes, asparagus, beans, beet, Cape gooseberry, carrot, cucumber, herbs, leek, lettuce, marrow, melon, parsnip, peas, potato, pumpkin, radish, silver beet, squash, sweet corn, tomato.

Transplant choko, eschalot, herbs, leek, lettuce, silver beet, sweet potato, and tomato.

Hoe and work up the soil surface.

Other work—plough under crops for green manure; prepare land for further spring sowing.

Hawkesbury-Nepean.

Crops to sow—

Maize—early or main crop varieties may be sown on river flats towards the end of the month.

Sorghum—sow for green fodder and seed for poultry or pigs. Early Amber cane and Planter's Friend are good varieties; the former is earlier and gives two and even three cuts per season.

Broom millet—White Italian is the best.

Millet—for green fodder, hay, and grain for pig and poultry feed.

Pumpkins, squashes, grammas, water and pie melons—main crops may be sown.

Peanuts—sow for pig and poultry feed in light friable soil.

Cowpeas—sow for green feed either alone or in conjunction with maize, sorghum, or millet.

Lima beans are also worth a trial.

Sunflowers—the Giant Russian is suitable for poultry feed, and mixes well with other crops for ensilage.

Lucerne—main spring sowing can be made.

Potatoes may still be planted, especially early in month for main sowing.

Jerusalem artichokes—for domestic use and pig feed may be planted in odd rich corners; they are difficult to eradicate, and should not be planted where it is not possible to get the land thoroughly cleaned by pigs or by hand.

Shade trees and hedges—if not planted out in autumn may be put in now.

Vegetables—sow French and other beans, red and silver beet, carrot (main summer crop), cucumbers, vegetable marrows, squashes, water and rock melons, leeks, lettuce, capsicums, egg plant, parsnip, radish.

Plant out sweet potatoes, herbs, lettuce, silver beet, capsicum, egg plant, chocos, and tomatoes.

South Coast.

Crops to sow—

Maize, sorghum and millets—mostly for green fodder.

Cowpeas may also be sown, and mangolds.

Vegetables—sow seed of French beans, beet, carrot, cucumber, leek, lettuce, melon, parsnip, peas, pumpkin, radish, silver beet, squash, tomato, and turnip. Plant potatoes.

Transplant choko, eschalot, lettuce, silver beet, sweet potato.

Keep all crops well cultivated and protect them from wind.

*Northern Tableland.***Crops to sow—**

Oats—sow long season varieties, such as White Tartarian, Abundance. It is too late to sow Algerian or similar season varieties.

Wheat—early maturing varieties, such as Florence and Clarendon, may be sown for both grain and hay.

Maize—a small area may be sown at the end of the month. Plant shallow, as the ground is still cold a few inches down.

Vegetables—Potatoes—make small sowings of early varieties. Sow artichoke, broad bean, beet, cabbage, carrot, herbs, lettuce, parsnip, peas, radish, silver beet, and white turnip, and (under cover) tomato.

Transplant cabbage, herbs, lettuce, silver beet.

Get land ready for planting maize in the beginning of October. Also get ready for sorghum, millet, &c. A small sowing of these might be made at the end of the month; also sugar beets and mangolds.

*Central Tableland.***Crops to sow—**

Potatoes—for early crop may be planted about the middle of the month. These should appear above ground early in October, when danger from frost is slight. Upon the lower lands planting should be delayed from one week to a fortnight.

Maize—near the end of the month may be sown on the uplands, but not yet on the river flats. Avoid deep planting.

Jerusalem artichokes may be planted about the middle of the month.

Lucerne and grasses.

Vegetables—Asparagus roots should be set out early in the month. Sow asparagus seed. Sow carrots, parsnips, turnips, kohlrabi, beet, cabbage, lettuce, early cauliflower, silver beet, herbs, peas, Brussels sprouts, tomatoes, capsicum, egg plant, radish, mustard and cress. Transplant upon highlands (and under cover) a few tomatoes, Cape gooseberries, capsicums, and egg plants.

*Southern Tableland.***Crops to sow—**

Oats may still be sown, especially in the very cold places, such as Nimmitabel.

Vegetables—Mangolds for stock food, cabbage, carrot, lettuce, parsnip, peas, radish, tomato (under cover), and turnip seed may be sown. Plant early potatoes where conditions are favourable.

Transplant cabbage, herbs, lettuce, silver beet.

Prepare ground for sowing maize next month. Top-dress lucerne with superphosphate; it is most beneficial. Harrow the fertiliser in well.

*North-western Slopes.***Crops to sow—**

Maize, potatoes, Sudan grass, sorghums, and millets.

Cowpeas—for green fodder.

Broom millet.

Vegetables—sow artichoke, beans (French), beet, carrot, herbs, lettuce, melons, peas (a small sowing), pumpkins, silver spinach, squash, and tomato.

Transplant young plants from previous sowing. In some cases protection will still be needed from late frosts.

Cultivation—continue following land for wheat, and cultivating for further sowing of spring crops.

*Central-western Slopes.***Crops to sow—**

Potatoes—plant early in month.

Maize, millet, and sorghum—towards the end of month for green feed, silage, and grain.

Cowpeas—for green feed and grazing.

Vegetables—sow asparagus (seed), beet, carrot, parsnip, lettuce, turnip (white), tomato, cucumber, capsicum, egg plant, French bean, radish, silver beet, marrow, melon, pumpkin.

Transplant cabbage, lettuce, leek, silver beet, and tomatoes (shelter from frost at night).

Cultivation—continue following the land for autumn crops.

*South-western Slopes and Riverina.***Crops to sow—**

Potatoes—planting should be completed.
Pumpkins and squashes—sow and protect seedlings from frost.

Melons and cucumbers—sow and protect seedlings from frost.

Sorghum and millet—sow for green feed and silage.

Maize—sow for green feed and silage. This is also a better time to sow for grain than a month later, in order to avoid hot summer winds during tasselling.

Vegetables—in localities not very subject to frost and later hot winds sow beans of all kinds (except broad). Transplant tomatoes, and shelter from frosts with a few twigs of pine.

Get land ready for main sowings of sorghum maize, and millet, including broom millet for heads and seed. Finish ploughing land to lie fallow for autumn sowing of cereals.

*Murrumbidgee Irrigation Areas.***Crops to sow—**

Sorghum—for green feed and seed.

Maize—early varieties may be sown this month, but there is a risk of damage to the setting of the grain from the hot, drying winds of midsummer. Green fodder maize may be sown.

Millet for green feed and seed. These may also be grazed off, and then allowed to shoot up for seed for next year's planting.

Sudan grass—for green fodder or hay.

Mangolds, beets, cowpeas, paspalum, Rhodes grass, may all be sown.

Vegetables—sow tomatoes, cucumbers, melons, vegetable marrows, French runner and Lima beans, pumpkins, artichokes, asparagus (seed), herbs, lettuce, radish, rhubarb (seed), silver beet.

Transplant herbs, lettuce, silver beet, tomato.

Prepare land for autumn crops to be sown end of year.

*North-western Plains.***Crops to sow—**

Lucerne, grass, millet, pumpkins, sorghum, cowpeas, potatoes.

Vegetables—sow French beans, cucumber, and marrow.

Transplant tomatoes.

Get land ready for cropping in December with maize, sorghum, cowpeas, for silage and green fodder.

OCTOBER.*North Coast—Richmond-Tweed Section.***Crops to sow—**

Maize—late varieties may be sown towards the end of the month, but it is getting too late for good yields from early varieties.

Sorghum and millet—for green fodder, silage, or grain.

Sugar-cane—set out for fodder and milling.

Cowpeas—sow for seed.

Cotton—Complete sowing this month.

