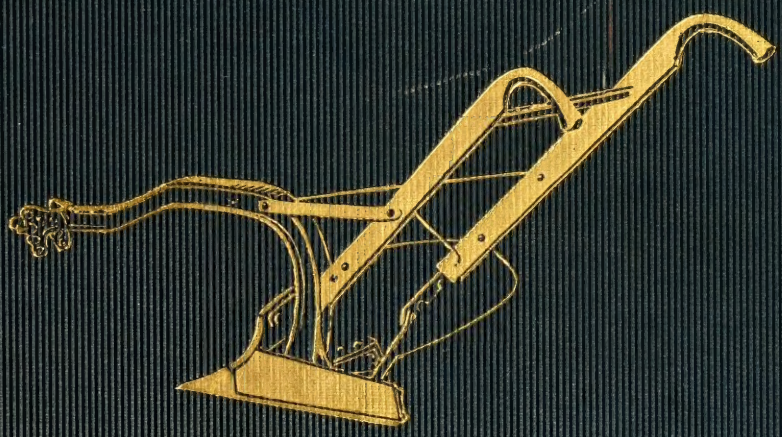
THE RURAL SCIENCE SERIES

by

L. H. BAILEY

FORAGE CROPS



The Rural Science Series

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FORAGE CROPS

The Rural Science Series

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Forage Crops.

Fig. 1. A field of fodder corn. Minnesota.

FORAGE CROPS

FOR SOILING, SILAGE, HAY AND PASTURE

BY

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PREFACE

This work is intended to give brief and practical farming suggestions that will be helpful in the growing and using of forage crops. Special attention has been given to soiling crops and to rotations, in order to suggest a continuous supply of forage throughout the growing season, a subject of increasing importance to dairy farmers in the vicinity of large cities.

These suggestions for both crops and rotations have been found to be satisfactory in practice, but the work must be carefully planned if it is to prove successful. The systems of forage-crop rotations here outlined are intensive, and to secure the full benefits from their adoption the cropping must be accompanied by liberal use of manures and fertilizers and by extra good tillage.

The suggested improvements in the systems of rotation for general farm practice, where grain crops are the chief object, have also been found to be practicable for many conditions, although they

are yet largely experimental, and in use mainly on small farms; their adoption, however, would result both in increasing the yield and quality of forage from a given area, and, if judiciously carried out, result in a better preparation of the land for grain crops.

No attempt has been made to discuss all crops that may be used for forage, although those which have been found of service under special conditions have been included, as, for example, the millets, kafirs and a few of the less well-known grasses. The data in reference to these, however, have been drawn largely from the experience of others. Special attention has been given to the legumes, as their use is of the utmost value in any system of forage cropping, and many of those recently introduced possess such habits as to permit their use without interfering with regular grain-crop rotations.

E. B. VOORHEES.

New Brunswick, N. J.
May, 1907.

CONTENTS

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

CHAPTER VI

CHAPTER VII

CHAPTER VIII

CHAPTER IX

CHAPTER X

CHAPTER XI

CHAPTER XII

CHAPTER XIII

CHAPTER XIV

CHAPTER XV

CHAPTER XVI

CHAPTER XVII

CHAPTER XVIII

CHAPTER XIX

LIST OF ILLUSTRATIONS

FORAGE CROPS

CHAPTER I

GENERAL VIEW OF FORAGE CROPS

THE subject of forage crops has grown rapidly in interest in recent years. This is due primarily to two causes,—to the general increase in knowledge of what constitutes a food, and the best method of using it; and to the increase in demand for dairy products, especially of whole milk in large towns and cities, which makes it desirable that a larger supply of succulent food shall be raised by the farmers engaged in its production near the point of consumption.

In a narrow sense, the term "forage crops" is frequently applied only to those crops that are suitable for use as green food, and thus the term conveys the idea of soiling, or carrying the foods in their green state from the field to the animal. In a broader sense, "forage crops," or perhaps better, "roughage crops," includes not only those suitable and adapted to soiling systems, but those used as pasture, for hay and for silage; or, in other words, it includes the entire number of

crops of the different classes used to supply the roughage necessary in rations for farm animals, as well as to reduce the need for purchased feeds.

In this book the term "forage crops" is used in the broadest sense. The common-language usage of forage (and which must prevail) would make the term a general one applying to all kinds of rough or coarse natural herbage food, such as animals might find freely provided by nature; as hay, pasture, herbage of maize, oats, cowpeas, vetch, sorghum. "Roughage" is practically synonymous, but is applied more particularly to the coarser kinds, that is, exclusive of hay and pasture. "Fodder" is the dried or cured herbage. "Soiling" is the feeding of animals on green herbage that is cut and carried to them (as distinguished from pasturing).

THE MEASURES OF VALUE IN FORAGE CROPS

The value of any forage crop is determined by a number of conditions, the first, and in the long run probably the most important, being the actual food, or the amount of dry matter, that may be secured from a given area and its usefulness as measured by the kind and proportion of the nutrients contained in it. A second consideration is its adaptability and usefulness for the various purposes, as, for example, for a soiling

crop, for pasture, for hay or for silage; third, its time of growth and season of maturity, as influencing its usefulness at specific times; and fourth, the nature of the plant, as having reference both to its composition as a food and the influence that its growth may exert on the fertility of the land.

Indian corn, or maize, is very highly regarded as a general forage crop, because it can be grown successfully over a wide area. It is capable of producing a large yield of nutritive substance, highly digestible, very palatable, and relished by all farm stock. It serves an excellent purpose as a green forage for use in soiling; it can be so grown as to furnish succulent food through a comparatively long period of the growing season; it is the best crop to supply succulent winter food in the form of silage; it also serves as an excellent source of both dried roughage and of concentrates when ripened and handled in the usual way. It therefore fulfils in a larger degree than any other one plant the chief requirements of a forage crop. Because of its vigorous habit and its season of growth, it is capable of acquiring its food from sources not so readily available to other plants; therefore, good results can be secured on land that would not be capable of producing crops more dependent on immediately usable food supplies.

Red clover is another example of a forage crop that possesses valuable characteristics. It can be

very generally grown, is rich in nutrients, palatable, and capable of use as a green forage or as hay; it possesses an important advantage in being capable of deriving a part at least of the nitrogenous food necessary for its growth from the air, and for this reason is regarded as an improving rather than an exhausting crop. It supplements the corn crop in composition, as well as in its power of obtaining nitrogen. Thus, in the growing of corn and clover in rotation, better rations are obtained and the soil less quickly depleted, than if corn alone is grown.

On the other hand, such crops as rye and wheat, while readily grown, are serviceable only for a short period as green forage or for soiling, and are not so generally useful in their dried state as corn or clover. Their usefulness is due chiefly to their time of growth and season of maturity, which permits of their use as green forage or pasture when such crops as corn and clover are not yet ready.

The cowpea possesses the characteristics attributed to the clover in food acquirements, but it is possible to grow it only in the hot season, and it therefore serves only as a late summer or fall food.

Another point of very great importance, and one which should be observed in comparing the various forage crops, is the food-content in the green state. Succulence is of course very impor-

tant in soiling crops, but it cannot take the place of actual nutrition; therefore, in measuring the value of crops for soiling, those that produce the largest quantity of actual food per acre should be given the preference, other things being equal. In other words, the value of a forage crop is measured by the dry matter, or food-substance other than water, and not by the ton basis without regard to the percentage of dry matter. It has been shown, for example, that certain of the crops which have their origin in hot climates make enormous yields, as teosinte and Pearl millet, yet the actual nutriment produced by them in a short period is relatively much less than from corn or some other crops whose natural habitat is the temperate zone. In many cases, one ton of corn, when in a state suitable for use as green forage or soiling, will contain twice as much dry matter or digestible nutrients as two tons of these crops which grow much more luxuriantly and are apparently superior sources of food-supply.

In comparing the values of different forage crops, the character of the nutritious materials of the dry matter contained in them should not be forgotten, and the influence of these in the nourishment of the animal. It has been very clearly shown by nutrition investigations that nutrient substances in feeds are of two general groups or classes: (1) Those containing a relatively large percentage

of protein, of which nitrogen is the base; (2) those containing a low percentage of protein, and, therefore, usually richer in carbohydrates. Corn is a representative of the second class, whereas clover, particularly in its green state, represents the first class. A judicious combination of these two groups of substances results in a more economical feeding of the animal than the use of either one or the other in too great proportion. In the growing of forage crops, therefore, both classes should be represented. For this reason, the various crops are classified and discussed in groups: (1) The group including those that belong to the grass family; (2) those belonging to the legume or clover family; (3) root crops; (4) and finally a brief account of permanent meadows and pastures. All this is preceded by a discussion as to their use in systems of crop-rotation, and how to combine those of each group in order that a continuous summer feeding for soiling purposes may be best accomplished.

IMPORTANCE OF SUCCULENT FOODS FOR DAIRY COWS

Aside from the mere question of food production, the interest in forage crops has increased because the results of investigations of the dairy business have shown that if the product of the cow is to be kept up to the full standard, the animal must be supplied with an abundance of succulent food

throughout the entire year. Under old systems, when definite areas were devoted to pasturage and the entire supply of succulent food was from this source, animals were frequently poorly fed, because climatic conditions did not permit of a continuous and abundant growth of the various kinds of pasture. The crops were frequently lessened by droughts, extending over shorter or longer periods when the animals, not having supplementary food, were either insufficiently nourished or did not have food of the right kind. In other instances, late winter forage having been exhausted at the usual time, animals were turned out on pasture before it was abundant enough to supply the entire demands, or when the plants were so immature that, even with sufficient bulk, the necessary amount of actual nutriment was not obtained. Frequently, also, in certain regions where river or brook meadows serve as the entire source of pasture, summer floods interfere with the continuous supply of food, because the floods leave a deposit of mud and silt, and three or four days are required before the grass grows sufficiently to enable the meadow to be fully pastured again. Under these circumstances, animals frequently were not sufficiently nourished. Often heavy storms soak the ground so as to make the pastures wet and soggy, besides requiring considerable energy on the part of the animal to move about the fields, with consequent loss of product.

Pastures were too often the only source of succulent food; no provision was made for succulent winter food, and the less suitable dry foods were fed exclusively. Under all of these circumstances, where conditions were necessarily variable, the milk flow was naturally interfered with, and the actual profits from the dairy materially prevented. Therefore, the introduction of new crops, or the adoption of any practice which will result in providing for a continuous supply of food, must meet the approval of progressive dairymen.

Aside from suggestions as to continuous supply of food by summer soiling, the growing of various forage crops must have a bearing on summer pasture, and on the necessity of supplementary feeds to meet the requirements when conditions are unfavorable, as well as to provide succulent foods for winter. To be sure, many farmers have it in their power to supply these supplementary feeds from the regular crops at certain seasons,—as, for example, when corn reaches a sufficient state of maturity to permit of its use, or when grass or clover from the mowing fields has reached the proper stage of maturity,—but ordinarily no provision is made to meet the possible demands at such seasons. Many of the crops that serve an excellent purpose for soiling may be grown in small areas, and thus provide food when needed; and if not needed, the crop may be made into hay

for dry roughage in winter, and thus reduce the necessity for purchasing feeds.

REGIONAL QUESTIONS

The semi-arid regions of the West present peculiar conditions in relation to forage. In certain seasons, it is possible to secure good yields of the ordinary forage crops; but large areas which were formerly considered to be beyond the reach of profitable cropping are now productive, because of the improvements of methods and of the introduction of new plants. These lands have now a distinct crop-producing value, notwithstanding the shortage in rainfall. Advance in knowledge of the conditions may not make it possible to grow corn, but other well-established plants, that may be called "dry weather" plants, have been introduced, and are likely to be of greater service than those now regarded as better adapted for conditions of greater rainfall. Among these plants are the non-saccharine and saccharine sorghums, the first of which includes kafir corn and plants of that type, and the second the regular sugar-producing varieties. It seems desirable, in a work of this kind, that special mention should be made of these plants and their usefulness for these conditions, as their value has now been well established.

In certain parts of the South, owing to the

character of the climate, it has not been possible successfully to grow the grasses which do well in the northern and central parts of the country. Timothy, orchard-grass, red-top and other grasses, which serve to very good purpose for pasturage and hay in the North and West, are not well adapted to these regions. Therefore, special crops, which may or may not be adapted to rotations, answer an excellent purpose in providing grass, where the production of live-stock and the maintenance of soil fertility are matters of special importance. In many of the southern states, varieties of grasses have been introduced that possess such peculiarities of growth as to enable them not only to survive but to provide hay and pasture of an excellent quality, while at the same time protecting the soil from losses due to washing from heavy rains, so prevalent in the South. Bermuda grass is probably one of the most useful for the South; its characteristics are discussed not so much in reference to its place among other forage crops in a rotation, as to its special usefulness in providing a satisfactory forage that is suitable for the conditions which exist there.

In many of the colder regions, also, grasses whose value is established do not always survive the hard winters. These conditions have been met by the introduction of plants that, in a measure, will take the place of those which are not to be

depended on. Therefore, such kinds as have the requisite hardiness, although they possess unfavorable characteristics (as, for example, *Bromus inermis*), have been found to be most useful in these regions.

PASTURES AND MEADOWS

One other line of practice of very great importance is the proper management and maintenance of grasses in meadows and pastures. Pastures will continue to be the main source of summer forage for far the greater number of farmers for a long time to come, although it is the exception, rather than the rule, that permanent pastures are regarded as equally important with other field crops. It does not seem to occur to the farmer that pastures, as well as other crops, must have food in order to furnish profitable results. As a rule, pastures are allowed to take care of themselves, and they become infested with weeds, brambles and unpalatable grasses, when by a little care the weeds may be kept out and sweet grasses maintained, and the yield largely increased. The necessity for growing many of the crops here discussed would in many cases be reduced if more attention were given to pastures; and the cost to the farmer would be relatively much less than is generally supposed. The expense of the labor involved in pastures is a comparatively small item. They require, mainly, that

the land shall be top-dressed occasionally with lime and commercial fertilizer or manure, that wet places be suitably drained, that fresh seeding be made as occasion demands and that care be exercised in grazing them. With increased supplies of concentrated plant-food, and knowledge concerning their adaptability and usefulness in feeding plants, we can now give suggestions which cannot fail to be of great service to the farmer, not only in reducing the expense of forage, but increasing the value of lands.

The same is true, in a degree, as to the maintenance of mowing meadows. Much labor would be saved, and the period of profitable cropping extended, if proper care were taken in seeding down the meadows and judicious treatment were given them afterward. Hay is one of the most valuable crops, taken all in all; yet less care is expended in the growing of this crop than in any of the cultivated crops. It is regarded largely as a scavenger crop, which gathers up that which other crops have not used; but rather it should be regarded as a crop that responds to proper treatment and that can utilize profitably direct applications of plant-food.

CHAPTER II

FORAGE CROPS FOR HAY AND FOR IMPROVING THE LAND

THE principles that underlie the successful growth of forage crops apply quite as well whether the crops are used for dry forage or for soiling, although the number and kind of crops used for the two purposes are not necessarily the same. The advantage of a larger use of land for hay crops is not determined by the value of the hay crop itself. In many cases, the indirect value in soil improvement, which is a result of the frequent introduction into rotations of hay crops (both of grasses and legumes), is quite as great as the direct value of the forage. The more complete covering of the land with vegetation prevents losses that may occur when the fields are continuously cropped with grain, without intermediate cover-crops, or only infrequently cropped with hay, besides adding vegetable matter, the only natural source of humus. This humus is a result of the decay of the vegetable matter introduced by the roots and stubble; the humus is especially valuable when it comes from the frequent introduction of leguminous crops, thereby increasing the con-

tent of the valuable element nitrogen. The principal reasons for the rotation of crops are based on these facts. The purpose of a rotation is to prolong the period during which profitable grain and other crops may be produced with the natural supplies of plant-food.

Under present conditions in this country, the area that is devoted to the growing of hay is relatively large, although the average yield per acre is comparatively small. It is probable that the maintenance of fertility by means of rotations is not so greatly influenced by the growth of leguminous hay crops as would be the case if, aside from their value as forage, there were a better understanding of their usefulness in soil improvement. The low average yield per acre of hay may be ascribed to several causes, chief among which are:

1. Too extensive systems of practice, which do not provide for sufficient available plant-food.

2. Lack of general information concerning the habits of growth, usefulness and composition of many grasses and legumes, which are well adapted to special conditions, including lack of knowledge of the best combinations of these plants.

3. Defective systems of rotation, which do not provide for a proper succession of cereals and legumes, or which leave the land bare for long periods.

4. Too little care in the preparing and manuring of the land for seeding.

5. Careless and imperfect methods of seeding.

In regions where grain farming is practiced, and the grain sold, little attention is given to the hay crop; it is not a money crop in the same sense as corn, oats or wheat. If enough hay is procured to meet the needs of the working stock, no special efforts are made to secure thick and uniform stands, and thus the possibilities of the land are not realized, and the value of the crop, as a soil renovator, is not obtained. The small quantity of manure that is made is used on corn or wheat, and the grass or clover is seeded with the wheat, rye or oats. By these methods the added fertility in the manure has been largely used by the preceding crop of corn, or by the wheat or other grain crops, and only in exceptional cases, especially in the East and South, is a good catch secured, and, consequently, the yield is not large and it is often of poor quality. When dairying or stock-growing is combined with grain-farming, more attention is naturally given to hay, although even then the corn crop, which is regarded as the forage crop par excellence, is usually given first consideration.