Pumpkins—sow extensively for cattle and pigs.

Sweet potato—set out cuttings.

Plant out sets of Queensland cattle cane.

Vegetables—sow French, runner, Lima, and butter beans, squashes, marrows, and melons of all kinds, beet, cucumber, herbs, lettuce, parsnip, radish, silver beet.

Transplant herbs, silver beet, leek, tomato.

Get land ready for later sowings of maize and sorghum for silage.

*North Coast—Clarence Section.***Crops to sow—**

Maize—medium early and mid-season varieties may still be sown, but late varieties not until near the end of the month for best average yields.

Sorghum and millet—for fodder and grain.

Mauritius bean and Florida Velvet bean—for green manuring and fodder.

Indian cane—plant cuttings 5 feet apart for fodder.

Cowpeas—for fodder, grain, or green manuring.

Cotton—Complete sowing this month.

Sunflower—for poultry.

Pumpkins—sow largely for cattle and pig feed.

Sweet potatoes—plant out shoots.

Vegetables—sow all kinds of beans, cucumber, water and rock melons; make small sowings peas, cabbage, radish, lettuce, carrot, parsnip, beet, (red and silver), and onions.

Transplant silver beet, herbs, leek, tomato.

*Central Coast.***Crops to sow—**

Maize—main crop varieties; also for fodder and ensilage.

Sorghum—Saccaline for fodder.

Millets, Sudan grass—for green fodder.

Cotton—Complete sowing this month.

Broom millet, pumpkins.

Sweet potatoes—plant out cuttings.

Cowpeas—alone or with maize and sorghum.

Sorghums, artichokes, sunflower, melons and squashes, cotton, summer grasses.

Vegetables—sow artichokes, asparagus, beans, beet, Cape gooseberry, cucumber, herbs, lettuce, marrow, melon, peas, parsnip, pumpkin, radish, silver beet, squash, sweet corn, tomato.

Plant out—eschalot, herbs, lettuce, silver beet, sweet potato, and tomato.

Water and protect—keep weeds down.

Other work—keep surface soil implements in action to destroy weeds and conserve moisture.

*Hawkesbury—Nepean.***Crops to sow—**

Maize—late or main crop varieties may now be sown on the flats. In many localities the October sown crops will do better than September sown ones, owing to growth being unchecked by cold weather.

Sorghum—continue sowing for green fodder and ensilage.

Broom millet—sow without delay.

Cotton—Complete sowing this month.

Cowpeas—main sowings may be made.

Pumpkins, melons—sow as largely as desired.

Sweet potatoes—set out cuttings or "rooted plants" in rows 3 feet apart and 2 feet in rows. Warm, sandy situations suit this crop best.

Lucerne—final sowings may be made early in the month.

Vegetables—sow French and all other kinds of beans (except broad), red and silver beet, carrot, cucumbers, marrows, melons, leeks, onions, lettuce, herbs, parsnip, radish; plant out tomatoes, herbs, silver beet.

*South Coast.***Crops to sow—**

Maize—main planting for grain and for ensilage.

Sorghums—if season is favourable.

Japanese millet, mangolds, sunflowers, cowpeas, and velvet beans may be sown.

Paspalum dilatatum, Rhodes grass.

Vegetables—sow seed of French beans, beet, carrot, cucumber, leek, lettuce, melon, parsnip, peas, pumpkin, radish, silver beet, squash, tomato, and turnip.

Transplant choko, eschalot, lettuce, silver beet, sweet potato.

*Northern Tableland.***Crops to sow—**

Maize—may now be planted, this being the best month generally for New England. Only early-maturing varieties have much chance of ripening properly in the short season. Seed should be sown at a shallow depth.

Millet—for hay.

Sorghum—Amber Cane and Planter's Friend, two excellent sorts for green feed and ensilage.

Cowpeas—Black cowpea does the best in this district.

Field peas—Partridge and Suntop are two good varieties.

Potatoes—whole potatoes for planting are generally advised in preference to cut sets.

Vegetables—

Frosts should now be over, except from Black Mountain to Ben Lomond, and, therefore, a number of vegetables may be planted—such as artichokes, beans (French), beet, cabbage, carrot, cucumber, herbs, lettuce, melons, parsnip, peas, potato, pumpkins, radish, silver beet, squash, white turnip, and (in frost-free localities) tomatoes.

Transplant cabbage, herbs, lettuce, silver beet, and (in frost-free localities or under cover) tomatoes.

*Central Tableland.***Crops to sow—**

Maize, sorghums, millets, cowpeas, pumpkins, melons, sunflowers, and Sudan grass.

Mangolds, beet, carrots, Jerusalem artichokes, kale, and kohl rabi.

Tobacco can be transplanted into field about middle of month upon lowlands; it may be set out somewhat earlier upon the highlands.

Vegetables—plant early potatoes. Sow for main crop pumpkins, melons, cucumbers, squashes, sweet corn, French, butter, and Lima beans, peas, silver beet, radish. Sow in seed beds, cabbage, lettuce, and kohl rabi, herbs.

Transplant cabbage, Brussels sprouts, herbs, lettuce, tomatoes, capsicum, egg plant, and Cape gooseberries. Make a small sowing of cauliflowers.

Other work—Towards the end of the month the first cut of lucerne will be ready to make into silage, if so desired. Residues of winter-grazing crops should be ploughed under.

Southern Tableland.

Crops to sow—

Maize—for green fodder and grain, except in the colder portions.

Japanese millet may be sown for green feed if the season is moist.

Mangolds—may be sown.

Field peas should be sown if the seed is required.

Potatoes may now be planted.

Vegetables—sow artichoke, French beans, cabbage, carrot, lettuce, melon, parsnip, peas, potato, pumpkin, radish, tomato, and turnip seed.

Transplant cabbage, herbs, lettuce, silver beet, and tomato.

North-western Slopes.

Crops to sow—

Maize, Sudan grass, sorghum, cowpeas, millet, and broom millet.

Cotton—Complete sowing this month.

Vegetables—sow beans (French), beet, herbs, melons, New Zealand spinach, pumpkin, radish, silver spinach beet, sweet potatoes, tomato.

Transplant sweet potato and tomato.

Cultivation—Continue fallowing land for cereals, and ploughing and cultivating land for summer crops. Cultivate between rows of maize and potatoes where sufficiently developed. Hill

early-sown potatoes and maize. Generally the rape and early-sown cereal crops will have ceased to produce further growth, and should be finally fed off and the residues ploughed under. Hay making will be in full swing this month.

Central-western Slopes.

Crops to sow—

Sorghum, maize, Sudan grass, cowpeas, and millet—main sowings for green-stuff and silage. Maize for grain is a risky crop in this district, except on well prepared river flats, or under irrigation.

Vegetables—sow French beans, melons, pumpkin, cucumber, marrow, squash, silver beet, carrot, parsnip, tomato, lettuce, turnip, radish.

Transplant tomatoes and sweet potato "plants" from cold frame or seed bed.

Other work—make provision to safeguard the standing crops to be left for grain against fire by cutting strips for hay around and through them.

South-western Slopes and Riverina.

Crops to sow—

Sorghum and Sudan grass—sow without delay.

Maize—for green fodder and ensilage; also for grain under irrigating.

Cowpeas—for green fodder, hay, ensilage, or green manure.

Millet—for greenstuff and hay.

Vegetables—Pumpkins, squashes, melons, and cucumbers—sow without delay.

Murrumbidgee Irrigation Area.

Crops to sow—

Maize—for green feed. Not a safe month for sowing for grain crops, owing to hot summer winds prevailing during tasselling period.

Sorghum and millet—for green feed and grain.

Cowpeas—for green feed.

Cotton—Complete sowing this month.

Mangolds, beets.

Sudan grass, Rhodes grass, paspalum.

Vegetables—sow French beans, artichokes, cucumber, melons, vegetable marrows, tomatoes, pumpkins, radish.

Plant out sweet potatoes and tomato.

North-western Plains.

Crops to sow—

Maize, millet, sorghum, cowpeas, and pumpkins.

NOVEMBER.

North Coast—Richmond-Tweed Section.

Crops to sow—

Sorghum, mixed with cowpeas—sow on any land that is not required for other purposes.

Broom millet—sow a small patch so as to have the crop ripening in succession, which will permit of more time for harvesting.

Maize for grain—best month to plant late varieties.

Maize, mixed with cowpeas—sow for green fodder and ensilage.

Cowpeas—sow for seed or green feed.

Pumpkins and melons—sow a good patch for storage.

Grammas—sow for storage.

Sugar-cane—plant for milling or fodder.

Vegetables—sow full crop French, butter, and Lima beans; small sowing of cucumbers, squashes, and tomatoes.

Transplant sweet potato, tomato.

Get land ready for late maize and sorghum.

Paspalum ground broken up will allow of grass dying, thus making the land more easily prepared for cultivation.

North Coast—Clarence Section.

Crops to sow—

Sorghum—for fodder and grain.

Maize—sow main crops of late varieties for grain, fodder, and ensilage.

Pumpkins, grammas, and melons—sow largely for storage.

Indian Cane—for fodder.

Mauritius bean—for fodder, green manuring, and pulse.

Florida velvet bean—for fodder, green manuring, and pulse.

Cowpeas—sow largely for fodder and green manure.

Vegetables—sow French, butter, and Lima beans, cucumbers, melons, tomato, sweet potato.

Transplant sweet potato, tomato.

Central Coast.

Crops to sow—

Maize—main crop varieties for grain.

Crops for ensilage and green fodder.

Sorghum—Saccaline.

Millet—for green fodder.

Broom millet, pumpkins, sweet potato, soy bean, sunflower.

Cowpeas—alone or in maize crops.

Melons, squashes, cotton, summer grasses.

Vegetables—sow French beans, beet, cucumber, lettuce, melons, peas, pumpkin, squash, marrow, sweet corn, tomatoes, turnips. Sow in cool weather.

Transplant silver beet, sweet potato, and tomato. Plant out in cool portion of day.

Hoe and mulch surface soil. Keep down weeds. Water young plants and seeds.

Other work—keep surface soil implements in action to conserve moisture and destroy weeds in furrow crops.

Hawkesbury-Nepean.

Crops to sow—

Maize—main crops may still be sown.

Sorghum and millet—for fodder and ensilage.

Cowpeas may be sown on land used for cereals, cut as green feed or hay.

Vegetables—sow all kinds of beans (except broad), red and silver beet, pumpkins, vegetable marrows; set out further cuttings of sweet potatoes and tomatoes; sow lettuce seed in permanent bed and thin out.

South Coast.

Crops to sow—

Maize—for grain and ensilage.

Sorghum—for ensilage and green fodder.

Cowpeas, velvet beans, sunflowers—for green fodder.

Vegetables—sow seed of French beans, cucumber, lettuce, pumpkin, radish, squash, and tomato.

Transplant sweet potato slips and tomato plants.

Northern Tableland.

Crops to Sow—

Potatoes—main crop.

Maize for grain—early-maturing varieties only may be planted up to the middle of this month. Maize for silage may also be sown.

Sorghum—Amber Cane and Planter's Friend may be sown for cutting for cattle or for ensilage; both are much-relished by stock.

Millet—all kinds may be sown.

Vegetables—sow French bean, beet, cabbage, carrot, cucumber, lettuce, melon, parsnip, potato, pumpkin, radish, squash, tomato.

Transplant cabbage, lettuce, silver beet, tomato.

Central Tableland.

Crops to sow—

Sow early maize, sorghum, millet, cowpeas, pumpkins, melons, potatoes, sunflowers, and buckwheat.

The residues from rape and other crops should be turned under as quickly as possible.

Vegetables—sow beet, radish, peas, pumpkins, melons, cucumbers, squashes, sweet corn, potatoes, beet, and French, Lima, and butter beans. Sow in seedbeds cauliflowers for main crop, cabbage, and Brussels sprouts.

Transplant cabbage, lettuce, kohlrabi, Brussels sprouts, and tomatoes.

Southern Tableland.

Crops to sow—

Maize—for green fodder.

Potatoes—main sowing.

Japanese millet—if the season is favourable.

Paspalum dilatatum for pasture.

Vegetables—sow artichoke, French beans, cabbage, carrot, lettuce, melon, parsnip, peas, potato, pumpkin, radish, tomato and turnip seed.

Transplant artichoke, cabbage, lettuce, silver beet, and tomato.

Keep ground well worked to check weeds and conserve soil moisture.

North-western Slopes.

Crops to sow—

Maize, sorghum, Sudan grass, cowpeas.

Vegetables—sow beans (French), beet, melon, New Zealand spinach, pumpkin, radish, squash, sweet potato, and tomato.

Cultivation—Work the land between the rows of growing crops, and where maize and potatoes are sufficiently developed, shallow or deep hilling, according to the nature of the soil, should be carried out. The balance of the rape and early-sown cereal stubble should be ploughed under to prevent seeding.

Cutting for hay and hay-making will be completed this month, and harvesting of the grain crops in full swing. Generally the grain crops are fully matured early in this month, the late-sown July portion coming in in the latter part of the month.

Central-western Slopes.

Crops to sow—

Maize for grain—early varieties may still be sown.

Maize and sorghum—for greenstuff and ensilage.

Cowpeas—for grazing and greenstuff.

Vegetables—sow silver beet, French beans, tomato, radish, marrows, squashes, and pumpkins.

Transplant sweet potatoes and tomato.

Cultivation—as opportunity occurs cultivate the growing crops that are in drills: feed off and harrow the fallows.

South-western Slopes and Riverina.

Crops to sow—

There are few crops, except sorghum, maize, and millet for green feed, that can be safely sown this month, and these only where irrigation is possible.

All drilled crops should receive attention in the way of cultivation of the soil to retain moisture.

Murrumbidgee Irrigation Areas.

Crops to sow—

Maize—for grain, medium early varieties may be sown towards the end of the month.

Sorghum—good sowings for late autumn and early winter feed.

Millet, cowpeas, Sudan grass, Rhodes grass, and paspalum.

Vegetables—sow French beans, cucumber, marrow, melons, pumpkin, radish, squash, tomato.

Transplant tomato, sweet potato.

North-western Plains.

Crops to sow—

Maize, pumpkins, and sorghum—if they can be irrigated.

DECEMBER.

North Coast—Richmond-Tweed Section.

Crops to sow—

Maize for grain—late varieties may be sown.
 Maize and cowpeas—sow for green fodder and ensilage.
 Sorghum and cowpeas—sow for green fodder and ensilage.
 Broom millet—sow for broom and seed.
 Sweet potatoes—set out as large an area as possible for domestic use and stock fodder in winter.
 Paspalum—sow seed and plant out rootlings.

Vegetables—sow French bean, cabbage, cucumber, celery, cauliflower, radish, pumpkin, marrow, melon, tomato.

Transplant tomato.

Get land ready for further sowings of autumn fodder crops such as maize, or sorghum, with cowpeas.

Cultivation of crops should be continued. Sugar-cane requires particular attention, ploughing between drills and chipping weeds.

North Coast—Clarence Section.