Hay standards

The grass most generally grown for hay is timothy, which is a most excellent plant for the purpose, particularly from the standpoint of sala-

bleness, as the various grades fixed by hay associations are based on this variety as a standard. Any admixtures of other grasses or clovers reduce the value in proportion to the quantity of timothy present. It is probable that for a long time to come timothy hay will remain the standard for market grades. Notwithstanding these facts, there are a number of other plants which, because of their adaptability to peculiar conditions, their larger yields, and their excellent quality for feeding, must sooner or later be recognized. Among these are orchard-grass, red-top, Kentucky blue-grass, Italian rye-grass, and others, some of which are discussed in some detail in other parts of this volume. The common recognition of the value of mixtures would result, in many instances, in largely increasing the possible yield from a definite area, because mixtures of grasses that have different characteristics meet and average up the inequalities in seasons, soils and other conditions. The same is true of the legumes: many are suitable for mixtures, and they improve the feeding value of the hay at the same time.

Until recently, red clover has been the only member of the legume family extensively used for forage. It is well adapted to rotation-cropping, can be grown on most soils, and is a most excellent forage for all kinds of farm stock, but it cannot fulfil all requirements. Alsike clover, mam-

moth clover, cowpea, soybean, and spring and winter vetch are legumes that possess similar qualities from the feeding standpoint, and which, because of their habits of growth, supplement the red clover in improving rotations, while at the same time they permit a much larger production of forage from a unit of land. Alfalfa also belongs to this group, and is in many respects superior to any of them; but because it grows more rapidly and is perennial in its habits, it is not so well suited for mixtures or for rotations.

Improvement of rotations

In this country, extensive or large-area systems of farming are more generally adopted than intensive systems, and the crops are usually the cereals, as maize, oats, wheat and barley. These crops must depend on soil sources almost exclusively for their food supply, as the manures are made from a limited number of animals, and those secured in purchased supplies are not universally used.

A rotation very generally adopted in the East and central West is corn, oats, wheat, hay, clover, or clover and timothy mixed. This is not, in all cases, a better rotation than any other, but it allows the growing of a larger proportion of grain crops. One method in such a rotation is to apply the manure on the sod for corn, which is harvested

in the early fall and the land left bare of vegetation until spring, when it is seeded with oats without further manuring. After the oats are harvested the land either grows weeds, which in this case are of some value, or is plowed and allowed to lie bare until September or October, when it is seeded with wheat. An even less rational method, from the standpoint of economical use of the manure, because it results in loss of fertility elements, is to apply manure to the wheat instead of the corn. By this system, but one, or at most two hay crops (if the second crop is harvested) are taken, and the land has but one year of partial rest in four; besides, there are two periods in the rotation when the land is bare, and suffers loss by leaching, blowing or washing, and possible lowering of "condition" due to the destruction of organisms.

The above rotation is inexpensive of labor, and may prove profitable for grain-growing for a long time, on lands originally very fertile; but the fertility may be improved by the introduction of cover-crops and catch-crops, which will prevent possible losses of constituents, but which need not reduce the number of grain crops, and besides add one or more crops of hay. To accomplish this, the first crop (corn) may be seeded with the rye or wheat before, or immediately after, it is harvested. The rye will absorb and retain the nitrates formed in late summer and not used by the corn, and

Fig. 2. Harvesting a grain crop in the rotation.

also bind the soil and prevent the washing and blowing away of the finer particles in winter and spring, thus keeping the land in better condition for the oats crop, besides accumulating organic matter.

If either clover or the Essex rape is seeded with the oats, the land does not lie bare and exposed to the direct rays of the sun through the hot season, but is shaded with plants, which keep it cooler, and which are useful for pasture until it is time to prepare for wheat. The wheat crop is usually harvested early in July; if immediately afterward the land is thoroughly disked, and seeded with cowpeas, the land will again be covered during the hot months of July and August, and this will prevent, in large part, the possible destruction of bacteria, and at the same time make a crop of hay, which, under ordinary conditions of fertility, should yield from one to two tons per acre, and be harvested in time for seeding to timothy and clover. This better preparatory treatment of the land will encourage a better germination and more rapid growth of the crop in the fall. The crop will reach maturity at the usual time for hay-making, and since the object sought is the hay crop, and the land is entirely given up to this object, it is likely to make a better catch and be freer from weeds than if seeded with a grain crop. This method has proved to be entirely feasible in practice. With

but slight expense for labor and seed it makes possible a larger yield of forage in the same period and at the same time increases rather than reduces fertility.

When oats is not a profitable grain crop, the rotation may be changed so as to have two crops of maize in succession, a method which has been practiced with great success, particularly in the eastern parts of New York and Pennsylvania, and in New Jersey, Delaware, Maryland and parts of Virginia. This system requires that crimson clover be seeded in the corn at the last cultivation, which will make a crop of hay by the middle or latter part of May, or in time to plant corn again, which crop may be removed in time to seed to wheat. After harvesting the wheat, the land may be disk-harrowed and seeded with cowpeas or soybeans, which may be made into hay, and the land then seeded to clover and timothy as in the first example.

The value of the frequent introduction of cowpeas and soybeans, which not only keep the land occupied, but add to the forage capacity of the farm, can hardly be overestimated, as the land increases in productive value by the added crops of hay, and it is improved both because of the continuous occupation with crops, and the added nitrogen derived from the air; all this aids in the growth of cereals, and results in a larger pro-

duction of manure, due to feeding the extra hay. In these improved rotations, the same number of grain crops are secured, besides a crop of hay in the first year and two crops in the second year.

When wheat and corn are the main crops, as in Ohio, Illinois, Indiana and Iowa, the rotation may be improved, also, by seeding cowpeas or soybeans after the wheat is removed. After the hay is harvested, rye may be seeded, which covers the land in winter; it may be plowed down as a green crop for corn, and wheat be seeded after the corn. Hopkins, of the Illinois Experiment Station, suggests a four-year rotation of corn, wheat, corn and clover, including the cowpea or soybean as a catch-crop for hay, the legumes to be fed as hay or pasture, and the manure returned to the land. Or a five-year rotation may be used in which timothy is seeded with clover, and the land pastured the fifth year. These rotations greatly increase the possibilities of the land for hay-growing, while at the same time they prevent rapid exhaustion. These suggestions may undoubtedly be adopted with profit throughout the other corn-growing and wheat-growing states of the central Mississippi valley.

In the southern states, there has been a shortage of hay crops, because the tendency has been to grow cotton and tobacco continuously, or with only infrequent rotation when corn and cotton are raised. The advantages of the introduction of the

cowpea, soybean, vetch and clover in a rotation, and used as hay, are now recognized in part, and wherever used they result in largely increasing the amount of feed, without decreasing the total yield of corn, cotton or tobacco.

An improved rotation, recommended by the Alabama Station, is (first year) corn with cowpeas planted between the corn rows in May or June; second year, fall-sown oats or wheat, followed by cowpeas in June; third year, cotton. The cowpeas, after the crop of small grains is removed, are usually cut for hay, but may be picked for seed, or pastured, or plowed under in January or February.

In California, and a number of the northwestern states, continuous cropping has been generally practiced, although the desirability of rotation is becoming apparent, especially in connection with sugar-beet and wheat-growing.

The main point, in all rotations, from the standpoint of forage, is so to adjust the rotations as to keep the land occupied, without sacrificing in any great degree the number of cereal or root-crops that may be grown.

Land and seeding

Another important consideration which is beginning to receive the attention that the condi-

tions warrant, is the complex question of adaptation of soil, and its preparation, for different kinds of hay crops; for while many of the grasses and legumes may be grown successfully on a wide variety of soils, they are peculiarly adapted to certain specific conditions. Red clover, for example, will grow well on lands adapted to corn. Alsike clover will succeed on those that are colder and more compact and not so suitable for the red clover. Timothy is adapted to lands rich in humus, and to those which, because of their higher content of clay, are colder than those most suitable for clover. Therefore, mixtures of timothy, red clover and alsike are much safer than either one alone, under general conditions, because if the conditions are unfavorable for one kind they may be favorable for another.

In seeding any of these crops, the land should always be well prepared, which means not only that it shall be plowed and harrowed, but that it shall be worked frequently, so as to compact the soil and leave only the surface fine and mellow—the finer and mellower the better, except for soils that contain a high content of fine silt, in which case it is better not to make the surface too fine, else the land is likely to puddle and to become so hard as to prevent full germination and to retard growth. Seeding should be carefully performed. As a rule, too little seed is

used. However, when large quantities are applied, the importance of good preparation and fertilization is more imperative, because with a more complete occupation of the land, there is a greater call for plant-food and moisture. The quantities of seed to be sown will vary with the kind and the mixtures of seed and manures used, matters which are fully discussed in other chapters.

Harvesting and curing

Another matter of great consequence in the handling of forage crops, especially if the purpose is to feed them on the farm, is the time of cutting. The largest quantity of digestible matter usually is contained in the crop when it is in blossom, although it does not follow that the largest total yield per acre will be secured if cut at that time. In the harvesting of grasses for hay, whether they shall be cut at their best stage for feed depends on whether the purpose is to feed on the farm, or to sell, the markets demanding a more mature forage than is best for the purpose of feeding. The difficulties of harvesting are greater when hay is cut for home use than for the market, as, in the earlier stages of growth, there is a larger proportion of water in the plant, which requires more handling than when nearer ripe.

Clover should be cut in the morning, tedded thoroughly, and if possible raked into windrows the afternoon of the same day. If the day following is clear, the windrows may be thrown open and tedded in the morning early, then raked together and put in small cocks and allowed to stand over night; the following day they may be opened to the air, and dried further, and the crop housed. By this method, there is little danger of loss of leaves by handling, or of deterioration in quality, because of being exposed to sun and dew.

The hay made from grasses, when cut at the proper time, and well cured, is especially suitable for horses and cattle, and may be used as the main source of roughage for these animals. For dairy cows, fattening stock, sheep, swine and young stock of all kinds, the clovers or other legumes are much better adapted for growth and development than the grasses, as they contain a higher content of protein and mineral matter, in digestible forms.

A judicious introduction of the different crops into the various rotations, as outlined, will not only increase the possibilities for hay-growing, but will be an important factor in maintaining the fertility of soils, now so carelessly and wastefully managed.

CHAPTER III

FORAGE CROPS FOR SOILING

THE principles of feeding are the same whether animals are fed dried or succulent foods. That is, the relative values of the actual digestible nutrients are not changed, nor are the functions of the nutrients different in the one case from the other; yet, in comparisons that have been made of the feeding-value of nutrients contained in dry-forage rations with those in green and succulent forage, it has been found that a unit of digestible food of the same kind in the succulent ration has a greater efficiency than a unit of the same kind in the dry ration. This is thought to be due to the fact that a slightly greater expenditure of the total energy contained in the food is required in the utilization of a unit of food than of its equivalent in dry succulent food, with a corresponding increase in the net energy. This fact has a bearing on the question of soiling, because it enables the feeder to utilize more completely the nutrients that are raised on his farm. The same facts, however, apply in pasturing as well as in soiling, although, in the case of pasturing, animals do not always have at their command the ration in its best or most succu-

lent form, for many times it is partially dried and not very palatable. That is, it is not possible, in pasturing, always to control the conditions in such a way as to secure reasonable uniformity in the proportion of contained water, or in the kind and quality of the nutrients in the food.

BALANCED RATIONS

Another consideration in feeding, important from the physiological standpoint, is the proper relation of the kinds of nutrients to each other in any given food; from the economical point of view, this principle cannot always be applied in soiling systems, although it should always be considered.

It has been very clearly demonstrated that for the best results in stock-feeding, there should be a reasonably definite ratio between the digestible nitrogenous and the digestible non-nitrogenous nutrients. An excess of the nitrogenous nutrients usually causes a greater increase in the cost of the ration when feeds are purchased than when the carbohydrates, or non-nitrogenous nutrients, are in excess. In the case of crops suitable for soiling purposes, it is often quite as economical, or even more economical, to feed a ration richer than the standard in its content of digestible nitrogenous nutrients than to attempt to widen the ration by the use of carbohydrate feeds. This is due to the

fact that many of the crops that are suitable for soiling belong to the legume family, which are relatively richer in nitrogenous substance than the cereals; and, because these legumes do not need nitrogenous manuring, they may be more cheaply raised than others. It frequently happens, also, that many of the cereal crops, when in a fit condition for soiling, are more highly nitrogenous than when approaching maturity; and a larger use of this nitrogenous food would probably be quite as economical as if smaller quantities were used and carbohydrates purchased. Hence, in soiling systems, the observation of those laws which are frequently very potent in regulating the cost of nutrients per unit of product when dried foods are exclusively used, may be in part ignored.

A soiling system properly conducted requires a large number of crops, varying widely in their proportion of nitrogenous and non-nitrogenous nutrients. The land must be kept occupied; and a proper and self-sustaining rotation usually includes leguminous plants in order to maintain or increase the productiveness of the farm. If the feeder thinks that with every change of forage he would be required to change his feed ration, he might be deterred from adopting the system; but, as has already been pointed out, this change would not necessarily be required.

SOILING VERSUS PASTURING

The chief advantages and disadvantages of soiling, as compared with pasturing, have been pointed out by many writers, and special points are alluded to in succeeding chapters; but it may be well to consider the question briefly at this time, as the subject is not well understood, and its importance is not appreciated as it should be.

Among the advantages of the soiling system, the following are important:

1. A larger quantity of food may be secured from the same land under soiling systems than under pasturage. It has been shown by many careful experiments that one acre of land in soiling crops will maintain from two to four cows per acre during the growing season, or practically from May 1 to November 1 in the latitude of Pennsylvania.

2. The food may be made more uniform in quantity and in quality when cut and carried to the animals, and fed in the barn or paddock, than when the animals are allowed to select their own. Under exclusive pasturage systems animals are frequently unable to obtain a full supply; thus their food fluctuates both in quantity and quality, and the varying conditions do not permit of the full and constant flow of milk. Animals cannot be kept to their full capacity throughout the year unless they are uniformly and abundantly supplied with food.

3. Practically all the food can be made available for use, while systems of pasturing prevent the entire use of any crop, a large part of it being wasted by the tramping of the animals.

4. The expense of fencing is saved, and the land is more completely utilized. The only fences required on farms where soiling systems are followed are those around the exercising grounds. A five-acre exercising lot is ample for fifty to seventy-five head of cattle.

5. In the production of sanitary milk (that is, clean milk, free from taints, odors and flavors), the soiling system is much superior to pasturing, as the source of supply of food and water may be controlled. Under the soiling system, there is no necessity that milk at certain seasons taste grassy or garlicky or bitter, due to the consumption of various weeds, which are likely to be present even in the best of pastures. Furthermore, the animals do not have access to stagnant pools of water, which frequently contribute undesirable characteristics to the milk.

The disadvantages of the soiling system are chiefly two:

1. The greater expenditure for labor and expense in the preparation of soil, seeding and fertilizing in providing for the crop, and in cutting and carrying the food to the animals. In pasturing, the minimum of labor is required.

2. In wet spells, it is frequently difficult to harvest and cart the food to the animal, without injury to the land, and without reducing the palatability of the forage, although this also applies in part to pasturing.

COST OF NUTRIENTS IN SOILING CROPS

It is difficult to establish definite relations between the cost of food in soiling and in pasture, owing to the wide variety of conditions that occur. In the first place, in many soiling systems it is possible to utilize catch-crops (those grown between times, or incidental to other crops) at relatively little cost or to very great advantage. In other cases, in order that the continuity of supply of food may not be broken in complete soiling systems, it may be necessary to expend relatively large amounts for fertilizers, manures and seeds. On the other hand, in the case of the pasturing in many of the rougher sections of the country, land can be utilized that could not be profitably tilled, thus enabling the growing of suitable crops by the one system which would not be possible by the other. If land is expensive, and the markets for dairy products are good, the cost of nutrients per animal is relatively much less with soiling than with pasturage, largely because of the decrease in the capital necessary to provide the land.

A farmer having a one-hundred-acre farm could provide, under the soiling system, summer and winter roughage for fifty to seventy-five head of cattle. Under the pasturing system he would not have a sufficient area to provide more than summer pasture, as each animal would require about two acres; thus he would not be able to provide any forage for winter use. In other words, the soiling system virtually increases the efficiency of areas available for dairying from four to six times.

Under good systems of pasturage, it would require at least 100 acres to supply the pasture necessary for fifty cows, whereas by the soiling system 100 acres would be capable of providing food for 300 cows for the same period. All of the large dairies producing sanitary milk for the best city trade, and keeping from 50 to 500 cows, practice soiling and find it much more economical than pasturing; in fact, it would be practically impossible, in many instances, to conduct the business if pasture were the only source of summer succulent food.

EXPERIMENTS TO DETERIMINE THE COST OF NUTRIENTS

In experiments at the New Jersey Station on the yield and cost of nutrients in soiling systems, it was shown that, while both yield and cost varied

with the season and kind of crop, nevertheless the cost of dry matter in the various crops, not including the labor required to bring the food to the barn, averaged about $6.50 per ton, while the feeding-value of the dry matter was nearly as great on the average as that in fine feeds, which averaged over $20 per ton; and furthermore, that the yield per acre of dry matter ranged from three to four and one-half tons.

In these experiments the land was used, in many cases, for three crops, and in others for two; or, in other words, the soil was constantly occupied with growing crops. It is more than likely that the expense of growing these crops would be much greater in the East and South than in the richer lands of the Central West, because, in addition to the manures, it is usually necessary to apply commercial fertilizers in order to secure maximum crops.

ROTATION SYSTEMS

As already indicated, in soiling systems it is necessary, in order that the largest returns may be obtained and that a continuous supply of forage may be provided, to adopt systems of rotation that will result in the largest yield of food per acre. It is impossible to give rotations that are likely to be most useful for all conditions, as climate, season, and adaptability of crop, vary widely

in different localities; but in order to give an idea of how rotations work out, the record of one year's soiling crops at the New Jersey Experiment Station is here presented:

A Rotation of Soiling Crops Which Supplied Fifty Animals Six Months

Kind	Seed used (bushels)	Date of seeding	Period of cutting and feeding	Yield, tons
Rye, 2 acres	4	Sept. 27	May 1–7	9.4
Rye, 2 acres	4	Oct. 3	May 7–19	19.2
Alfalfa, 1 acre, first cutting	$\frac{7}{12}$	May 14	May 19–25	11.1
Wheat, 2 acres	4	Sept. 26	May 25–June 1	10.4
Crimson clover, 6 acres	$1\frac{1}{5}$	July 16	June 1–21	42.8
Mixed grasses, 1 acre			June 21–26	8.3
Oats-and-peas, 2 acres	4 3	April 2	June 26–July 4	12.4
Oats-and-peas, 2 acres	4 3	April 11	July 4–9	8.2
Alfalfa, second cutting			July 9–11	2.1
Oats-and-peas, 5 acres	10 7½	April 19	July 11–22	16.4
Southern white corn, 2 acres	½	May 2	July 22–Aug. 3	17.7
Barnyard millet, 2 acres	1⅜	June 19	Aug. 3–19	23.2
Soybeans, 1 acre	2	June 1	Aug. 19–25	8.8
Cowpeas, 1 acre	2	June 10	Aug. 25–Sept. 1	10.5
Cowpeas-and-kafir corn, 2 acres	2 1	July 10	Sept. 1–16	24.4
Pearl millet, 2 acres	¼	July 11	Sept. 16–Oct. 1	20.2
Cowpeas, 1 acre	1½	July 24	Oct. 1–5	8.0
Mixed grasses, 5 acres (partly dried)			Oct. 5–27	20.0
Barley, 2 acres	3½	Sept. 2	Oct. 27–Nov. 1	5.2
Total				278.3

The above crops supplied sufficient green forage for an equivalent of fifty full-grown animals from May 1 to November 1, fine feeds being used in addition as the animals seemed to require them. It will be observed that the average quantity of food consumed daily by each animal was 60.4

pounds. The number of acres was twenty-four, ten of which were used exclusively for forage crops, while the other fourteen were used only part of the season. The records for several years at this Station show that three and one-fourth cows may be kept on an acre for six months of the growing season.

Other combinations of crops, which may be applicable in other localities, are indicated in the following table:

ANNUAL YIELD OF ROTATING SOILING CROPS PER ACRE

No. of acre	Crops in one-year rotation	Approximate: Time of seeding	Approximate: Time of cutting	Yield per acre—tons
1	Rye and crimson clover	September	May 1–10	8.05
	Oats-and-peas	May 10	July 1–10	7.60
	Soybeans	July 10	Sept. 1–10	9.00
	Total			24.65
2	Wheat fodder	September	May 10–20	7.00
	Cowpeas	May 20	July 10–20	8.20
	Japanese millet	July 20	Sept. 10–20	7.00
	Total			22.20
3	Oats-and-peas	April 1	June 10–20	7.34
	Japanese millet	June 20	Aug. 1–10	8.73
	Barley-and-peas	Aug. 10	Oct. 10–20	6.03
	Total			22.10
4	Oats-and-peas	April 10	June 1–10	6.80
	Cowpeas	June 10	Aug. 10–20	8.20
	Barley-and-peas	Aug. 20	Oct. 20–30	6.30
	Total			21.30
5	Rye	September	May 1–7	9.60
	Cowpeas	June 10	Aug. 25–Sept. 1	10.50
	Barley	Sept. 2	Oct. 27–Nov. 1	2.60
	Total			22.70

ANNUAL YIELD OF ROTATING SOILING CROPS PER ACRE—Continued

No. of acre	Crops in one-year rotation	Approximate Time of seeding	Approximate Time of cutting	Yield per acre—tons
6	Rye	October	May 7–19	9.60
	Soybeans	June 10	Aug. 19–25	8.80
	Barley	Sept. 2	Oct. 27–Nov. 1	2.60
	Total			21.00
7	Crimson clover	July	May 20–June 1	8.00
	Corn	June 1	July 20–Aug. 1	9.56
	Total			17.56
8	Mixed grasses	September	June 20–30	7.00
	Corn	June 20	Aug. 20–Sept. 1	12.24
	Total			19.24
9	Rye-and-vetch	Sept. 10	May 10–19	8.60
	Corn	May 27	July 20–29	11.80
	Total			20.40
10	Rye	August	May 1–10	8.50
	Pearl millet	May 18	Aug. 8–15	15.10
	Total			23.60
11	Oats-and-peas	April 10	June 26–July 4	10.20
	Cowpeas	Aug. 1	Sept. 16–22	8.00
	Total			18.20
12	Oats-and-peas	April 21	June 29–July 6	10.20
	Flint corn	July 10	Sept. 22–30	11.00
	Total			21.20
13	Oats-and-peas	April 2	June 16–23	6.20
	Cowpeas-and-kafir corn	July 10	Sept. 1–16	12.20
	Total			18.40
14	Alfalfa—First year, two cuttings			8.00
	Alfalfa—Second year, four cuttings			20.21
	Alfalfa—Third year, five cuttings			26.60
	Alfalfa—Fourth year, four cuttings			21.70

In these schemes, when one crop is removed another is put in immediately. As the time of

seeding, as well as time of harvesting, varies greatly, the dates are of course only approximate.

In order that the land may be covered in winter, rye or wheat is seeded when the last crop is removed. To accomplish this in the case of Nos. 4, 5 and 6, rye is seeded with the barley or barley-and-peas, and it will usually grow sufficiently, after the forage is removed, to make a good cover for the winter.

It will be observed that in the rotations in the latter table, alfalfa is not included, although a small area was used in the rotation indicated in the previous table. Where it is possible to grow alfalfa, it would be quite unnecessary to use so large a number of crops. In fact, rye, crimson clover, alfalfa and corn would serve to provide practically a continuous supply of food, as the alfalfa will be ready for harvesting usually the fourth week in May, and the cutting can be so arranged afterward as practically to provide a continuous supply of forage until the middle of September. Alfalfa is one of the cheapest and most satisfactory crops that can be grown for soiling.

THE ROTATIONS MUST BE CAREFULLY PLANNED

It will be observed from a study of the tables of rotations that, in order to provide for a continuous supply of forage crops, careful plans must

be made beforehand, or a period will occur when there is a lack of sufficient food. In the central states, the period likely to be most difficult to fill is the latter part of July and early August, especially should the season be so dry as to prevent maximum growth. To avoid interruptions, it is necessary, therefore, to plant a larger area and plan for a greater quantity of food than would be requisite if normal conditions prevailed. It is also necessary, if the land is to be fully occupied and maximum yields secured, that care be taken to follow the schedule of seeding and harvesting very closely. A difference of two or three days in the time of seeding, especially in spring, will very often make a difference of ten days in the time of harvesting. This is particularly true in the case of oats and peas.

The period required for growing the crop to the proper stage, as well as the period during which crops may be useful for forage, will also vary to some extent; but if harvesting is begun early enough, as pointed out in the discussion of individual crops, the period of usefulness will range from six days to two weeks. For example, rye seeded at different times will in some seasons provide excellent forage for fully two weeks, while in certain other seasons, especially if the early season is dry and hot, profitable feeding cannot be continued for more than a week or ten days. The

period of successful feeding will also depend on the kind of crop. Corn may be fed for a much longer period than any other of the regular forage crops, while millet is not useful ordinarily for more than six days. All of these factors must be taken into consideration in making plans for a season, in order that the forage will be in the best condition for soiling, and that the land may be fully utilized for crops.

Many farmers using green forage crops for the first time make the mistake of waiting until the plant is too far matured before beginning its use. The result is that the food is not palatable, digestibility is reduced, and the milk flow is decreased, due not to the system of soiling, but to a lack of observation of the essential rules.

PLANT-FOOD MUST BE PROVIDED

Another point of considerable importance, and which is often overlooked, is the fact that in such intensive practice there is a greater demand for available food than when a period of rest occurs between the different crops. Therefore, it is essential not only that very careful cultivation shall be practiced, but that the land shall be well supplied with plant-food. In any system of rotation, it is desirable, also, that one crop each year shall be a leguminous crop, and also that the land shall

receive a dressing of manure once a year. In addition to this, the summer crops especially should be well supplied with phosphoric acid and potash.

At the New Jersey Station, nine acres were devoted to the growing of soiling crops, during a period of nine years, crops succeeding each other immediately, and the soil, instead of becoming less fertile, increased in productiveness, notwithstanding the continuous drain on the land and actual removal of large quantities of fertility constituents. This was undoubtedly due to extra cultivation, to manure applied once each year, to commercial fertilizers applied with the other crops, and to the further fact that the land was covered with some crop in winter. This practice of cover-cropping not only provided abundance of food, but prevented losses of constituents, as the land was not left bare in fall and winter.

PREPARATION OF LAND

In the growing of soiling crops under intensive systems, it is better, as a rule, to plow but once a year, preferably in spring. In the preparation of land for the other crops, it is advisable to use a cutaway harrow, thoroughly pulverizing the soil at a depth of three to four inches. The advantages of this method are that the cultivation conserves moisture should the weather be dry; while the

plowing causes too great loss of it, since it breaks the capillary connection with the lower layers at a too great depth from the surface. A dried-out plowed surface, not having proper connection with the lower layers, does not contain sufficient moisture to cause the rapid germination of seed and to provide what is necessary for immediate and continuous growth.

COVER-CROPS

To keep the land constantly occupied with growing plants is particularly important, both in the hot summer months and in fall and spring. The covering of the land in summer prevents the temperature from rising so high as to destroy the organisms in the soil, while the covering in fall and spring prevents the mechanical losses that occur from wind and rain, and by the carrying away of food in the soil-water. Owing to the fact that certain crops, as, for example, barley or late-seeded oats, are harvested too late to permit of seeding other cover-crops, it has been found practicable to seed either rye or wheat with the barley or oats; and the rye, if the nurse crop is removed by the latter part of October, will usually make growth enough in the central states to prevent the losses referred to, and to be used in spring for green manure or for forage, as may be most convenient.

FORAGE-CROP RATIONS

In the use of soiling crops, it is quite possible to have the green forage serve as the entire ration; although it is better, on the whole, that the soiling crop provide only the larger part of it, for the reason that in many cases the green crop contains such a small proportion of dry matter as to make it necessary for the animals to consume a too large bulk, even though it might be no greater than in pasturing in those periods when pasture grasses are growing rapidly and are very watery.

Experiments show that it is possible to use green forage exclusively, and, while the yield of product is less, the cost per unit is also less than when fine feeds are used in connection with it. It is largely a question as to whether the dairyman desires to keep his animals up to the full standard of production, by supplying in reasonable bulk sufficient amounts of digestible food in best forms, or whether he desires to secure his product at the lowest cost even though the total production is reduced. If it is cheaper for him to supply the animals entirely by means of forage crops, this is the practice for him to follow,—that is, cheaper in the sense that if the milk yield is less, the relative cost is also so much less as to enable him to secure a larger profit. These are matters that individual farmers must determine for themselves.

SUMMER SILAGE

In considering the question of feeding of cattle throughout the year with succulent food, the summer silo must be included. There is no doubt but that in many instances, and for many conditions, the summer silo would meet all the requirements of the dairy farmer for this particular form of food. The advantages of the silo are, chiefly, a saving of labor in the season when it is specially needed for other work, and providing a uniform food supply without regard to the character of the season.

Whether the use of the summer silo will result in materially reducing the cost of the ration, is a question that will have to be determined by the actual conditions on a particular farm. To judge from the reports on cost of silage, there would undoubtedly be a saving in actual cost of food, providing the silos were so constructed as to result in a minimum loss of dry matter. It must be remembered, however, that in the construction of a silo for summer use the surface areas of the silo should be less per animal than for winter silage, owing to the more rapid fermentation of the silage in hot weather. At least double the depth, or about four inches, should be removed daily, instead of two inches, as in the case of winter silage.

The use of a summer silo does not prevent the profitable production of other crops than corn. Frequently such crops as rye and crimson clover, when they are grown as catch-crops, have been successfully ensilaged in the spring for summer use.

With the use of the summer silo it would be quite possible to carry as many animals as by the soiling system, providing the rotations were so arranged as to permit of more than one crop per year on the same area (as, for example, rye, wheat and crimson clover), and if a large area of alfalfa were grown for hay to furnish protein for both winter and summer rations. The economics of the summer silo have not yet been fully worked out, but the question is one that has much promise as a means of reducing the cost of food, and of increasing the number of animals that may be kept on a given area.

CHAPTER IV

STRAW CEREALS AND GREEN-FORAGE GRASSES

All cereal or grain crops produce herbage that is acceptable and nutritious to animals. It is often allowable to grow such crops solely for the herbage, or forage, rather than for the grain. Such crops usually adapt themselves well to farming plans; or, rather, farming plans are likely to have been so formed as to adapt themselves to these common crops. In their ordinary relations, these crops are well known, and only a brief discussion is necessary to explain their forage crop cultivation.

Many of the regular hay crops can also be utilized to advantage for soiling and for other green foraging. The utilization of such crops for special purposes, when conditions are right, increases the productiveness of animals and also allows, in some cases, of a better system of handling the land. Two of the commonest of such grass crops are discussed in this chapter.

RYE AS A FORAGE CROP (Fig. 3)

Although not generally regarded favorably, rye is a valuable soiling crop, primarily because in

many states it is available for feeding earlier in the spring than any other crop suitable for the purpose. In the central states and the middle west, it is ready for use about the first of May, or at a time when pastures are too young to use and when some green crop is especially desirable. A

Fig 3. Rye, at best stage of maturity for soiling.

suitable variety of rye is one that makes a large growth of leaf, although any variety may be improved in this respect by proper seed selecting and manuring. The common winter rye is generally used, although Excelsior, Thousandfold and Giant are all desirable, since, in order to obtain a large yield of grain, there is a heavy leaf development.

In the southern states, and as far north as southern New Jersey, spring rye is frequently used as a forage crop, as well as for grain. This plant has not succeeded well as far north as central New Jersey, although fair crops have been obtained when the plant has been used as a grain crop. It does not possess any peculiar advantages, and is not recommended in preference to other spring-seeded crops, on which greater dependence can usually be placed.

When conditions are not favorable for soiling (to which it is best adapted), rye makes an excellent pasture; and while but one-third to one-half as much food is obtained as from soiling, it can be used through a longer period, provided it is not pastured too closely in its early growth. Pasturing is a favorite method of utilizing rye in many dairy districts, and the crop serves a most excellent purpose as a source of food as well as to protect the regular pastures from injury from too early use. If weather conditions are favorable later, a light

early pasturing will not seriously interfere with the maturing of the grain.

Another advantage of rye, which should not be lost sight of, is its usefulness as a cover-crop, not only in absorbing and holding plant-food, but in preventing the waste of soil by washing or blowing.

Rye can be seeded later in the fall than almost any other crop, and starts earlier in spring than most others. It will usually pay well to seed rye on raw ground as a cover-crop alone.

Rye can also be utilized for silage. It is not so well adapted for silage as corn, yet if allowed to head out fully before cutting and to wilt slightly before packing in the silo, it may be preserved without serious loss. Its food value in silage will also compare favorably with that in the green material.

Made in the proper way, rye hay is also a good means of utilizing the crop. It should be cut when at its best stage for forage, that is, before fully headed out, and cured in the usual way.

Soils, manures, and fertilizers for rye

When grown for forage purposes, the preparation of soil and the seeding are of great importance, as these points have a direct bearing both on the earliness and the yield, notwithstanding that

rye is a crop that makes a good growth in relatively poor soils. The land should be prepared in the same way as when the crop is grown for grain. Particular care should be exercised to make the surface soil very fine, in order that the feeding rootlets may readily occupy the entire area.

Manures should be used liberally for rye. If available, from six to eight loads of good barnyard manure should be broadcasted after plowing, and thoroughly harrowed into the soil. If commercial fertilizer is used, a mixture rich in phosphoric acid is especially recommended. A formula carrying

Nitrogen	3 per cent
Phosphoric acid (available)	8 per cent
Potash	4 per cent

is one in which the constituents are well proportioned; and its liberal use will very materially influence the character of the growth, not only in the fall, but in the following spring. The fact that fall-grown crops will store food in the tissue ready for elaboration in the spring makes it desirable that such crops as are intended for early forage shall make a vigorous growth in fall, in order that this appropriation of food may be accomplished to the best advantage, and that the spring growth may be early and rapid. Fertilizer should be applied at the rate of 200 to 400 pounds per acre, depending on the character of the soil. It may

be broadcasted before seeding or drilled with the seed.