Crops to sow—

Maize for grain—large areas may safely be sown up to the end of the month.
 Sorghum—sow largely for grain, fodder, and silage.
 Broom millet—sow for broom and seed.
 Sweet potatoes—plant largely for winter pig feed.
 Indian Cane—sets may still be planted.
 Cowpeas—for fodder and grain.

Vegetables—sow French beans, cucumber, squashes, marrows, cabbage, celery, cauliflower, radish, melon, tomato.

Transplant tomato.

Central Coast.

Crops to sow—

Maize—main crop varieties. Choose blight-resistant varieties.
 Sorghum—Saccaline.
 Millets—for green fodder.
 Broom millet—early in month.
 Pumpkins.
 Cowpeas—alone or in maize crops.

Vegetables—sow French bean, cabbage, cauliflower, celery, cucumber, lettuce, marrow, pumpkin, squash, sweet corn, tomato.

Keep abundant moisture up to young plants.

Transplant sweet potato and tomato.

Keep surface soil implements in action to conserve moisture and destroy weeds.

Hawkesbury-Nepean.

Crops to sow—

Maize for grain—late varieties may be sown during first week of this month; it is getting late for early varieties.

Maize, sorghum, millet—for green fodder and ensilage.

Cowpeas may be sown for pig feed or green manure, but may not mature seed where early frosts are common.

Vegetables—sow beans of all kinds (except broad), celery (under shade), radish, pumpkins, cucumbers, bush marrows, &c.; set out in seed-bed cabbage and cauliflower.

Transplant tomato.

Get land ready for autumn crops of potato, turnips, rape, and lucerne.

South Coast.

Crops to sow—

Maize, sorghum, cowpeas, sunflowers—for green fodder and ensilage.

Vegetables—sow seed of French beans, cabbage, cauliflower, celery, cucumber, lettuce, melon, pumpkin, radish, squash, tomato.

Transplant sweet potato slips and tomato plants.

Northern Tableland.

Crops to sow—

Sorghum—may be sown for green fodder and for silage. The two best varieties for this district are Early Amber Cane and Planter's Friend.

Millet—for hay and for green fodder.

Potatoes—may still be planted for the main crop.

Oats—may be fit to harvest this month,

Vegetables—sow French bean, beet, cabbage, celery, cucumber, leek, lettuce, parsnip, peas, potato, radish, squash.

Transplant cabbage and tomato.

*Central Tableland.***Crops to sow—**

- Potatoes—main late crop.
 Maize and sorghum—for green fodder.
 Pumpkins and melons may still be sown at the beginning of month.
 Swedes—a small sowing towards end of month.
 If practicable, land from which hay was gathered could be ploughed. This may be fitted in during damp weather.

Vegetables—sow French and butter beans, cabbage, swedes, Brussels sprouts, celery, squashes, cucumbers, beet, peas, radish, lettuce, and sweet corn.

Transplant cauliflowers, cabbages, and tomatoes.

*Southern Tableland.***Crops to sow—**

- Maize—for green fodder.
 Japanese millet, Red clover, and *Paspalum dilatatum*.

Vegetables—sow French beans, beet, cabbage, cauliflower, celery, cucumber, leek, lettuce, parsnip, peas, potato, radish, and squash seed.

Transplant cabbage and tomato plants. Keep the ground well worked.

Tie tomato plants to stakes, keeping the laterals pinched out—it promotes early setting of the fruit.

Other work—cultivate potato crops to keep the moisture in the ground. Have you tried green peas. A planting of peas as a side line would come in perhaps about Easter. Richard Seddon, Green Feast or Yorkshire Hero are suitable varieties.

*North-western Slopes.***Crops to sow—**

- Maize, sorghums, millets, cowpeas.

Vegetables—sow French beans, marrow, New Zealand spinach, pumpkin, radish, squashes, tomato.

Cultivation—continue as opportunity arises to cultivate between rows of maize and potatoes, and where these are sufficiently developed hill if advisable. Prepare further land for cropping in January and early autumn. If fallowed

land is weedy or set by rains it should be worked with disc or spring-tooth cultivators or harrows. If only an inch of soil is loose on the surface the evaporation of moisture is greatly retarded. The cereal harvest is generally completed before the end of this month, and hay stacked in field or shed.

*Central-western Slopes.***Crops to sow—**

- Maize (early varieties) and sorghum—for greenstuff, silage, and grain.
 Cowpeas—for grazing and greenstuff.

Vegetables—plant French beans, marrows, squashes, pumpkins.

*South-western Slopes and Riverina.***Crops to sow—**

- Maize, sorghum, millet—sow for ensilage and green fodder only where irrigation is possible.

Vegetables—stake tomatoes, and mulch after watering.

Get land ready, if at all in suitable condition for early autumn sowing.

*Murrumbidgee Irrigation Area.***Crops to sow—**

- Maize—for green feed; only sow maize that can be used as green fodder before frosts and use early maturing varieties. If sown for grain it must be early in the month. After Christmas is generally too late.

Millet and sorghum.

Vegetables—sow peas, French beans, white turnips, cabbage, cauliflower, celery, tomatoes, sweet corn, cucumber, radish, marrow.

*North-western Plains.***Crops to sow—**

- Maize and pumpkins—only if they can be irrigated.

Other work—commence to plough land for autumn sowing, plough in all the stubble, especially on the black soil.

A PLANTING TABLE.

The great variation in the conditions under which crops are grown in different districts and for different purposes, makes it impossible for a general recommendation to be made as to the detail of the methods of planting and the quantities of seed per acre required. In the following pages an effort has been made to particularise this information to the districts previously described in this calendar. It must be pointed out again, however, that farmers who find that the conditions of the locality in which they are situated, are not represented, should communicate with the Department for advice.

Crop.	Purpose for which grown.	Drilled.		Broadcast.	Period of growth of crop (approx.)	Notes.
		Distance drills apart.	Quantity seed per acre.	Quantity seed per acre.		
months.						
North Coast—Richmond-Tweed.						
Artichokes	Pig and cattle food.	3 ft.	6 cwt. tubers	...	4-6	
Cotton	.....	3-4 ft.	10-12 lb.	.....	3-4	Thickly in drills.
Cowpeas	Fodder	2 ft. 6 in.	9 lb.	.....	3½-4	
	Green manure	.....	.....	40 lb.	4-6	
Field peas. (See "Oats")	Grain	4 to 5 ft.	8-12 lb.	.....	4-6	For grain—small early varieties 4 feet between drills, and 8 to 12 inches between plants, or 3 grains every 2 to 3 feet; late varieties 4 feet 6 inches to 5 feet between drills and 12 to 16 inches between plants, or 3 grains every 3 to 4 feet
Maize	Ensilage or green fodder.	3 ft.	20-25 lb.	1-1½ bus.	3-4½	
Miller	Green fodder	.....	.....	8-10 lb.	2	
	Hay	.....	.....	8-10 "	3	
Oats	Green fodder	.....	.....	2½ bushels	3	
	Hay	.....	.....	2½ "	5½	
Oats and Field peas	Green fodder	.....	.....	1½ "	1-2-3	
Rye	.....	.....	.....	½ bushel	2	
	Green fodder	.....	.....	1½-2 bus.	3	
	Ensilage or green fodder.	2½ to 3 ft.	6-8 lb.	20 lb.	3-4½	
Sorghum	Seed	3 ft.	6 lb.	.....	4	
Sugar-cane	Cattle food	4½ to 5½ ft.	Sets 15 in. apart.	.....	8	
Sweet potatoes	Pig and cattle food.	3 ft.	Sets or tubers.	.....	4	
North Coast—Clarence.						
Artichokes	Pig feed	3 ft.	6 cwt. tubers.	.....	7	
Barley and Vetches	Green fodder	.....	.....	1½ bushels	4-5	
	.....	.....	.....	1 bushel		
Barley (Skinless)	Green fodder	.....	.....	2 bushels	4-5	
Beans (Florida Velvet)	Fodder	4 ft.	15-20 lb.	.....	6½	
	Pulse	4 "	15-20 "	.....	7½	
(Mauritius)	Fodder	4 "	15-20 "	.....	6	
	Seed	4 "	15-20 "	.....	7	
Broom millet	Broomheads	3 "	5 lb.	.....	6	
Cotton	.....	3-4 ft.	10-12 lb.	.....	3-4	Thickly in drills.
	Green fodder	2 ft. 6 in.	9 lb.	30 lb.	3½-4½	
Cowpeas	Seed	3 ft.	9 "	.....	4½	
	Green manure.	.....	.....	20 lb.	4	
Kale (Thousand-headed)	Fodder	4 ft.	1½ lb.	9 "	4	
Lucerne	Hay and green fodder.	.....	.....	15-20 lb.	4-5 (first cut).	