In order to secure the best yield, the early growth should be stimulated, particularly with nitrogenous food ; therefore an application of 100 to 150 pounds of nitrate of soda per acre, broadcasted, usually about the first of April, is to be recommended. Experiments at the New Jersey Station show that an application of 150 pounds of nitrate of soda per acre has caused an average increase in yield of 37.6 per cent, besides giving the further advantage of lengthening the time during which the crop may be fed. This increase in yield is a very important consideration, because one of the strongest arguments in favor of soiling, as distinguished from pasturing, is that smaller areas are required to supply the needs of the animals; and there is thus great reason for proper manuring or fertilizing, since the larger yields result in decreasing the area required for producing the food for a definite number of animals. If possible, this application of nitrate should be made just preceding or after a rain, in order that the salt may be immediately dissolved and carried to the roots. In order to prevent injury, it should be applied only when the foliage is dry. The purpose is to get as much of the nitrogen into the plant as possible; thus it should be applied as soon as active growth begins, or when the plant

has resumed its vegetative functions. If applied earlier than this, the rate of absorption will be slower, and the danger of loss from leaching will be greater. The application may be made broadcast by hand, or with a good fertilizer distributer. As the nitrate is a heavy salt, and it is difficult evenly to distribute the small quantities usually recommended, it should preferably be mixed with some other substance, as plaster, bran, sawdust, or dry earth.

Seeding and harvesting

The quantity of seed will vary according to the character of the soil. Ordinarily, when rye is seeded for forage, it is desirable that it should be thick, even though under good appropriation of food the plants will stool largely. If the seeding is thick, the great number of shoots will thicken the forage and make it useful for a soiling crop for a longer period, because the finer the stem the longer will the plant remain palatable.

When grown primarily for forage, the quantity of seed should be greater than when the crop is grown for grain,—usually two bushels per acre.

The yield per acre, even under good methods of management, will vary widely, according to character of soil and season. The range is from four to twelve tons per acre. In experiments at the New Jersey Station, the average yield for seven

years has been seven tons per acre. The cost of seeding and fertilizing has been five dollars and fifty cents, making the crop one of the cheapest of those used for soiling.

In order that the best results may be obtained from the use of rye as a green forage crop, harvesting should begin as soon as the plant begins to head. At this period, the forage is very succulent, palatable and highly digestible. In the first feedings, smaller amounts should be used than are sufficient to supply the entire needs of the animal. If the plant is left until it is fully headed out before beginning to cut,—at which period perhaps the largest total amount of food would be obtained, —the time during which the crop may be used is very much shortened, and the usefulness of the crop, either as a source of all of the succulent food or as a supplement of pastures, is considerably reduced. Under average conditions, when the practice outlined here is followed, rye may serve to supply the herd with a palatable food for ten to twenty days, the period depending on the method of seeding and the character of the season.

If it is desirable to have a long period of feeding, the crop should be seeded at different times. The first seeding should be made in the middle states in August, and the second as late as the middle of September, or first of October. This later seeding will make a much less vigorous growth in fall, will

start later in spring and will therefore be ready for feeding a week or ten days later than that from the first seeding, and which has been stimulated as outlined.

Chemical composition of the rye crop

If the rye crop is used when in the best condition for forage, it contains a high content of water, or an average of only about 18 per cent of dry matter. In this stage of growth, the content of nitrogenous matter is relatively large, although it is not entirely organized into albuminoids. As the crop matures, the dry matter increases and the crude fiber and nitrogen-free extract increase relatively much more rapidly than the nitrogenous compounds, and the nutritive ratio is widened. The average composition of green rye and yield of nutrients are as follows:

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	81.95	. . .	. . .
Dry matter	18.05	361.0	2527.0
Ether extract	0.65	13.0	91.0
Crude fiber	4.29	85.8	600.6
Protein	2.13	42.6	298.2
Ash	1.36	37.2	259.4
Nitrogen-free extract	9.61	192.2	1345.4

A yield of seven tons, therefore, will furnish about one and one-fourths tons of dry matter, which will contain about 300 pounds of protein,

and nearly one ton of carbohydrates, including fiber; the total protein is practically equivalent to that contained in one ton of wheat bran, and the carbohydrates are equivalent to that contained in nearly two tons, but with a rate of digestibility much higher than for the bran. The relatively large yield of nutrients, together with the fact that the crop may be secured without large expense, and without interfering with the growing of other crops the same season, make rye a crop worthy of consideration. It is now chiefly grown in the northeastern states, but its area might be profitably extended.

Feeding rye

It is desirable in the beginning, and when the plant is in an immature state, to feed about one-half the quantity that the animals usually require, say thirty pounds per day, and by the third day increase it to fifty or sixty pounds for a 1,000-pound cow. Sixty pounds will supply about ten pounds of dry matter, or nearly one-half of the total required in a daily ration for a cow in full flow of milk. Larger amounts are often fed, but usually not to good advantage. Dairy animals are very fond of green rye, when cut at the proper time, and its feeding will always result in an increase in the flow of milk, due both to its succulence and to the fact that at the right stage of

growth for soiling it is very well balanced in its proportions of nutrients.

WHEAT AS A FORAGE CROP

Wheat can be successfully used for forage purposes. It will be ready for use usually as soon as the rye has reached the unpalatable stage. Wheat is not so economical as rye in many respects; the seed is more expensive, it is less hardy and thus liable to suffer greater injury from unfavorable weather conditions, and does not start so rapidly in spring. It also requires a richer soil for its best growth. As in the case of rye, when it is designed as a forage crop, either for soiling or for pasture, the crop should be seeded a little earlier than the usual time of seeding for grain, that is, not later than September 1 in the middle states.

Any variety that is well adapted for grain to the soil and climate of the given locality will be suitable for forage, although the kinds that make large straw,—and preferably beardless varieties, —are to be recommended.

Wheat also makes excellent pasture, and if managed carefully a large quantity of food may be obtained. Care should be used to prevent too close early cropping.

Wheat also makes a highly nutritious and palatable hay if cut when just in full head, and

carefully cured. In this way it is used with great satisfaction in many parts of the country.

Preparation of soil, and seeding

The land should be as thoroughly well prepared as in seeding for the grain crop. Land should be well cultivated, thoroughly firmed and the surface two or three inches made very fine, so as to provide conditions favorable for quick germination and the easy penetration of the fine rootlets.

When yard or stable manure is available, it is good practice to apply it broadcast on the surface at the rate of six to eight tons per acre, and thoroughly incorporate it with the surface soil. This may be reinforced by the application of 100 to 150 pounds per acre of dissolved bone; or, when the land is reasonably well supplied with nitrogen, the same quantity of acid phosphate may be used per acre. It is essential that an abundance of available phosphoric acid should be at the disposal of the plant in the early stages of growth. In the absence of home manures, an application of a fertilizer reasonably rich in nitrogen and phosphoric acid should be applied, as the principles indicated for rye hold true also in the case of wheat: that is, the plant, having an abundance of available food in the fall, will absorb it, and that which is not converted into plant substance will be retained, in part at

least, in the tissues and be ready for elaboration in early spring. A suitable application may be made of 300 pounds per acre of a fertilizer containing

Nitrogen	3 per cent
Phosphoric acid (available)	8 per cent
Potash	5 per cent

If wheat is sown primarily for forage the quantity of seed should be larger than when grain is the purpose, or at the rate of two to two and one-half bushels per acre. This is heavy seeding, but there should be no bare spots, and the plants should be so thick as to make the proportion of leaf large and the stems very small, and permit of a longer use as forage.

Value and yield of wheat

The wheat crop is at its best when just in full head, although its use should begin just as it is heading out. Wheat is superior to rye, as it can be fed for a longer period, and is usually more palatable. Wheat is also superior to rye because it contains more dry matter when in a condition suitable for soiling; therefore, a smaller amount will supply a larger quantity of actual nutrients. When just heading out, analysis shows it to contain on the average 23 per cent of dry matter, and in proportions of constituents such as to make the product a fairly well-balanced ration. In its more nearly matured state it contains a larger proportion

of digestible nitrogen-free substance than the rye. Owing to the fact that wheat contains more dry matter than rye, when at the best stage of growth, it can be fed immediately in the usual quantities without injury. From fifty to sixty pounds per day is the quantity most generally used.

The average yields per acre are slightly greater than for rye, due mainly to the fact that it can be cut at a later stage of maturity. Yields are much increased by a judicious top-dressing of nitrate of soda, as recommended for rye, the increase being usually greater than in the case of rye, because of the longer period in which the plants have access to the food previous to cutting,—rye having about a month for the absorption of the nitrate, whereas the wheat has from six to seven weeks. The average increase in yield from the application of 150 pounds of nitrate of soda per acre, at the New Jersey Station, was over 60 per cent.

Wheat is slightly less useful as a cover-crop than rye, because it usually does not make so vigorous growth in the fall, and starts off much less rapidly in the spring. Still, it has its use for this purpose, and one which should not be ignored. Wheat and rye, because of their early maturity, are especially suitable for supplementing early spring pastures. In fact, they are the only crops, except in the South, that possess this most valuable characteristic.

AVERAGE COMPOSITION OF FODDER WHEAT AND YIELD OF NUTRIENTS

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	77.30	. . .	. . .
Dry matter	22.70	454.0	3632.0
Ether extract	0.70	14.0	112.0
Crude fiber	5.90	118.0	944.0
Protein	2.40	48.0	384.0
Ash	1.80	36.0	288.0
Nitrogen-free extract	11.90	238.0	1904.0

Wheat well grown and cut at the right time, will yield more than rye, as high as twelve tons having been secured at the New Jersey Station. At an average of eight tons per acre, the nutrients will compare favorably with many of the more common forage crops on this basis of yield. The protein considerably exceeds that in an average crop of rye.

OATS AS A FORAGE CROP

Oats are also used as a soiling and as a hay crop, and are very well adapted for these purposes. The best soils are rich loams, containing an abundance of organic matter. Because of the season in which the plant grows, fertilizers should contain an abundance of nitrogen in an available form. When oats are used for forage purposes, the nitrogen may be used in greater excess than when they are grown for grain, as the stimulation of the plant will not result in injuring the quality

of the crop. The forcing of leaf and stem prevents normal ripening and encourages those conditions which are favorable for the attack of fungous diseases. The fertilizer should contain a large proportion of its nitrogen in the form of a nitrate. A good dressing should consist of at least

Nitrogen	12 pounds
Phosphoric acid (available)	20 pounds
Potash	10 pounds

Or, an application of 300 pounds of a mixture containing

Nitrogen derived from nitrate	4.0 per cent
Phosphoric acid (available)	7.0 per cent
Potash	3.5 per cent

It is well known that after the food in the seed is used by the plant, the crop does not grow rapidly. This is thought to be due in part at least to the absence at this season of available plant-food of the right kind, since liberal applications of nitrates and superphosphates seem to produce a continuous and rapid growth. That this suspension of the vegetative activities should be overcome in the case of forage crops is important, as it hastens the development and makes it possible to secure the crop at an early period.

When seeded primarily for forage, the quantity of seed should be greater than when sown together with peas. From two and one-half to three

bushels per acre are recommended. The thicker seeding causes a finer growth of stem and a greater proportionate growth of leaf, besides making the crop available for soiling purposes for a longer period.

Time of harvesting oats

The time of harvesting should be regulated by the development of the plant, which is at its best for forage when the oat grain is in the milk stage. At this period, the lower leaves are still green, and the succulence is maintained. At this time, also, the plant is richer in protein than either wheat or rye, and apparently the protein is much more digestible than in those crops. Cool, moist seasons are most favorable. Light, warm soils, which heat up readily, are uncongenial.

Yields and value

The yields vary widely, as the plant is very materially affected by seasonal conditions. The range is from four to ten tons per acre. The average content of dry matter is about 25 per cent.

The oat crop is also very useful for pasturage, and also for hay when cut at its best period of maturity for forage. The entire plant is much richer in digestible constituents than is timothy hay, and is peculiarly valuable in rations for dairy

cows. Therefore, if not needed for supplementing pastures, it serves an excellent purpose as hay for winter feeding.

COMPOSITION OF OAT FORAGE AND OAT HAY

	GREEN FORAGE Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	75.00	. . .	. . .
Dry matter	25.00	500.0	3500.0
Ether extract	0.92	18.4	128.0
Crude fiber	7.40	148.0	1036.0
Protein	2.25	45.0	315.0
Ash	1.65	33.0	231.0
Nitrogen-free extract	12.77	255.4	1787.8
	HAY		
Water	25.00	. . .	. . .
Dry matter	75.00	1500.0	. . .
Ether extract	2.76	55.2	. . .
Crude fiber	22.20	444.0	. . .
Protein	6.75	135.0	. . .
Ash	4.95	99.0	. . .
Nitrogen-free extract	38.31	766.2	. . .

Winter oats

In the southern states, and as far north as southern New Jersey, winter oats serve an excellent purpose as early summer forage. The advantages are chiefly that it serves as a cover-crop in the fall and winter, and saves time of seeding in spring. It should be seeded not later than the middle of September at the rate of two to two and

one-half bushels per acre. It thrives on soils well fertilized, as for wheat or rye. In spring it should receive a top-dressing of nitrate of soda of 100 to 150 pounds per acre.

The winter oats will be ready for harvesting a little earlier than spring oats. They should be harvested as other grains, in the milk stage, or just before hardening. The yield is usually not so large as for the spring oats, although when well suited to the soil and well fertilized, from six to eight tons per acre may be secured. This crop also makes an excellent hay if cut when at its best stage for soiling. It will serve a good purpose for late fall and early spring pasture. When used for this purpose, the land would be ready to plant to corn the latter part of May.

BARLEY

In the more northern of the eastern and central western states, barley is a most excellent forage crop. It is better suited for fall forage than for spring forage. It is similar to oats in its soil and manurial requirements. A rich, deep soil, containing an abundance of vegetable matter, is particularly well adapted to the crop. Its requirements in the way of nitrogenous manures are similar to those for oats; therefore, the recommendations for oats would apply equally well to barley.

Barley is particularly well adapted for late fall forage, as it is not injured by light frosts, as are oats. It may be seeded the middle of August, at the rate of two to two and one-half bushels per acre, depending on the character of soil, and will make a succulent forage after frost has killed the ordinary summer plants.

Its composition is similar to that of oats. If it has reached the heading stage, it will contain a high content of dry matter. It is richer than oats in protein. It is highly relished by all farm animals. Because of its season of growth, it is a very useful plant in the saving of regular winter forage materials. The yields run from five to seven tons per acre.

Barley also makes excellent late fall pasture. Of course the quantity of food secured by pasturing is much less than if the crop is harvested and taken directly to the barn or paddock for feeding. Owing to the fact that it matures late, it is not generally useful for hay.

ORCHARD-GRASS

Orchard-grass (*Dactylis glomerata*) is among the earliest grasses that are useful for soiling or for pasture. It possesses many valuable characteristics, and is worthy of more careful attention than is usually accorded it. Its chief advantage

lies in the fact that it is ready for use two or three weeks earlier than the grasses ordinarily grown; it is a plant, also, that makes a very heavy growth under good conditions of soil and season. It is not so suitable for sowing with grain as timothy and red top, and therefore the soil should be prepared with the idea of securing the largest stand of it growing alone.

Preparation of soil and seeding

As with other grasses, it is desirable that the preparing of land for orchard-grass should be carefully performed, and particularly that the surface should be well pulverized and a fine tilth secured.

The quantity of seed required will depend somewhat on the character of soil. It is not desirable to grow this grass for forage except on good soils, and then two bushels, or about twenty-eight pounds of seed, should be used per acre. Thick seeding is more likely to ensure a growth of fine small stems and leaves, which are very essential in the best use of all forage crops. If not sown thick enough, or if it is uneven, its natural tendency to grow in bunches or tussocks is encouraged, making a coarse, rank stem and leaf, which are less palatable and digestible. For forage purposes, seeding should preferably be made in late summer or fall,

For the eastern, middle or western states, from the middle of August to the middle of September is the proper time.

Manures and fertilizers for orchard-grass

Like other grasses, orchard-grass requires abundance of nitrogenous food, and therefore the promise of a crop is very much increased by the application of manures or fertilizers containing nitrogen at the time of seeding, and by top-dressings with nitrate of soda in the spring. The recommendations usually made for seeding down with grass in general, can be followed here with success, — to use eight to ten tons of yard manure per acre when it is available, thoroughly incorporating it with the soil previous to seeding. If such manures are not available, then an application is recommended of 300 to 500 pounds of a fertilizer containing

Nitrogen	4 per cent
Phosphoric acid (available)	8 per cent
Potash	8 per cent

The fertilizer should be applied previous to seeding, and well harrowed in. On most soils, it will also pay well to follow this in spring with a top-dressing of nitrate of soda, at the rate of 100 to 150 pounds per acre, applied as soon as the plants have begun their vegetative functions, usually dur-

ing the first half of April in Pennsylvania and Ohio.