A PLANTING TABLE—continued.

Crop.	Purpose for which grown.	Drilled		Broadcast.	Period of growth of crop (approx.).	Notes
		Distance drills apart.	Quantity seed per acre.			
months.						
North Coast—Clarence—continued.						
Maize	Grain	4 to 5 ft.	8-12 lb.	..	4-6	See remarks in Richmond-Tweed section on distances for sowing.
	Fodder or ensilage	3 ft.	20-25 "	1-1½ bus.	4½	
Millet (Hungarian)	Green fodder	..	..	20 lb.	2½	
Oats	Hay	..	..	2 bushels	5	
Oats and Peas	Fodder	..	..	1½ bushels	4-5	
	..	..	..	1 bushel	..	
Paspalum	Pasture	..	..	8 lb.	6 (to establish)	
Potatoes	Market	2 ft. 6 in.	8-10 cwt.	..	4½	
Pumpkins	Pig feed	10 ft.	3 lb.	..	5	
Rape (Essex)	Green fodder	2 ft. 6 in.	2 "	6-8 lb.	3	
Sorghum	"	2½ to 3 ft.	6-8 lb.	15-20 lb.	1½	
	Seed	3 ft.	6-8 "	15-20 "	5-6 "	
Sugar-cane	Fodder	5 "	1,700 sets.	..	8	
Sweet peas	Pig feed	3 "	3 lb.	..	1	
Sweet potatoes	Domestic uses and fodder.	3 ft. x 2 ft.	7,200-shoots	..	7	
Wheat	Fodder	..	..	1½-2 bus.	4-5	
Central Coast.						
Artichokes	Pig fodder	3 to 3½ ft.	5-6 cwt.	..	4-6	
Barley	Green fodder	..	..	2 bushels	3-4	
Broom millet	Brush for brooms and seed	3 ft.	4-6 lb.	..	4	
Buckwheat	..	..	..	20 lb.	4	
Cotton	..	3-4 ft.	10-12 lb.	..	3-4	Thickly in drills.
	Seed	3 ft.	8-9 lb.	..	4 ½	
Cowpeas	Green manure	..	..	20 lb.	4	
	Green fodder	3 ft.	8-9 lb.	30 "	4	
Field peas	Fodder	2½ to 3 ft.	24-30 lb.	60 "	4-5	
	With cereals for fodder.	..	20-25 "	40 "	..	
Grasses—	Green manure	2½-3 ft.	24-30 "	60 "	4	
	Pasture	..	..	40-50 lb.	4-6	
Cocksfoot	..	..	..	40-50 "	4-6	
Prairie	..	..	..	6-8 lb.	4-6	
Rhodes	..	..	..	2 bushels	3-4	
Rye grass	..	..	..	..	..
Indian cane	Green fodder	4-5 ft.	Sets 8-10 in. in rows.	..	..	Permanent.
Lucerne	Green fodder and hay.	..	..	15-20 lb.	..	
Maize	Grain—early	3-3½ ft.	10-12 lb.	..	4-4½	
	late	3½-4 "	8-10 "	..	4½-6	
Mangolds	Green fodder or ensilage.	2½-3½ ft.	14-20 "	1 bushel	4-4½	
	Pig and cow fodder.	3 ft.	4-6 lb.	..	6-8	
Melons and squashes	Domestic use	Hills 4-6 ft. apart each way.	1-3 "	..	2½-3	
Millet	Green fodder	3 ft.	3-4 "	8-12 lb.	2½-3	
Oats	Green fodder and hay.	..	..	1½-2 bus.	3 (5 for hay)	
Onions	..	1-2 ft.	3-4 lb.	..	6-11	Sown in seed-bed. ½ lb. seed gives enough plants to sow an acre in drills 2-3 feet apart—plants 4-5 inches.
Paspalum	Pasture	..	..	8-12 lb.	6	
Peanuts	Pig feed, domestic use, and oil.	Hills 4 ft. apart each way.	20-25 lb. in husks, 8-10 lb. shelled.	..	4-5	
Potatoes	..	2½-3 ft.	10-12 cwt.	..	4 ½	Sets 10-11 inches apart in rows.

A PLANTING TABLE—continued.

Crop.	Purpose for which grown.	Drilled.		Broadcast.	Period of growth of crop (approx.) months.	Notes.
		Distance drills apart.	Quantity seed per acre.	Quantity seed per acre.		
Central Coast—continued.						
Pumpkins	Domestic use, cow and pig fodder.	7-11 yds. 3-6 yds. in row	4-6 lb.	.....	4-5	
Pigeon peas	Green fodder	2-3 ft.	2-4	6-8 lb.	2½	
Sweet potatoes	" "	3 ft.	6-8 lb.	15-20 lb.	4-5	
Soybeans	Green manure and fodder.	3 "	4-5	20 lb.	4-6	
Sudan grass	Pasture	" "	4-8	20-25 lb.	4-6	
Sunflowers	Fowl and stock feed, ensilage	4 ft.	8-10 lb.	14-20 "	4-5	
Sweet turnips	Domestic use, pig and cow fodder.	3 "	3-4 lb.	4-6 lb.	4	
Sweet potatoes	Domestic use, pig and cow fodder.	3-4 ft. square	11-14 thousand slips.	.....	6-7	
Tick beans	Green manure and fodder.	3-4 ft.	10-14 lb.	30-40 lb.	4-5	
Vetches and tares	Fodder	" "	" "	30-40 "	4-5	
	Green manure	" "	" "	30-40 "		
	With cereals	" "	" "	20-30 "		
Wheat	Green fodder and hay.	" "	" "	2 bushels	3-5	

Hawkesbury-Nepean.

Barley	Greenstuff	7 in.	1½ bushels	2 bushels	4	Generally sown with peas.
Broom millet	Broomheads	3 or 3½ ft.	5-6 lb.	.....	6-7	
Cabbages	Market	3 x 2 ft.	7,200 plants	.....	4-6	
Cotton	" "	3-4 ft.	10-12 lb.	.....	3-4	Thickly in drills.
Cowpeas	Greenstuff, ensilage, or hay.	2 ft. 6 in.	7-10 lb.	20-30 lb.	4-6	
Field peas	Greenstuff, with barley, oats, or wheat.	Drilled with cereal.	½ bus. peas, 1 bushel cereal.	Same as drilled.	4-5	
Lucerne	Greenstuff and hay.	.....	.....	12-15 lb.	5 (first cut)	Permanent (3-6 cuttings per annum).
Maize	Greenstuff or ensilage.	3 to 3½ ft.	20-25 lb.	1-1½ bushels.	4-5	Keep cultivators going.
	Grain	4 to 5 ft.	6-10 lb.	.....	5-7	See above remarks on distances for sowing.
Mungolds	Stock feed	2 ft. 6 in.	7 lb.	.....	7-8	
Melons	" "	Hills 6 x 8 to 6 x 10 ft.	2-3 lb.	.....	4-6	Keep cultivated until runners cover ground.
Millet	Greenstuff, ensilage, and hay.	7 in.	6-10 lb.	10-15 lb.	2½-4	
Oats	Greenstuff	7 in.	1½ bushels	2 bushels	4	
	Hay	7 "	1½ "	2 "	5	
Potatoes	" "	2½ to 3 ft. in row, 14 in. apart.	7-10 cwt.	.....	5-6	
Pumpkins	" "	10 x 10 ft. to 12 x 12 ft. hills.	2 lb.	.....	5-7	Keep cultivated until runners cover ground.
Turnips	Greenstuff	7 in. or 2 ft. 6 in.	10 lb. or 3 lb.	10-15 lb.	2-3 (2 or 3 cuttings).	Pigs or sheep may be turned into crop when 12 inches high. The wider sowing permits of cultivation.
Rye	Greenstuff	7 in.	1½-2 bus.	2 bushels	4	
	Grain	7 "	1½-2 "	2 "	6	
Sorghum	Greenstuff, ensilage, and hay.	2½ to 3 ft.	6-8 lb.	17-20 lb.	5-6 (2 cuttings).	
Swedes	" "	2 ft. 6 in.	2-2 "	6 lb.	4	
Sweet potatoes	" "	3 x 2 ft.	7,200 rooted cuttings	.....	6-8	2 cwt. seed needed to produce the cuttings.
Tares. (See Vetches)	" "	4 x 4 ft. to 6 x 6 ft.	to 2,745 to 1,210 plants.	.....	4-6	
Turnips	" "	2 ft. 6 in. 3 ft.	2-3 lb.	6 lb.	4	

A PLANTING TABLE—*continued.*

Crop.	Purpose for which grown.	Drilled		Broadcast.	Period of growth of crop (approx.) months.	Notes.
		Distance drills apart.	Quantity seed per acre.	Quantity seed per acre.		

Hawkesbury-Nepean—*continued.*

Vegetables (or tares)	Greenstuff with barley, oats, or wheat.	Drilled with cereal.	$\frac{1}{2}$ bus. tares, 1 bushel cereal.	Same as drilled.	4-5.	
Wheat	Greenstuff	7 in.	1 bushel	1 $\frac{1}{2}$ bushels	4	
	Hay	7 "	1 "	1 $\frac{1}{2}$ "	5	

South Coast.

Barley	Green fodder	6 in.	1 $\frac{1}{2}$ bushels	2 bushels	5	
Beans	Domestic	2 ft.	45 lb.		3	Cultivate lightly.
Beet and mangel wurzels	Fodder	3 "	6 "		7-8	Thin out to about 1 foot.
Clover	Pasture			12 lb.	5	
Cowpeas	Fodder	2 ft.	20 lb.	40 "	4-5	Cultivate until they run.
Grasses	Pasture			2 bushels	5 (to establish)	
Lucerne	Greenstuff or hay.	6 in.	8-12 lb.	16 lb.	6 (first cut).	
	Grain	3 $\frac{1}{2}$ to 4 $\frac{1}{2}$ ft.	9-12 "		5-6	For grain—early sowings of early varieties, 3 $\frac{1}{2}$ feet between drills and 8 to 12 inches between plants, or 3 grains every 2 to 3 feet; late sowings 4 to 4 $\frac{1}{2}$ feet between drills and 12 to 16 inches between plants, or 3 grains every 3 to 4 feet.
Maize						
Millet	Fodder	2 $\frac{1}{2}$ to 3 ft.	25-25 lb.	1-2 bushels	3-4	
		6 in.	10 lb.	20 lb.	2 $\frac{1}{2}$ -3	
Oats	Hay	6 "	1 $\frac{1}{2}$ bushels	2 $\frac{1}{2}$ bushels	5	Harrow until plants are 5 inches high.
Onions	Market and domestic.	2 ft.	2 lb.		6	Cultivate freely; keep weeds in check.
Peas (Field)	Fodder	2 "	40 "	1 $\frac{1}{2}$ bushels	3-4	Cultivate between rows.
Potatoes	Market and domestic.	3 "	7-10 cwt.		3-4	
Pumpkins	Domestic	6 x 6 ft. or 8 x 8 ft.			5-6	Cultivate between rows until they run.
Pumpkins (cattle)	Fodder	6 x 6 ft. or 8 x 8 ft.	2 "		5-6	" "
Rape		6 in.	6-10 lb.	15 lb.	4	Fit to graze in 6 to 8 weeks.
Rye		6 "	1 bushel	1 $\frac{1}{2}$ bushels	4	
Rye grass	Pasture			2 "	5	
Sorghum	Fodder	2 $\frac{1}{2}$ to 3 ft.	6-8 lb.	15-20 lb.	5-6	
Tares or vetches		2 ft.	40 lb.	1 $\frac{1}{2}$ bushels	4-5	Cultivate.
Turnips (Swede)	Cattle or pig fodder.	2 "	2 "		6	Cultivate, and thin out in rows.
Wheat	Grain or hay	6 in.	1 bushel	2 bushels	5	

Northern Tableland.

Barley	Grain	7 in.	40-60 lb.	50-70 lb.	5-7	Quicker maturing when spring sown than when autumn sown.
	Green fodder	7 "	40-60 "	50-80 "	4-6	Best fed when in ear (3-5 months).
Clover	Green fodder and hay.	7 "	6 lb.	10 lb.	2 $\frac{1}{2}$	Three cuts in flower in a year except in cooler parts.
Grasses	Pasture	7 in. to 3 ft.	15-3 lb.	20 "		
Lucerne	Green fodder and hay.	7 in.	8 lb.	12 "	2 $\frac{1}{2}$	Three cuts in flower in a year except in cooler parts.
	Grain	3 $\frac{1}{2}$ 4 ft.	8-16 lb.		4 $\frac{1}{2}$ -6	Plants 12-15 inches apart in rows or hills of 3 plants, 3 feet apart.
Maize						
Mangolds	Green fodder or silage.	3 ft.	20-30 lb.	60 lb.	3-4	
	Stock feed	2 3 $\frac{1}{4}$ ft.	4-3 lb.		5-7	
Oats	Grain	7 in.	40-60 lb.	50-70 lb.	5-7	
	Green fodder	7 "	40-60 "	50-80 "	4-6	
Peas and beans	Green or dry seed.	2 $\frac{1}{2}$ 3 ft.	50-60 "	100 lb.	3-5	Green, 3 months; mature, 5 months.

A PLANTING TABLE—*continued.*

Crop.	Purpose for which grown.	Drilled.		Broadcast.	Period of growth of crop (approx.) months.	Notes.
		Distance drills apart.	Quantity seed per acre.	Quantity seed per acre.		

Northern Tableland—*continued.*

Potatoes	Market and domestic use.	2-3 ft.	12-8 cwt.	4 6.			
Rape	Green feed	7 in.-3 ft.	8-2 lb.	10 lb.		May be fed-off or cut at any time.	
Rye	{	Grain	7 in.	40-60 lb.	50-70 lb.	5-7.	
		Green fodder	7 in.	40-60 "	50-80 "	4-6.	
Sorghum	{	Green fodder and silage.	2½-3½ ft.	8 6 lb.	14 lb.	4-6.	Should not be fed until nearly mature and should be cut 24 hours before feeding.
Sudan grass	{	Green fodder and silage.	7 in.-2½ ft.	14-4 lb.	14 "	2½ "	Two crops in 12 months may be obtained by cutting before plants are too fully in flower.
Turnips	{	2-3 ft.	4-3 lb.	10 "	4-6.		
Wheat	{	Grain	7 in.	40-60 lb.	50-70 lb.	5-7.	
		Green fodder	7 "	40-60 "	50-80 "	4-6.	