Harvest and yields of orchard-grass

Under favorable conditions, plants of orchard-grass reach a height of three to four feet. The leaves are abundant and coarse, although they make a very palatable and nutritious food if cut at the right time, which is just as the crop is beginning to head. The plant hardens very rapidly after coming into head. It can be used for eight to ten days only, providing cutting begins early enough. In average seasons, in the middle states, first cuttings can be made the last week in May. Under good conditions of soil and season, the yield for the first cut will range from five to eight tons of green forage per acre.

Orchard-grass in bloom,— which is the latest period in its development when it can be used successfully for green forage,— contains about 27 per cent of dry matter. It is less nitrogenous than either rye or wheat; therefore, feed rations should be richer in protein than in the case of those two crops.

When cut at the usual time, if immediately top-dressed, either with yard manure or a fertilizer, a second cutting may be secured the same season. The yield of this crop usually will not be so large as the first cutting, although the treatment of the

crop and the character of the season will materially influence this point. If the season is good, the second cutting may be made in August, and a yield of four to six tons secured, and it will be quite as rich in dry matter as the first cutting; usually it will be richer in protein, as in the second crop the tendency to form stems is lessened.

Pasture and hay

When not desired as a green forage crop, orchard-grass may be pastured successfully, and if it is rather closely eaten, it is an excellent crop for the purpose. It should not be allowed to make too large growth before the animals are turned on, as it soon hardens and becomes unpalatable, particularly if the weather is dry. If cut just at the period of blooming, or even a little earlier, it makes good hay, and the largest quantity of palatable and digestible food per acre may be expected.

COMPOSITION OF ORCHARD-GRASS

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	73 0	. . .	. . .
Dry matter	27.0	540	5,400
Ether extract	0.9	18	180
Crude fiber	8.2	164	1,640
Protein	2.6	52	520
Ash	2 0	40	400
Nitrogen-free extract	13.3	266	2,660

An average yield of ten tons for the two cuttings will give for the season 5,400 pounds of dry matter, of which 510 pounds will be protein, while the content of crude fiber is relatively greater than in rye. The digestibility, therefore, is likely to be hardly as high as for rye, although no data on this point are recorded.

ITALIAN RYE-GRASS

Another grass that has received some attention as a forage crop, particularly for summer pasture and soiling, is Italian rye-grass (*Lolium Italicum*). This grass is native of Europe, and has been grown there for a long time. It is especially suitable for moist soils, or for soils that can be irrigated, and responds very profitably to the application of water or heavy fertilization.

Preparation of soil and seeding

The preparation of soil and seeding should follow the same lines as those suggested for orchard-grass. When seeded in the fall, great care should be exercised to ensure rapid germination and early growth.

From twenty to thirty pounds of seed should be used per acre, preferably broadcasted both ways by hand, and lightly covered with the harrow.

When there is not sufficient moisture to ensure an immediate germination, it is good practice to go over the soil with a light roller. This compacting of the surface will encourage the upward movement of water, and have a tendency to ensure quick germination and growth.

Yield and value of rye-grass

Rye-grass produces abundant leaves. It grows two to three feet high. It may be harvested in the eastern states by the middle of May or first of June. While the yield is usually not so great as that of orchard-grass, it grows much more rapidly, and when suitably manured will make two or three cuttings for soiling purposes in the same season. When an abundance of plant-food is available, very heavy yields are obtained, as high as sixteen to eighteen tons of green forage per acre having been recorded as the entire yield from three cuttings.

When in the best condition for soiling, or when just heading, rye-grass contains about the same amount of dry matter as orchard-grass, although it is richer in nitrogenous substance and poorer in crude fiber. It thus makes a more palatable and richer food than orchard-grass. It does not stand the northern winters well, and its best use in this country, except in the South, has been as an

annual, the land being re-seeded each year. It makes excellent pasture, relished by all stock, and yields an abundant crop of hay of good quality for dairy cows.

COMPOSITION OF ITALIAN RYE-GRASS

	Per cent.	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	73.2	. . .	. . .
Dry matter	26.8	536	6,432
Ether extract	1.3	26	312
Crude fiber	6.8	136	1,632
Protein	3.1	62	744
Ash	2.5	50	600
Nitrogen-free extract	13.3	266	3,192

The large quantity of dry matter, over three tons per acre (assuming an average yield of twelve tons), that may be obtained from a careful growing and handling, and its capability of being cut several times, make it a most desirable crop when the conditions favorable for its best development are present. In order that these large yields may be secured, however, it should not be allowed to ripen, but cut when in the blossom stage. After each cutting it should be top-dressed with fertilizers rich in nitrates, particularly on light soils.

CHAPTER V

MILLETS AND TEOSINTE

Among the summer-growing forage plants, the millets have long been prominent. There are several distinct kinds of millets, belonging to different genera of the grass family. The Barnyard millet is *Panicum Crus-galli*, an improved form of the common weedy barnyard grass. The Hungarian and German millets belong to the group of foxtail grasses of the genus Setaria or Chætochloa, a type of weedy late summer grass known as pigeon-grass and foxtail grass. The Pearl millet is a Pennisetum (*P. spicatum*). Another group of millets is of the genus Panicum (forms of *P. miliaceum*). The Broom-corn millet (not the same as the broom-corn grown for brooms) is of this species. The term Japanese millet is often used, but it has little significance for there are Japanese forms of several kinds of millets; it is oftenest used for the Barnyard group. It will be seen, therefore, that the term millet includes a number of plants very unlike botanically; but they are all similar in being grassy summer-growing plants suitable for haymaking as well as for green forage.

The millets belong to a group of crops that grow quickly, and are what may be termed "hot weather plants." They do not thrive in cool weather. They are useful as hay catch-crops, or as regular forage crops for substituting pastures, or for soiling. All the kinds of millet that have been tested possess valuable characteristics, although the recently introduced Japanese or Barnyard varieties are proving more useful for green-forage purposes than the older and better known kinds, largely because of more rapid growth and larger yields.

All the millets are native to the Old World, but the cultivated forms are cosmopolitan. In some countries, some of the millets are grown for the grain for human food.

BARNYARD MILLET (Figs. 4, 5, 6)

Of the oriental forms, the Barnyard millet has given the best satisfaction in the East as green forage. It grows very rapidly, and frequently reaches a height of four to six feet. When cut at the right time, it is a most excellent soiling crop, as it is succulent and palatable. Maximum crops can be secured only when there is present an abundance of all of the fertility elements in available forms. A crop of ten tons per acre of this forage removes large quantities of plant-food elements, practically all of which are absorbed from the immediate sur-

Fig. 4. Head of Barnyard millet

face and within a very short time. Experience in the growth of this crop has shown that the artificial fertilizers are quite as useful as yard manure. When manure can be obtained cheaply, ten to twelve tons per acre should be applied as soon as the land is plowed and thoroughly incorporated with the soil. In the absence of yard manure, a heavy dressing should be applied of a mixture of nitrate of soda, acid phosphate and muriate of potash, furnishing at least twenty-five pounds of nitrogen, twenty of available phosphoric acid and fifty of actual potash per acre. An increase in yield of 75 per cent has followed the application of 160 pounds per acre of nitrate of soda, making a very profitable gain from this practice. The nitrate not only supplies the needed nitrogen, but encourages a larger development and greater activity on the part of the plant, thus enabling it to secure a larger proportion of nitrogen from soil sources, which would be impossi-

ble to a plant of less vigorous growth. Since the crop is grown only during the hot summer season, when droughts are frequent, this practice of applying available nitrogenous food is very important.

Preparation of soil, and seeding

The preparation of land should be very thorough, the entire surface deeply cultivated, and the soil particles made as fine as possible in order to insure a ready absorption and retention of moisture, making conditions favorable for quick germination and rapid continuous growth.

The crop may be seeded from the middle of May to the first of July, either broadcast or in drills. When labor is expensive, and the soil is reasonably free from weeds, the broadcast seeding is recommended.

The quantity of seed to use ranges from thirty to forty pounds per acre, broadcasted, and from ten to fifteen pounds drilled.

Harvesting and yields of Barnyard millet

In favorable seasons, the crop will reach the cutting stage in fifty days, but if the season is dry and cold proper maturity will not be reached in two months or longer.

Fig. 5. Barnyard millet (*Panicum Crus-galli*)

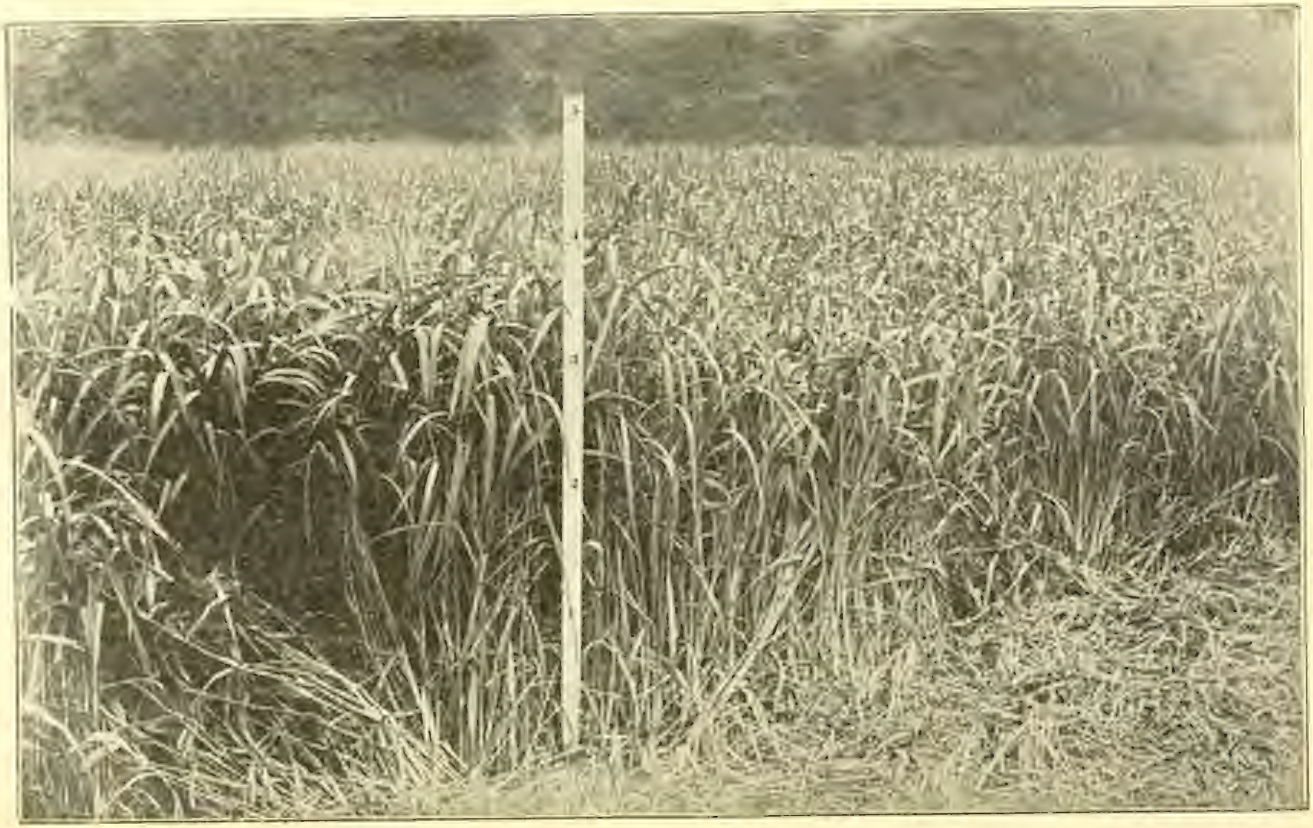

Fig. 6. Barnyard millet, ready for soiling forty-five days from seeding. Yield, fourteen tons per acre.

When used for soiling purposes, harvesting should begin when the plant is just beginning to show heads. At this stage, the plant is very succulent and is eagerly eaten by all farm stock. Inasmuch as it grows so rapidly, and because it develops and hardens so quickly in dry weather, it cannot be used for a long period for soiling purposes, from six to eight days being the range under ordinary seasonal conditions. Because proper attention is not given to this point, many farmers regard this kind of millet unfavorably. When cut at this stage of growth, Barnyard millet contains a relatively small percentage of crude fiber, although it is much richer in the non-nitrogenous substances than are oats, wheat or rye. It contains, on the average, about 15 per cent of dry matter. The large yields of green forage,—eight to twelve tons, or an average on good soils of about eight tons,—make the total amount of food very satisfactory; and animals will consume a relatively larger proportion of it than of certain other kinds. As high as seventy-five pounds per day have been fed with satisfaction.

For hay, Barnyard millet should be cut just as it is heading out. Although somewhat difficult to cure, it makes a forage which is very palatable and useful for winter feeding. Yields of hay have often reached as high as three to four tons per acre; but it is not recommended for hay-making

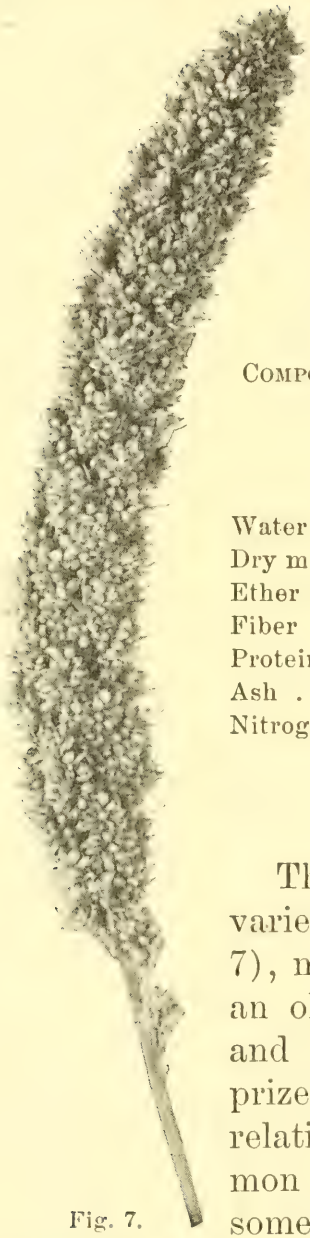

Fig. 7.
Common millet.
About natural size.

when other and better hay plants can be successfully grown. Farmers are too likely to defer cutting until the stalks begin to harden, when the hay made is unpalatable, even though well cured.

COMPOSITION AND YIELD OF NUTRIENTS OF BARNYARD MILLET

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	84.76	. . .	. . .
Dry matter	15.24	304.8	2438.4
Ether extract	.45	9.0	72.0
Fiber	4.50	90.0	720.0
Protein	1.50	30.0	240.0
Ash	1.63	32.6	260.8
Nitrogen-free extract	7.16	143.2	1145.6

FOXTAIL MILLETS (Figs. 7–10)

The foxtail millets are of several varieties. The common millet (Fig. 7), much grown in this country, is an old standby for summer forage and catch-crop hay, being much prized for its quick growth and its relatively fine soft hay. This common small millet is regarded as somewhat representing the original form of the foxtail millets (*Chæto-*

chloa Italica; or *Setaria Italica* of some botanies). By some authorities it is regarded as a developed form of the common weedy green foxtail grass (*Chætochloa viridis*), itself an introduction from the Old World. The German millet is a larger and bushy-headed dark-colored form (Fig. 8). The Hungarian millet or Hungarian grass (*Chætochloa Italica*, var. *Germanica* Fig. 9), is much like the common millet, but is somewhat taller, more branching, the head usually not nodding and compact. Golden Wonder millet (*C. Italica*, Fig. 10) is a very robust form, reaching six feet, and with compound, drooping, tawny or purplish heads sometimes a foot long. The four foxtail millets above mentioned are the ones that are best known. Except in time of maturity and yield, they do not differ greatly in agricultural value.

Fig. 8. German millet. Nearly natural size.

Hungarian millet grows very quickly and is very useful for supplementing a shortage in the regular hay crop, or for supplying the dairy herd with green forage, although not so desirable as the Barnyard millet. The German and Golden millets usually make a larger yield than the Hungarian, require a little longer time for growth, and should not be seeded later than the first of July.

In all these varieties, the quantity of seed to sow is about one bushel per acre. The practices recommended for Barnyard millet in preparation of soil, use of fertilizers and manures, and time of harvesting, should be adopted. All varieties of millet are surface feeders; large crops will absorb all of the available plant-food, leaving the land in poor condition for crops following the same season. The time of cutting is especially important, as too complete maturity results in poor and unpalatable hay.

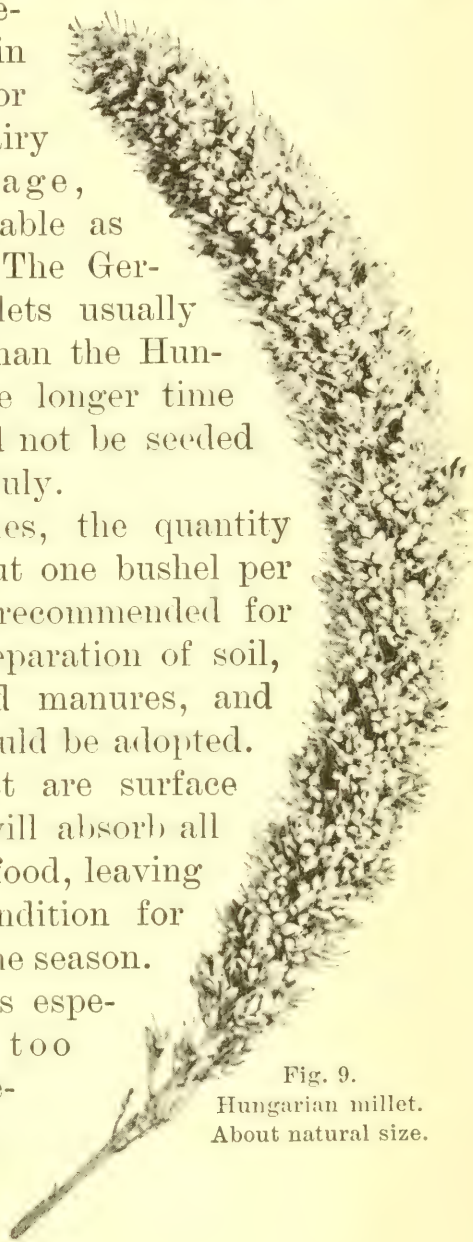

Fig. 9. Hungarian millet. About natural size.

COMPOSITION AND YIELD OF NUTRIENTS OF HUNGARIAN MILLET FORAGE AND HAY

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	71.10	. . .	. . .
Dry matter	28.90	578.0	3468.0
Ether extract	.70	14.0	84.0
Fiber	9.20	184.0	1104.0
Protein	3.10	62.0	372.0
Ash	1.70	34.0	204.0
Nitrogen-free extract	14.20	284.0	1704.0
	HAY		
Water	7.70	. . .	. . .
Dry matter	92.30	1846.0	. . .
Ether extract	2 10	42.0	. . .
Fiber	27.70	554.0	. . .
Protein	7.50	150.0	. . .
Ash	6.00	120.0	. . .
Nitrogen-free extract	49.00	980.0	. . .

Properly made millet hay of the above varieties is nutritive and palatable, the average composition showing it to be richer in protein than timothy.

The uses of the foxtail millets in New York are described as follows by Roberts and Clinton (Cornell Bulletin 135):

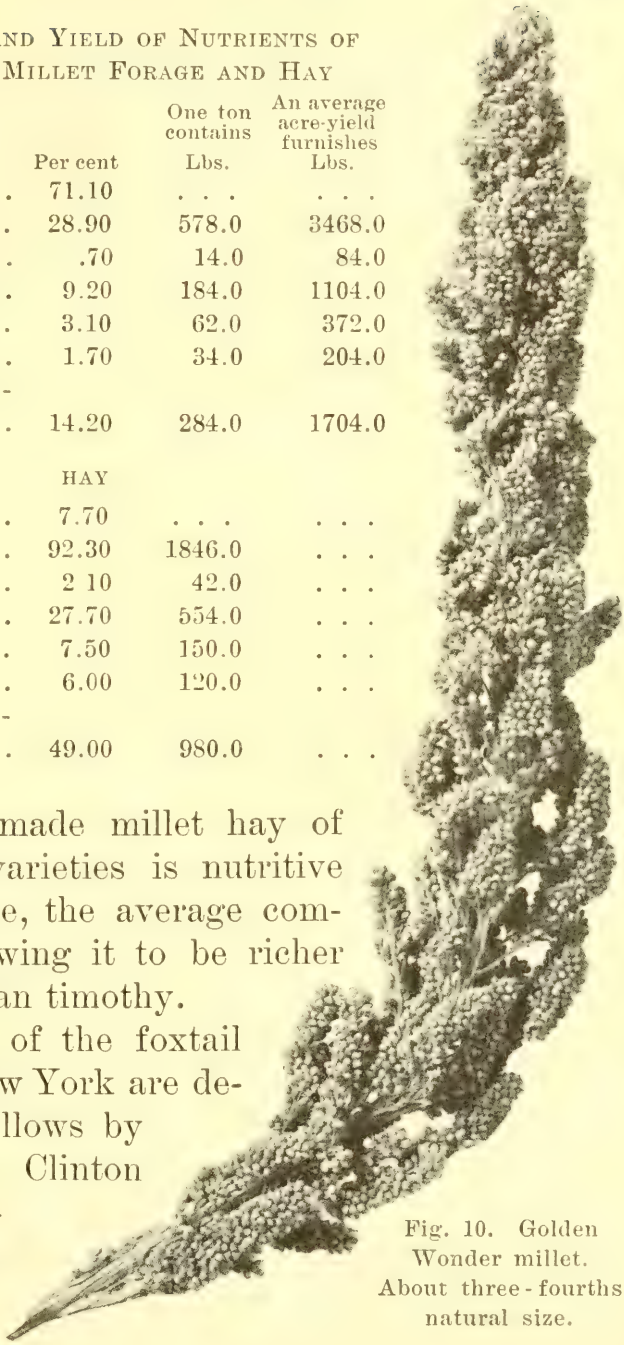

Fig. 10. Golden Wonder millet. About three-fourths natural size.

"They are not recommended as being valuable as a part of the regular rotation, but as catch-crops or special crops they have their place. They are very depleting to the soil and many have had unsatisfactory experience in feeding them to stock. . . . One value of millet lies in the fact that it can be sown late; in fact, it must not be sown until all danger from frost is over. It develops rapidly, and during midsummer is ready to begin cutting for forage about thirty days from time of seeding. The Hungarian is quicker maturing than the others and for late sowing is preferable to either the common or the German millet. In such a year as 1894 or 1895, when many farmers found their hay crop a disappointment and were at a loss to know how to supplement it, Hungarian or other millets would possibly have served the purpose well.

"The soil should be rich and given thorough preparation. Clay soils which are inclined to be lumpy require extra precaution in fitting. The amount of seed required varies from one-half bushel to three pecks per acre, which should be harrowed in lightly and rolled. On freshly cleared or bottom-land soils it makes a rank growth and is available for forage at a time when it is usually found necessary to supplement the pastures. Though it is a gross feeder, yet this fact may be of actual benefit to the kinds of soil just mentioned.

"When stock is turned in upon a field of green

millet for the first time, or a heavy feed is given, there is danger that serious results may follow. Animals not accustomed to green forage should not at first be allowed a full feed of any green crop, especially millet, but should be given only a part ration of the green material. If allowed to gorge themselves, serious results may follow. If it is desired that the animals be turned upon the crop to pasture, this should be done only after their appetite has been partly appeased by other food.

"Millet hay is not in popular favor, owing to the fatal results which, in some cases, have followed its use. Just why these unsatisfactory results sometimes follow does not seem to be clear. In feeding it to horses, caution should be observed and the millet hay used in conjunction with some other coarse fodder. Much of the value of millet hay seems to depend upon the time of cutting, which should be done soon after blossoming."

PEARL OR CAT-TAIL MILLET (Fig. 11, 12)

This millet is highly recommended over a wide range of country. It is a summer plant, a rank grower, attains a great height when mature,—seven to nine feet,—and produces an enormous quantity of forage. The Penicillaria and Maud's Wonder millets are of this same species (*Pennisetum spicatum*).

Manures and fertilizers for Pearl millet

In order that a large yield of succulent forage may be secured, Pearl millet should be grown only on naturally rich lands, or on those heavily manured or fertilized. The soil should be thoroughly and deeply prepared, for, although it is a surface feeder, the roots more completely occupy the soil than is the case with the Barnyard or other kinds of millet. The manures should be broadcasted, previous to seeding, at the rate of ten to twelve tons per acre. Fertilizing should follow the recommendations made for Barnyard millet.

Amount of seed and method of seeding

The quantity of seed required is relatively small, as the plants possess the branching habit. If planted in rows to allow of tillage, three feet apart, one pound of seed will be sufficient for an acre. This will provide a seed every three or four inches in the row. If broadcasted, three or four pounds per acre will be sufficient. Pearl millet germinates quickly, and grows very rapidly. It withstands drought well. It should be tilled, the surface being kept constantly stirred, if best results are to be had, particularly in dry seasons. Pearl millet is frequently grown with vining varieties of cowpeas, the stalks making a good support for the peas.

Fig. 11. German and Pearl millets, seeded on same day. German millet to the left, Pearl millet to the right.

Yield and value of crop

The largest yield of palatable and digestible food will be secured if Pearl millet is cut just as it begins to head. This stage will be reached in about three months from time of seeding; that is, if planted early in June, it will be ready for the beginning of harvest the latter part of August or first of September. It should not be allowed to head out fully before cutting, because the plants rapidly increase in crude fiber as the heads begin to form, and soon become hard and unpalatable. The yields vary widely, ranging from eight to over twenty tons per acre, the latter figure being reached when all soil and seasonal conditions are favorable, and when the crop is allowed to mature.

For the eastern and central states Pearl millet does not possess advantages over the Barnyard millet, except possibly in its yield, although the larger yield requires a longer period of growth. For a catch-crop it is not so desirable as the Barnyard millet. If cut just before heading, it is said that it will make a very rapid second growth, which may be harvested in a month to six weeks. The experience gained in the eastern and middle states does not confirm the advantages of this practice, for, while the plant makes a considerable second growth, it is not large enough ordinarily to pay for the use of the land. Farther south this

practice may be found to be more successful. If cut after making a growth of three or four feet, it might make a profitable second crop, the total crop being much larger than the larger first regular crop and the smaller second one. Much has yet to be learned concerning the best method of handling this plant.

When in the best condition for feeding, Pearl millet contains a relatively low content of dry matter. Analyses of crops grown at the New Jersey Station showed an average of but 17 per cent of dry matter, with a much higher content of crude fiber than in Barnyard millet. It may be fed in the same way as Barnyard millet, however, both as regards the method and the amount. While Pearl millet has been recommended for hay and for silage, it does not possess any superior qualities for these uses, corn being a much superior plant, both from the standpoint of palatability and yield of digestible material per acre. In the more southern states, and in the semi-

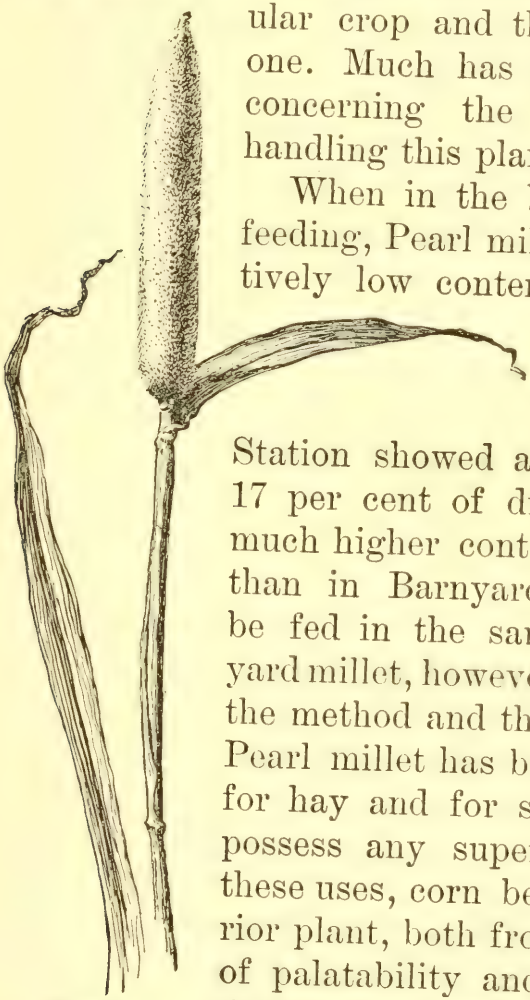

Fig. 12.
Pearl millet (*Pennisetum spicatum*)

arid parts of certain of the western states, the plant is very highly recommended, because of its adaptability to the longer season and hotter weather.

COMPOSITION AND YIELD OF NUTRIENTS IN PEARL MILLET WHEN SUITABLE FOR SOILING

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	83.04	. . .	. . .
Dry matter	16.96	339.2	2713.6
Ether extract	.37	7.4	59.2
Fiber	5.45	109.0	872.0
Protein	1.13	22.6	180.8
Ash	1.73	34.6	276.8
Nitrogen-free extract	8.28	165.6	1324.8

BROOM-CORN OR PROSO MILLET (Figs. 13, 14)

The Broom-corn or Panicle millets (*Panicum miliaceum*) is not widely known as a farm crop in this country, as it is not so useful as the foxtail millets. It produces heavily of seed as well as of forage, it matures in a short season, and it seems to be able to withstand dry weather; for these reasons it is somewhat grown in the northern parts of the semi-arid regions, where its grain may be substituted for corn. There are several varieties, distinguished more or less by the color of seeds. This plant seems to be the millet of history, and it is more popular in Europe than here.

Broom-corn millet was included in an experiment at the New Jersey Station that was designed to test the value as forage of a number of plants not commonly used in the East, and to compare their yield, composition and usefulness with those generally grown. Broom-corn millet produced a large stalk, with but little foliage, and when fed at the time that it seemed most useful for this purpose (just when headed out), it was found to be unpalatable, more than one-half being uneaten. In composition, it was superior (in yield of dry matter) to all of the other kinds grown at that time, including several varieties of maize, kafir corn, millet,

Fig. 13. Broom-corn millet (*Panicum miliaceum*).

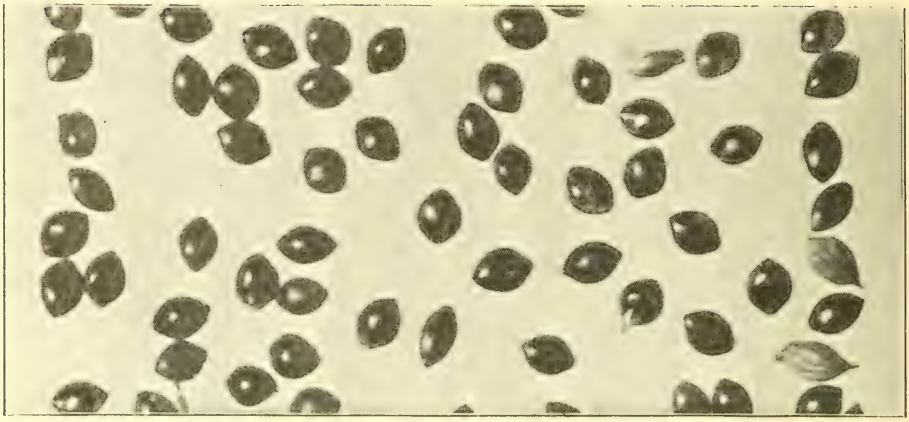

Fig. 14. Seeds or grains of Broom-corn millet.

sorghum and teosinte. The yield was sixteen and two-thirds tons of green forage per acre, which contained 7,637 pounds of dry matter, or practically twice as much dry matter as was contained in the yield of either red or white kafir corn. Its composition was such as to furnish nearly 700 pounds of protein per acre, or more than any other of the plants generally grown, and again more than twice as much as the kafir corn.

From the standpoint of yield of dry matter and of total nutrients, the Broom-corn millet compared very favorably with the varieties of maize usually grown for forage, yet because of lack of palatability it could not be used for the purpose. It possesses promising characteristics, in particular its power of gathering plant-food; and further experiments may show it to be a valuable plant for silage in regions where corn does not develop.

Fig. 15. Teosinte. Note the branching or bushy habit of the plant.

TEOSINTE (Fig. 15)

This plant is similar in general habit to millet, but differs in its tendency to stool. It belongs to a wholly different species (*Euchlæna*, or *Reana*, *luxurians*) from the other crops discussed in this chapter, but it is so much like millet in its cultural requirements and in its uses that it may be discussed with them. By some it is suggested as the original of Indian corn. A single plant of teosinte will branch and make a very large number of different plants. So far as plant-food is concerned, teosinte makes the same requirements as the other very rapid-growing summer plants. Teosinte should be planted in rows about three feet apart, and tilled. Three pounds of seed per acre is sufficient. It is adapted only to the far South.

Yields as high as twenty-four tons per acre have been secured, although, because of the low content of dry matter, the yield of actual nutriment is very much less than from ten tons of corn.

	Per cent	One ton contains Lbs.
Water	90.13	. . .
Dry matter	9.87	197.4
Ether extract	0.34	6.8
Fiber	2.69	53.8
Protein	1.42	28.4
Ash	1.36	27.2
Nitrogen-free extract	4.06	81.2

CHAPTER VI

THE KAFIR CORNS AND DOURAS

THE genus Sorghum, one of the grass family, contains three rather distinct classes of plants: (1) The sweet or saccharine forms, the plants usually known as "sorghum" among farmers; (2) the non-saccharine fodder sorghums; (3) broom-corn (wholly distinct from the broom-corn millet described in the last chapter). All these various sorghums are considered to be forms of one variable species, *Sorghum vulgare* or *Andropogon Sorghum*, native to the Old World.

The non-saccharine fodder sorghums include all the douras (spelled also dhoura and durra), Egyptian corn, milo maize, kafir corn. There is no one name that is now used to designate this group, but kafir corn is now best known and is thought by some to be destined to become the popular class name, although doura is the oldest and most attractive name. The kafir corns bear a contracted dense panicle or head, in distinction from the long, wisp-like heads of the broom-corn; some of the sweet sorghums bear drooping heads, but they are chiefly distinguished by their sweet juice. Of the kafir corns there are two groups, —kafir corn proper, with erect, rather long heads

Fig. 16. Black-hulled White kafir Corn.

and not flattened seeds; and douras proper, with hanging or recurved short and compact heads and flattened seeds. Jerusalem corn and Yellow milo maize are douras. White milo maize belongs to the kafir group. Some of the forms are distinguished in Figs. 16 to 21 (all figures in this chapter except Nos. 19, 22 and 23 are from Kansas Experiment Station photographs). The grain in the heads of the kafir corns is useful, as well as the fodder, but it is not the purpose of this book to discuss the grain production. Forms of doura and kafir corn have been known in this country for many years, but it is only recently that they have come to have real agricultural importance, due largely to their adaptation to the hot and dry regions of the western country.