Central Tableland.

Artichokes (Jerusalem)	{	Tubers	3 ft.	6 cwt.	7 "	Plant like potatoes.	
		Maling	7 to 8 in.	50 lb.	6 "		
Barley	{	Green winter fodder.	7 to 8 "	40 "	50 "	5 (second growth, August till December).	
		Canary grass	Bird seed			20 "	6 "
Cowpeas	{	Grain	4 ft.	6 lb.		6 "	
		Fodder	2 "	20 "		6 "	
Lucerne	{	Hay	7 to 8 in.	6-8 lb.	10-15 lb.	Perennial summer crop.	
Maize	{	Grain	4 to 5 ft.	6-8 lb.		6 "	On uplands-drills should be 4 or 5 feet apart, and plants about 18 to 24 inches apart in rows. On irrigated flats distances can be reduced to 4 feet and 12 to 16 inches respectively.
		Fodder and Ensilage.	3 ft.	8-12 "	Not recommended.	6 (December till May).	
Melons	{	Market	10 x 10 ft.	1-1½ "		5 "	
Millet	{	Grain	18 to 30 in.	8-12 "		7 "	
		Fodder	18 to 30 "	8-12 "		6 "	
Oats	{	Grain	7 or 8 "	40 lb.	50 lb.	8 "	
		Hay	7 or 8 "	40 "	50 "	7 "	
Onions (from seed)	{	Main crop	15 x 6 "	10-12 oz.		11 "	Seeds sown in beds to be transplanted.
Potato onions (bulbs)	{	Domestic	15 x 6 "	3-5 cwt.		6 "	Bulbs are planted.
Tree onions	{		15 x 6 "	3-1 "		7 "	Bulbs from tops are planted.
Potatoes	{	Main crop	3 ft.	8-10 "		6 "	Plant 15 inches apart in drills.
		Early crop	3 "	8-10 "		4½ "	
Pumpkins	{		10 x 10 ft.	2 lb.		7 "	
		Fodder (to be cut).	2 ft. 6 in.	2-3 lb.		8 "	
Rape	{	Pasture	2, 6 "	3-5 "	4-8 lb.	8 "	The wider sowing permits of cultivation.
			7 or 8 in.	4-5 "	7-8 "	8 "	
Rye	{	Grain	7 "	40 lb.	50 lb.	7 "	
		Green winter fodder.	7 " 8 "	40 "	50 "	5 (second growth till December).	
Scarlet clover	{	Pasture			8-10 lb.	7 "	
Sheep's burnet	{				20 lb.	Perennial.	
Sorghum	{	Grain	3-4 ft.	6 lb.		7 "	
		Fodder	2½-3 "	6-8 lb.		6 "	
Tares	{		2 ft.	20 "	30-60 lb.	7 "	
Turnips (Swede)	{		3 "	2 lb.		6 "	
Wheat	{	Grain	7 cr 8 in.	25-30 lb. early, 35-40 lb. late.	45 lb. early, 45-50 lb. late.	8 "	
		Hay	7 " 8 "			7 "	

A PLANTING TABLE—continued.

Crop.	Purpose for which grown.	Dried.		Broad cast.	Period of growth of crop (approx.), months.	Notes.
		Distance drills apart.	Quantity seed per acre.	Quantity seed per acre.		
Southern Tableland.						
Barley	Green fodder	7 in.	60 lb.	80 lb.	5-6	
	Grain	"	"	"	"	
Clover (Red)	Pasture	7 in.	7-9 lb.	15 lb.	5-6	
	Green fodder	2 ft. 4 in.	60 lb.	120 lb.	4-5	
Field peas	Pasture	7 in.	25 "	40 lb.	7-8	
	Hay	7 "	10 "	15 "	7-8	
Grass (Rye)	Hay	7 "	10 "	15 "	7-8	Autumn sowing.
	Green fodder	3 ft.	30 "	50 "	4-5	
Maize	Grain	3 ft. 6 in.	10 "	"	5-6	
	Fodder	3 ft.	5-7 lb.	"	6-8	
Mangolds	Green fodder	7 in.	5 "	8-10 lb.	3-4	
	Hay	7 "	5 "	8-10 "	"	
Miller (Japanese)	Grazing	7 "	2 lb.	4 lb.	3-6	
	Green fodder	7 in.	60 lb.	80 lb.	6-8	
Mustard	Hay	7 "	60 "	80 "	6-8	
	Green fodder	7 in.	60 "	80 "	6-8	
Oats	Hay	7 "	60 "	80 "	6-8	
	Grain	7 "	60 "	80 "	7-8	
Onions	Main crop	15-18 in.	2-3 lb.	"	6-7	Space 4-6 inches apart, in rows.
	"	"	"	"	"	
Potatoes	"	2 ft. 6 in.	10-12 cwt.	"	4-6	
Pumpkins	"	8 ft. x 8 ft.	2 lb.	"	2-6	
Rape	Grazing	30 in. or 7 in.	2-4 lb.	4 lb.	3-4	
Rye	"	7 in.	60 lb.	90 lb.	3-4	
Swedes	"	36 in.	2 lb.	4 lb.	4-5	
Turnips	"	36 "	2 "	4 "	3-4	
Wheat	Green fodder	7 in.	90 lb.	120 lb.	6	
	Hay	7 "	90 "	120 "	7	
	Hay	7 "	60 "	80 "	7	
	Grain	7 "	60 "	80 "	8	
North-western Slopes.						
Barley	Grain	7 in.	40-50 lb.	54-75 lb.	4-7	Most valuable when in flower.
	Green fodder or silage.	7 "	40-50 "	54-75 "	3-4	
Cotton	"	3-4 ft.	10-12 lb.	"	3-4	Thickly in drills.
	"	"	"	"	"	
Grasses	Pasture	7 in.-3 ft.	15-3 "	20 lb.	"	Up to 5 cuts (one-third in flower) may be obtained if rainfall sufficient.
Lucerne	Hay or green fodder.	7 in.	8 "	12 "	2½	
Maize	Grain	3½-4½ ft.	10-7 "	"	4½-6	
	Green fodder or silage.	2½-3 "	15-12 "	40 lb.	3½-4	
Oats	Grain	7 in.	30-50 "	40-60 lb.	4-7	Autumn sowing is safer and the more profitable.
	Hay	7 "	30-50 "	40-60 "	3-5	
Peas and beans	Green fodder or silage.	7 "	30-50 "	40-60 "	3-4	
	Green or dry seed.	2½-3 ft.	50-60 "	100 "	2½-4½	
Potatoes	Market	2½-3½ "	10-8 cwt.	"	3½-4½	
Rape	Green feed	7 in.-3 ft.	8-2 lb.	10 lb.	"	May be fed-off or cut at any time.
Sorghum	Green fodder or silage.	2½-3 ft.	8-7 "	14 "	3-5	Should not be cut until it has tasselled and should be left 24 hours from cutting before feeding.
Sudan grass	Green fodder and silage.	7 in.-2½ ft.	14-4 "	14 "	2½	By cutting before the crop is fully in flower, 3 cuts may be obtained.
Turnips	Stock feed	2-3 ft.	4-3 "	10 "	3-5	Autumn sowing is safer and more profitable.
	Grain	7 in.	50-60 lb.	50-75 lb.	4-7	
Wheat	Hay	7 "	30-60 "	50-75 "	3-5	
	Green fodder or silage.	7 "	30-60 "	50-75 "	3-4	

A PLANTING TABLE—continued.