Kafir corn is a valuable plant for dry hot countries, and also for the East, since it is a rapid grower, producing a large number of wide, luxuriant leaves that are extremely palatable. It serves an excellent purpose for seeding with such leguminous crops as cowpeas, serving as a support for the pea, aiding thereby to produce a much larger yield of food of higher quality than if either were seeded alone. Plants of the same nature are Jerusalem corn, Rural Branching doura, Yellow Branching doura or milo maize, and Evergreen broom-corn.

The seed of all these plants is similar to that of sorghum and may be similarly treated. It may be

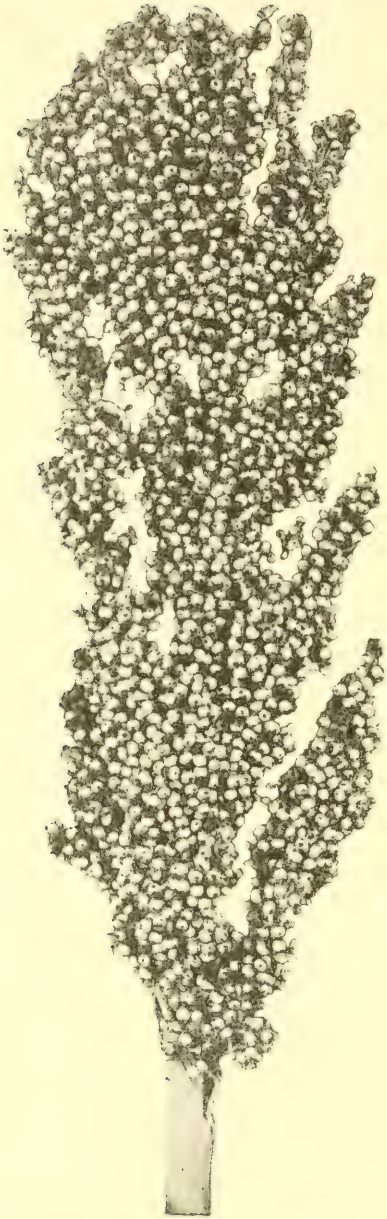

Fig. 17. Typical head of Black-Hulled White kafir Corn.

sown broadcast at the rate of four to five pounds per acre, or planted in rows and cultivated as for Indian corn; the latter is the better method when large yields are desired.

Kafir corn is similar to sweet sorghum in habit of growth. It grows from five to seven feet high, with a stalk much like corn. The leaves are heavy and somewhat stiffer than those of corn. They run from one to two and one-half feet long. The grain appears on a head that reaches a length of twelve to sixteen inches; but these heads are compact, and do not spread out, as in the sweet sorghums; on the mature head there is no stem in sight, except at the base, the grain only being visible.

The different kinds of

this class of plants should be seeded the latter part of May or first of June. They will make a crop ready for harvesting in two to two and one-half months. For green forage they should be cut as they are just coming in head, in order to secure the best yield of succulent and nutritious food. They harden rapidly after seed begins to form. In the western states, these plants are largely grown for the grain, the ground meal making an excellent substitute for corn meal. While the dried fodder or hay makes a good forage, it possesses no advantages in humid climates over crops that are better known and more easily handled, as, for example, corn. In regions of little rainfall, these crops are of unusual value.

COMPOSITION OF KAFIR CORN AND ALLIED PLANTS WHEN SUITABLE FOR SOILING

Kind	Water	Fat	Fiber	Protein	Ash	Nitrogen-free extract
	%	%	%	%	%	%
Red kafir corn	81.64	0.63	4.81	1.81	1.32	9.79
White kafir corn . . .	83.44	0.65	4.57	1.88	1.44	8.02
Rural Branching doura .	85.89	0.38	4.71	1.74	1.26	6.02
Evergreen broom-corn .	77.08	0.49	8.58	2.02	1.69	10.14
Yellow-branching doura, or milo maize	83.19	0.57	5.51	1.70	1.49	7.54
Early Leaming corn . .	76.43	0.64	4.93	1.89	0.96	15.15

The above analyses are of plants grown at the New Jersey Experiment Station. For comparison, Early Leaming corn was planted at the same time, and under the same conditions of soil and manage-

ment. The crops were cut when in best stage for soiling, and, with the exception of the Evergreen broom-corn, were palatable and readily eaten by regularly soiled dairy cows. It will be observed at once that, with the exception of the Evergreen broom-corn, all the crops showed a much lower content of dry matter than field corn.

NUTRIENTS PER ACRE IN AVERAGE CROPS

Kind	Yield per acre Tons	Dry matter Lbs.	Protein Lbs.	Fat Lbs.	Fiber Lbs.	Nitrogen-free extract Lbs.	Total nutrients Lbs.
Red kafir corn . . .	8.34	3,062	302	105	802	1,633	2,842
White kafir corn . .	8.68	2,875	326	113	793	1,392	2,625
Rural Branching doura	15.53	4,383	540	118	1,463	1,870	3,991
Evergreen broom-corn	16.66	7,637	673	163	2,859	3,379	7,074
Yellow-branching doura, or milo maize	19.55	6,573	665	223	2,154	2,948	5,991
Early Leaming corn .	15.26	7,194	577	195	1,505	4,624	6,900

In this table is shown the yield per acre as well as the actual nutrients produced. It will be observed that the Yellow Branching doura gave the largest yield of total fodder, and the Red kafir the lowest; the Evergreen broom-corn showed the largest yield of dry matter, and the White kafir the lowest; the Early Leaming corn showed the next largest yield of dry matter, and a much lower content of crude fiber than the Evergreen broom-corn. The yield of dry matter, excluding fiber, was 5,690 pounds for the Leaming corn, and 4,779 for the Evergreen broom-corn, a gain for the Leaming of

911 pounds, or 19 per cent. On the dry matter basis, therefore, the only variety that at all compared with maize was the Evergreen broom-corn, which is very inferior in palatability and digestibility. The kafir corns are not comparable with corn on the basis of yield of nutrients, and are not to be recommended except as substitutes for corn in climates too dry for the latter.

One point should not be lost sight of with all these quick-growing summer crops, — they are relatively exhaustive of the available plant-food in the surface soil. For example, a crop of eight tons of Barnyard millet, which fairly represents this group of forage crops, will remove from an acre in fifty to seventy-five days in round numbers

50 pounds of nitrogen,
26 pounds of phosphoric acid, and
104 pounds of potash.

The same yield of maize will remove from an acre in eighty to one hundred days only

Fig. 18. Typical head of Red kafir corn

Fig. 19. Yellow milo maize, one of the doura group.

45 pounds of nitrogen,
20 pounds of phosphoric acid, and
50 pounds of potash.

This is 10 per cent more nitrogen, 30 per cent more phosphoric acid and over 100 per cent more potash removed by the special crops than by the corn. The land, therefore, is more rapidly and completely depleted of its available plant-food by these summer-grown plants; and this accounts for the fact that they cannot be successfully grown on poor soils, and that subsequent crops, that have apparently less ability to appropriate plant-food, cannot be successfully grown without liberal manuring or fertilizing. These characteristics should be always taken into consideration when substituting this class of crops for corn in forage crop rotations.

KAFIR CORN FOR DRY REGIONS

It has been said that the non-saccharine sorghums are

especially adaptable to semi-arid and hot regions. It may be well, therefore, to present a brief account of these plants to show their value for the interior western country.

The results of experiments at the Kansas Experiment Station are probably applicable for those regions in which the crop is a prominent one, and a brief résumé and adaptation of the report of Professor J. G. Haney,[1] of that Station, comprises the remainder of this account of kafir corn.

Varieties for dry regions

There are many varieties of the non-saccharine sorghums, but only three that have come under the name of kafir corn. The name kafir comes from the name of a tribe of natives of South Africa, whose country is known by the same name of kafir. Kafir corn is sometimes known as African millet. The three varieties which have received most attention are, in the order they were introduced: (1) The White, (2) the Red, and (3) the Black-hulled White. The last may be easily distinguished from the first by noticing that the chaff or hull which partly envelops the grain is black, while in the first the chaff or hull is nearly the color of the grain; hence, the first is called White and the last Black-hulled White. In the Red, the

[1] Forage and Fodders, Kansas State Board of Agriculture, Report for 1900.

color develops as the seed matures, and at maturity is very nearly a brick-red. The kafirs should not be confounded with their sisters—Jerusalem corn, milo maize or rice-corn.

All the varieties of the non-saccharine sorghums that will mature in Kansas have been tested side by side. For the extreme northwestern counties of Kansas, observation shows that kafir corn is not so well adapted as Jerusalem corn or rice-corn. The altitude being high, the short seasons and cool nights seem to affect the kafir corns so that they often will not mature seed. Although they always make fodder, and sometimes a good crop of seed, they are not so reliable as the others. The White kafir corn with some is the favorite for fodder, and all varieties have their admirers, but at the Kansas Station all have been abandoned for the Black-hulled White. It has proved the heaviest yielder in both grain and fodder, and if there is any difference between it and the Red for resisting dry weather, it is in favor of the Black-hulled White. There is a greater difference between the Red and the White in these respects than between the Red and the Black-hulled White.

For the first seven years the Red was grown. The Black-hulled White was then tested, and from 1896 to 1898 the two varieties were grown side by side, the Red giving an average yearly yield of thirty-seven bushels per acre, and the Black-hulled

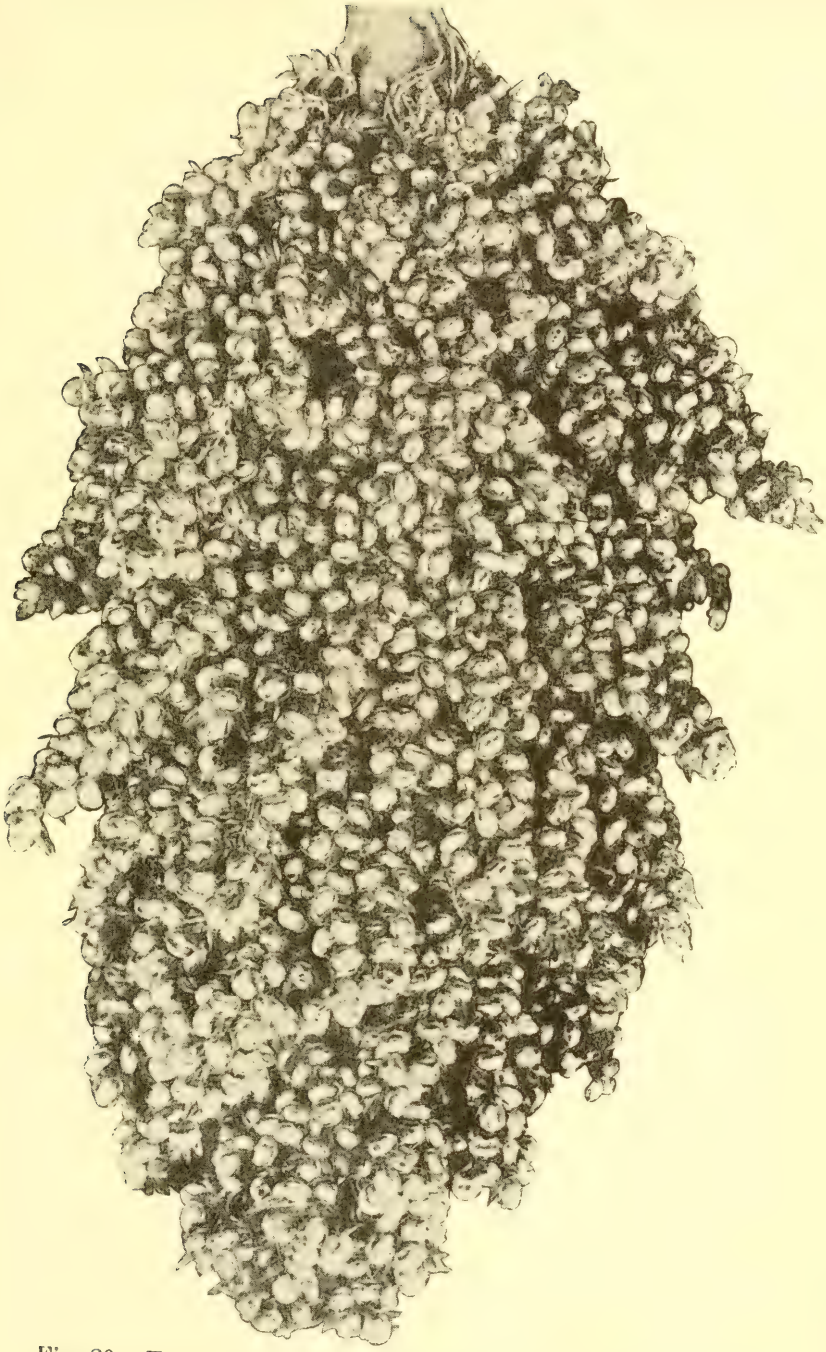

Fig. 20. Typical head of Dwarf milo maize, a form or strain of the Yellow milo maize.

White forty-three bushels per acre. The yield of grain per acre by years is as follows:

	Red bushels	Black-hulled White bushels
1896	41	48
1897	41	48
1898	28	33
Totals	110	129
Averages	37	43

In western Kansas, many farmers raise the Red, thinking it a little hardier and earlier. In central Kansas some feeders raise both the Red and the Black-hulled White, and feed alternately, the stock seeming to relish the change.

Records show the Red to be from a week to ten days earlier than the Black-hulled White, but this difference is of little importance in central Kansas. Kafir corn planted the middle of May is ripe the middle of September.

Soils and conditions of growth

Kafir corn will grow very nearly within the same climatic limits as Indian corn, and under ordinary conditions will produce a crop when corn does. However, it seems to require a slightly warmer climate for its best development. When its growth is being held back by unfavorable conditions, frost comes before it is ripe. It responds as readily to good soil and favorable conditions as

any other crop; yet, on poor land, and under conditions that would not produce a crop of corn at all, kafir corn does surprisingly well. It is a very strong feeder, having an extended root system which reaches deep and wide for necessary moisture.

Dry-weather-resisting qualities

Kafir corn is the greatest dry-weather-resisting crop that can be grown in Kansas. It grows and develops in proportion to the moisture which it can collect by its extended root system, and, when unable to continue growing, it stops and lies dormant, so to speak, until the moisture does come, and then continues its growth. If the rains are sufficient, and the frost does not come too soon, it will make a good crop, although it has stood comparatively dried up for six weeks. Corn to some extent will renew its growth after a moderately dry period, but not in comparison with kafir corn.

Preparation of land in dry regions

Listing is not generally satisfactory. Being slow to start, the plant needs to be up where it gets all the warmth possible, which is not the case in a lister furrow. And, after listing, if a dashing rain comes and runs the soil down in the furrows before the plants are well started, there will not be a good

stand. It does not have sufficient force to push through soil that has washed down and settled over it. Surface-planted land may be affected by dashing rains, but it is not likely to be. The washing and settling of the soil by rain, of course, depends a great deal on the character of the soil,

Fig. 21. Forms of kafir corn, and a sweet sorghum.—(1) Brown doura; (2) Black-hulled White kafir corn; (3) Red kafir corn; (4) Kavanaugh sorghum; (5) Yellow milo maize; (6) Large African millet, or White milo maize.

as some soils wash and pack more readily than others. Listing, however, in the western and drier sections is the favorite method of planting, as it takes less work, encourages the roots to go deeper into the soil, thus better resisting drought. The rows should be about three feet apart, and the seed dropped four to eight inches apart in the row for the western part of the state.

For surface planting, fall plowing is very generally favored. The disadvantages of fall plowing are: The blowing of the loose soil, and the weeds, which thrive best on fall plowing. Otherwise, a good disking or fall plowing furnishes the ideal seed-bed.

Spring plowing should not be done until time to plant. The plowing should not be deeper than is necessary to turn the ground well and cover trash. A very essential feature in the preparation of the seed-bed is to compact the soil as soon as plowed, so as to hold the moisture near the surface. The plowed soil should not be left as smooth on the surface as when a roller is used, nor as fine as an ordinary harrow would leave it. The day the land is plowed, it should be disked, harrowed, then rolled, and harrowed again, to make the surface fine and compact. The press drill, with all the drills left on, is the best implement for planting, if done the same day that the land is plowed.

Distance apart and seed required

For hay or fodder, it should be planted close, and the greatest yield may be secured by broadcasting or putting in with a wheat drill, set to sow one and one-half bushels of seed per acre. For producing grain it should be planted in rows with a view to cultivating. For the western and drier country, rows should be three to three and one-half feet apart, and the seed from four to eight inches apart in the rows, while for the eastern areas of greater rainfall, better results are obtained by putting the rows two and one-half to three feet apart, and the seed from two to four inches apart in the row. For western planting six to seven pounds per acre will be all the seed required, while for eastern planting ten to twelve pounds per acre will give the best results for grain.