Crop	Purpose for which grown.	Drilled		Broadcast.	Period of growth of crop, (approx.), months.	Notes.
		Distance drills apart	Quantity seed per acre.	Quantity seed per acre.		
Central-western Slopes.						
Barley	Grazing, greenstuff, silage, grain.	6 to 8 in.	$\frac{1}{2}$ - $\frac{3}{4}$ bushel	$\frac{3}{4}$ -1 bushel	4-6..	Fit to graze for greenstuff 6 to 10 weeks after planting. Will continue to grow after being cut or grazed.
Beans	Grazing, greenstuff and pulse	2 $\frac{1}{2}$ to 3 ft.	8-12 lb.	Not recommended.	3-6..	After being cut or grazed cowpeas will continue growing until frosts set in.
Lucerne	Greenstuff or hay.	.....	.....	8-10 lb.; 15 lb. on river flats.	Perennial..	First cut 3 to 4 months from planting.
	Greenstuff ensilage.	or 3 to 3 $\frac{1}{2}$ ft.	12-15 lb.	Not recommended.	4 ..	For grain, average distance between plants in rows should be 15 to 24 inches. If birds are troublesome and destructive, dip seed in coal tar and dry with ashes.
Maize	Grain ..	4 $\frac{1}{2}$ to 5 ft.	6-8 lb.	..	4-6..	
Millot	Greenstuff or ensilage.	or 2 $\frac{1}{2}$ to 3 ..	3-4 ..	10-12 lb. ..	2 $\frac{1}{2}$ -4 ..	Makes a rough class of hay for standby purposes.
Potatoes	Domestic	or 2 $\frac{1}{2}$ to 3 ..	8-10 cwt. ..	.....	3-4..	
Rape	Grazing greenstuff.	or 14 in. to 3 ft.	2-4 lb.	5-6 lb.	3-6..	Fit for grazing 6 to 8 weeks after planting, and continues growing until September.
Rye	Grazing, greenstuff, hay, or grain.	.....	40 lb.	$\frac{1}{2}$ - $\frac{3}{4}$ bushel	4-6..	Fit for grazing 6 to 8 weeks after planting and until spring, when, if allowed it will run up and produce a crop of hay or grain.
Sorghum	Greenstuff, ensilage, or coarse hay.	2 $\frac{1}{2}$ to 3 ft.	6-8 lb.	Not recommended.	5 ..	
Tares (or vetches)	Grazing or greenstuff.	or 2 $\frac{1}{2}$ to 3 ..	12-20 lb.	30-60 lb.	5-6..	
Wheat	Grain ..	6 to 8 in.	40-60 lb.	45-60 ..	6-7..	To prevent smut treat the seed with bluestone and afterwards with lime. Quantities of seed per acre will vary with variety, time of sowing, &c. See page 336.
	Greenstuff, ensilage, or hay.	6 to 8 ..	40-60 ..	60 ..	5-6..	

South-western Slopes and Riverina.

Barley	Grain ..	7 in.	25-30 lb.	60 lb.	5-6..
	Green fodder or silage.	7 ..	35-40 ..	60 ..	3-5..
Barley and Peas	" ..	7 ..	30 lb.	45 ..	3-5 ..
	" ..	7 ..	30 ..	30 ..	
Field peas	Green fodder.	7 in.	60 lb.	66 lb.	4-7 ..
	Green manure..	7 ..	60 ..	60 ..	4-5..
Grasses	.....	.....	.....	20-40 lb.	.....
Luzerne	Pasture ..	7 in.	4 lb.	10 lb.	Perennial.
	Hay ..	7 ..	6 ..	12-15 lb ..	
Maize	Green fodder ..	3 ft.	15-20 lb.	Not recommended	4-5..
Millot	Fodder ..	7 in.	8 lb.	10 lb.	3-4..
	Grain ..	7 in.	25 ..	40 ..	5-7..
Oats	Hay ..	7 ..	30-40 lb.	50 ..	5-6..
	Green fodder or silage.	7 ..	25 lb.	65 ..	4-6 ..
Onions	Domestic	3 ft.	2 ..	30 ..	.....

A PLANTING TABLE *—continued.*

Crop.	Purpose for which grown.	Drilled.		Broadcast.	Period of growth of crop (approx.).	Notes.
		Distance drills apart.	Quantity seed per acre.	Quantity seed per acre.		
South-western Slopes and Riverina <i>continued.</i>						
Potatoes	Domestic	3 ft. x 15 in.	5-7 cwt.	.....	4-5	
Pumpkins	Fodder	10 ft.	2 lb.	.....	5-6	
Rape	"	7 in.	3 "	3 lb.	.....
Rye	Green fodder	7 "	15 "	60 "	3-4½	
Sheep's burnet	Pasture	7 "	10 "	20 "	Perennial.	
Sorghum	Green fodder	2½ to 3 ft.	6-8 lb.	15-20 lb.	4-5	
Swedes	Fodder	3 ft.	2 lb.	.....	.....
Tomatoes	Domestic	5 x 5 ft.	1 oz.	.....	.....
Turnips	Fodder and table.	3 ft.	2 lb.	.....	.....
Vetches	Green manure.	7 in.	30-40 lb.	60 lb.	4-5	
	Green fodder	7 "	30-40 "	60 "	4-6	
Wheat	Grain	7 "	45-60 "	60 "	6	
	Hay	7 "	45 lb.	60 "	5	
Murrumbidgee Irrigation Areas.						
Barley	Grain	7 in.	40-45 lb.	60-70 lb.	5-6	
	Green feed	7 "	50-60 "	70 lb.	3-5	
Barley and Peas or Tares	"	7 "	50-60 "	70-80 lb. barley, 35 lb. peas, &c.	3-5	
Broom millet	Broomheads	3½ ft.	8 lb.	.....	4-5	
Cotton	.....	3-4 ft.	10-12 lb.	.....	3-4	Thickly in drills.
Field peas	Green feed	7 in.	50-60 lb.	.....	4-5	
	Green manure	.....	70-80 "	.....	4-5	
Lucerne	Pasture and hay	7 in.	8-10 "	Not advisable.	Perennial	
Maize	Grain	4 ft.	8-10 "	" "	4-6	Plants should not be closer than 15 to 18 in. in the rows.
	Green feed	3 "	20-25 "	35 lb.	3-5	
Millet	"	7 in.	8-10 "	12-15 lb.	2½-4	
Oats	Hay	7 "	60 "	60-70 "	4-6	
	Green feed	7 "	60-80 "	70-80 "	3-5	
Oats and Peas or Tares	"	7 "	50-60 "	70 lb. oats, 35 lb. peas, &c.	3-5	
Rape	"	7 "	4-5 lb.	5-6 lb.	3-6	
Rye	Green fodder	7 "	60 lb.	60-70 lb.	3-4½	
	Straw	7 "	40-45 lb.	50-60 "	5-6	
Sorghum	Green fodder	14 in.	14 lb.	20-25 "	3½-6	
Vetches	"	.....	.....	.....	.....	Best sown with a cereal.
Wheat	"	7 in.	50-60 lb.	65-75 lb.	4-6	
	Hay	7 "	60 "	60-70 "	5-7	
Grasses	Paspalum	.....	.....	.....	.....	Sow with cover crop such as millet through seed drill, using the manure box.
Cocksfoot	"	40-50 "	" "
Rhodes	"	6-8 "	" "
Prairie	"	40-50 "	" "
Sudan	Grazing, or hay	7 in.	10 lb.	Sow alone.
	Seed	3 ft.	6 "	

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