Any drill or drill planters may be used if adapted to such small seeds, and to drop them the proper distance apart. Perhaps the most practical is the ordinary grain drill, tacking a piece of pasteboard over all the holes except those which will plant the rows at the proper distance.

Time to plant

Kafir corn, having a rather low vitality, and growing slowly after starting, should not be

Fig. 22. Yellow milo maize (to the left) and Rural Branching doura (to the right).

Fig. 23. Millet (on the left); kafir corn (on the right).

planted until after the ground is well warmed, and there is no danger of frost. It comes properly just after corn planting, there being no hurry until the last week in May, but it should be in early enough to have plenty of time to ripen before frost, taking into consideration the fact that the plant makes but little growth in very dry periods.

Seeding in dry regions

As in all crops, it is essential that good seed be planted as a first requisite to a high yield and a good stand. Kafir corn heats very often, when stored in quantity in bins, or when sacked and in a dry place, especially if the sack is closely woven and there is some dust in the seed. It is always risky to trust seed that has been stored in any quantity in a close bin, as its germinating power may be impaired. Hence, seed that is not fresh, or new, should not be trusted. It may even sprout in a germinating pan, and yet have a low vitality that would give a poor stand.

The best heads from the best plant in the field, under ordinary conditions, should furnish the seed for the next year. If the seed is left to cure on the stalk in the shock, the selection may be made at any time before thrashing; if left on the head and stored away in thin tiers in a dry place, until needed for planting, good seed is insured.

Cultivation of kafir corn

The cultivation should be the same as for corn, frequent and shallow, rather than deep and infrequent. Harrowing early is almost indispensable in order to keep down weeds. After the plants are three inches high, they will stand almost any amount of harrowing and this may be continued until eight inches high.

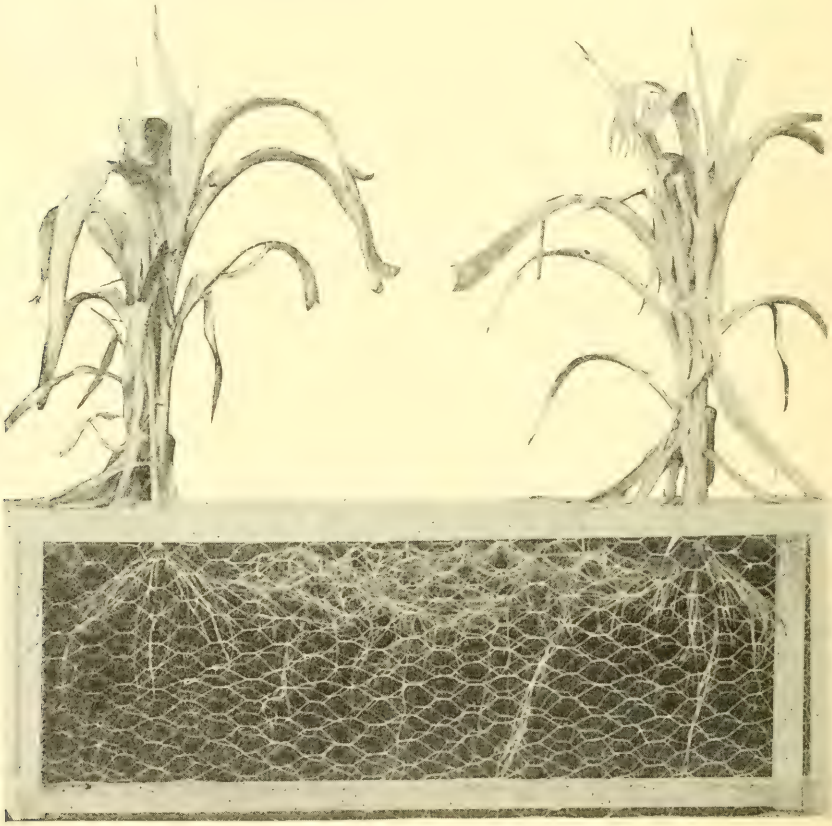

Fig. 24 Roots of kafir corn, sixty days after planting.

Harvesting time for grain

Kafir corn remains green until frost, and the seed does not shatter; so, if grain is the only consideration, there is no great hurry to harvest; it can stand until after frost and the stalk is dry. But, generally, the fodder is a consideration, as well as the grain, and then the problem is to cut when the best results from both may be obtained.

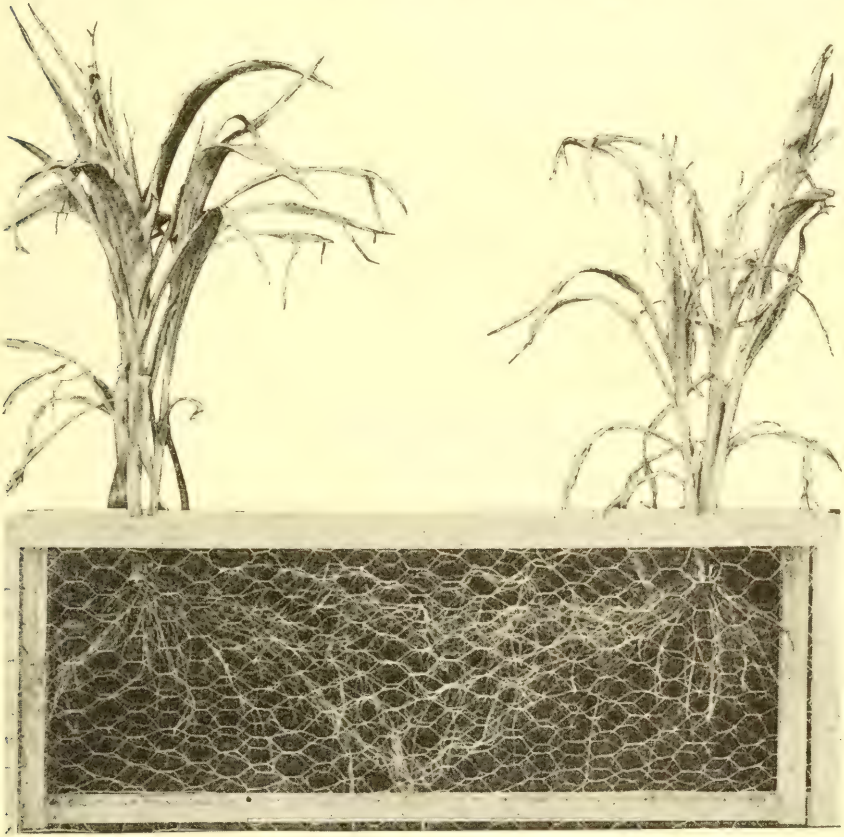

Fig. 25. Roots of sorghum, sixty days after planting.

The longer the fodder stands, the harder and less palatable it becomes, while if cut too early the best yield of grain is not secured. After the grain is hardened so that it is difficult to mash between the thumb and finger, and there is apparently little moisture in the seed, there will be very little shrinkage in the grain. This would perhaps be called "just past the hard-dough stage." If cut earlier, the fodder will be better feed, but there will be a considerable shrinkage in the grain.

Methods of harvesting

One thing that has kept this crop from being more generally raised is the problem of harvesting. There are a number of methods, and they all have their merits. If the fodder is desired for feed, it is perhaps best to cut stalk and all, and leave it in the shock until dry. The best machine for accomplishing this is the corn-binder, which leaves it in bundles of convenient size for handling, and the fodder is held together. In the western and drier regions, if not planted too thick, it does not grow so high that it cannot be cut with an ordinary grain harvester, and this method is quite extensively used. The ordinary corn sled may also be used for cutting, and if the seed is to be fed with the fodder, this is perhaps the most inexpensive.

In threshing, the whole stalk can be run through a common grain-separator, but this is hard on the machine, and as a general thing a thrasher will not do such work a second season. The fodder is cut and broken up, and, while some hold that this is an advantage, it soon loses its flavor, and, if not thoroughly dry, will heat and spoil after stacking. Stock will eat the thrashed, broken-up fodder while it is fresh better than when whole, but in a short time it gets stale.

When the kafir is bound, the grain may be removed by thrusting the heads into the cylinder of a thrashing-machine for an instant, and throwing the fodder off on a wagon. When it is desired to take the fodder at once from the field, this would perhaps prove the most economical method.

When planted thick or sown broadcast for hay or fodder alone, it should be cut when most of the seeds or heads are in the milk or early-dough stage. At this time more nourishment will be in the stalks and leaves; besides, not being so hard as when fully matured, it is more easily digested, stock eat it more readily, and there is less waste. A great many make the mistake of cutting too early, often with the view of getting a second crop. The nourishment in any feed is conditioned on the process of maturing; the compounds must be elaborated and fixed in the tissue before they are food. Cutting any feed before the blooming period

may give a great bulk of material, but it is watery; it dries out, the fodder shrinks, and an animal cannot eat enough of it to satisfy the appetite. One crop is all that ought to be expected from one seeding, and more profit is made by a single crop than two, if labor is counted as worth anything. The feed secured by two cuttings may go a little farther than the feed secured by the

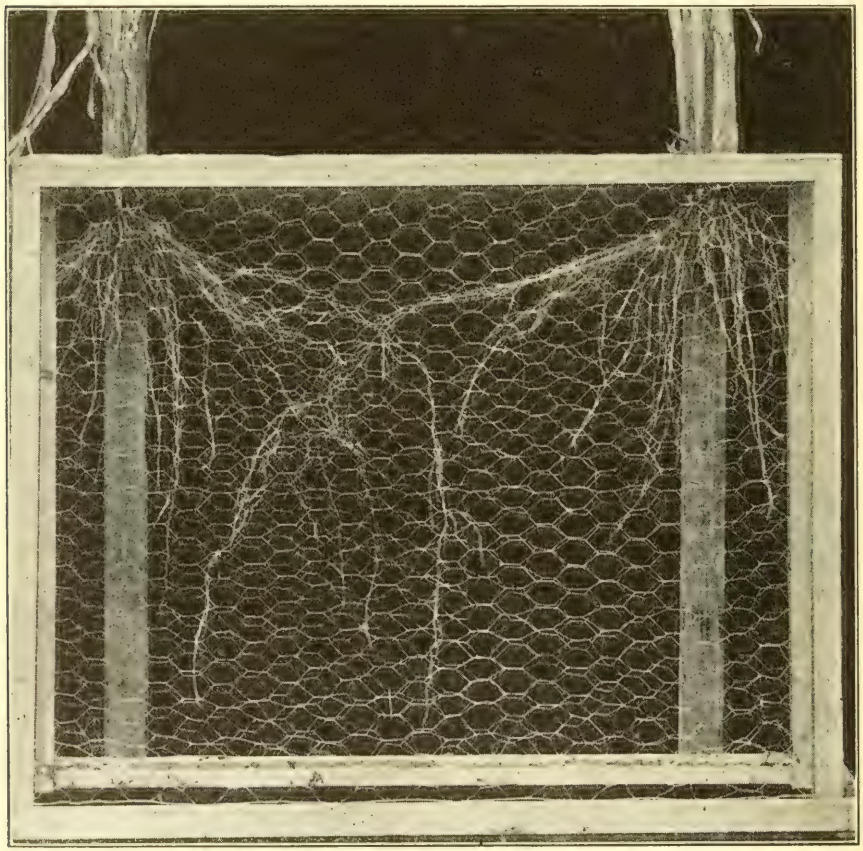

Fig. 26. Matured kafir corn roots.

single cutting, but it will not go nearly twice as far.

Cutting and curing for hay

As before stated, kafir corn should be cut when the seed is in the milk or early-dough stage. The cutting may be done with a grain-binder, and shocked to cure as small grain. This leaves it in a very fine condition to handle when feeding, but is

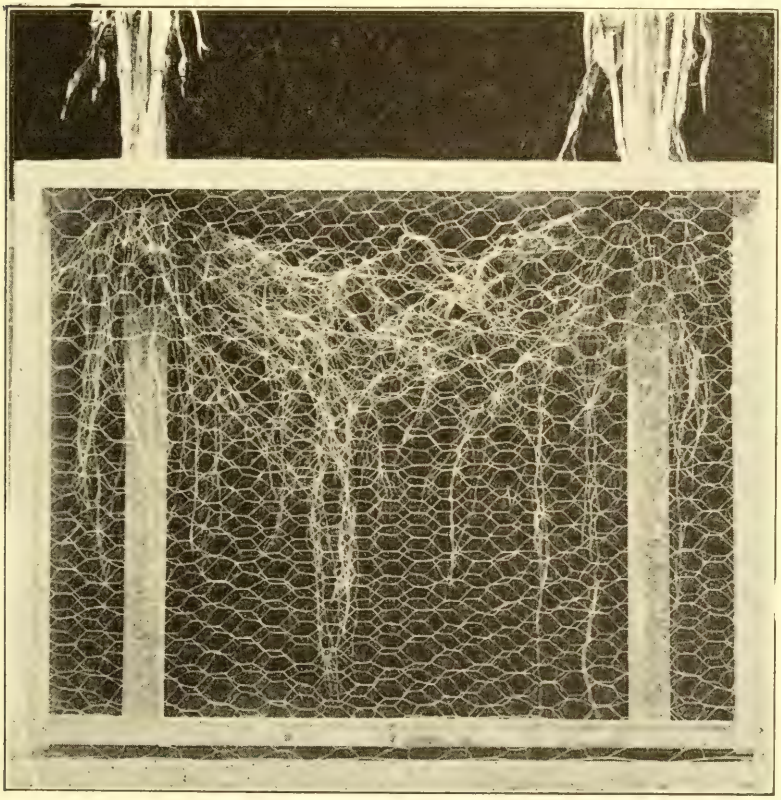

Fig. 27. Matured sorghum roots.

rather hard on a machine and somewhat expensive. The ordinary method is to cut with a mower, and the crop should be left to cure well before raking. Ordinarily, in the middle and western part of Kansas, after being cut and raked, it is put into large shocks or small ricks containing from a ton to three tons each. This is done with a hay-gatherer, "buck-rake" or "go-devil," and saves a great deal of handling. It keeps in excellent condition when treated this way, and can be hauled when needed. Under ordinary conditions kafir corn will be ready to harvest for hay in about 105 days after planting, and this should be before frost, as freezing while green is detrimental; besides, the hay will not cure as well in cool weather, and it is essential that it be as perfectly cured as possible.

Yield of grain in kafir corn

The yield of grain will range from twenty to ninety bushels per acre, with an average of about forty-five bushels in eastern Kansas; in the western and drier parts of Kansas it is smaller, though there the difference in yield between kafir corn and Indian corn is proportionately greater than in the eastern parts. At the Kansas Station the average yield of kafir corn for eleven years was forty-six bushels per acre, while for Indian corn it was thirty-four and five-tenths

bushels. The yield of hay will also vary widely from one-half to three tons per acre, according to climate, soil and season.

Storing the grain

Great care must be taken in storing the seed in close bins, in quantity, especially if not well cleaned. It settles together so closely that air seems to be excluded and heating results. In the spring during damp spells, it is often necessary to shovel the seed from one bin to another, or from one side of the bin to the other, to keep it from spoiling. Slightly-heating does not injure it for feeding purposes, but destroys its germinating power. There is often damage to the heads when stored in corn-cribs, but it is not so probable as in the thrashed grain.

CHAPTER VII

THE SWEET SORGHUMS

THE sweet or saccharine sorghums are used both for the making of syrup and for forage. They are more corn-like in appearance than the kafirs because the panicle is more like a corn tassel in form. This panicle or head is usually loose and open, although it may be more or less dense when its grain is ripe. The grain is borne in the panicle or tassel, not in ears. The general directions for the growing of the kafir corns (Chapter VI) apply very well to the sorghums.

The varieties of sorghum well adapted for soiling are Early Amber and Early Orange. The Early Orange produces a larger and heavier growth, and is a little later than the Early Amber, and is thus more suitable for sections in which the seasons are long. The soils best adapted for sorghums are deep, moist loams, or those most favorable for maize, although the crop may be grown successfully on light lands if they are well fertilized. Sorghum seems to be capable of withstanding drier conditions than corn, and thus its use is increasing where droughty conditions are liable to occur.

Preparation of soil and seeding

The preparation of soil for sorghum should be similar to that recommended for corn,—a deep, well-cultivated seed-bed, but for sorghum the crop should preferably be immediately preceded by a cultivated crop, in order to free the land of weeds. The plants germinate readily, but make a very thin and slow early growth, thus rendering it difficult to keep clear of weeds.

When the crop is intended primarily for forage, it may be seeded either thickly in rows, or broadcasted. If seeded in rows, from ten to twelve pounds of seed per acre are sufficient. If broadcasted, twenty to twenty-five pounds will be required. The crop should not be planted until the soil is thoroughly warmed, and the weather likely to be hot, as the plant does not thrive in cold, moist weather. Broadcast seeding is not recommended except on clean lands, as the weeds are likely to start vigorous growth and seriously reduce the yield of the sorghum.

To grow maximum crops the land should be well manured or fertilized; inasmuch as it is a cultivated plant, which roots more deeply than the millets, the nitrogen requirements are not so exacting. However, the soil should be abundantly supplied with available phosphoric acid and potash. A good dressing of manure of six to eight

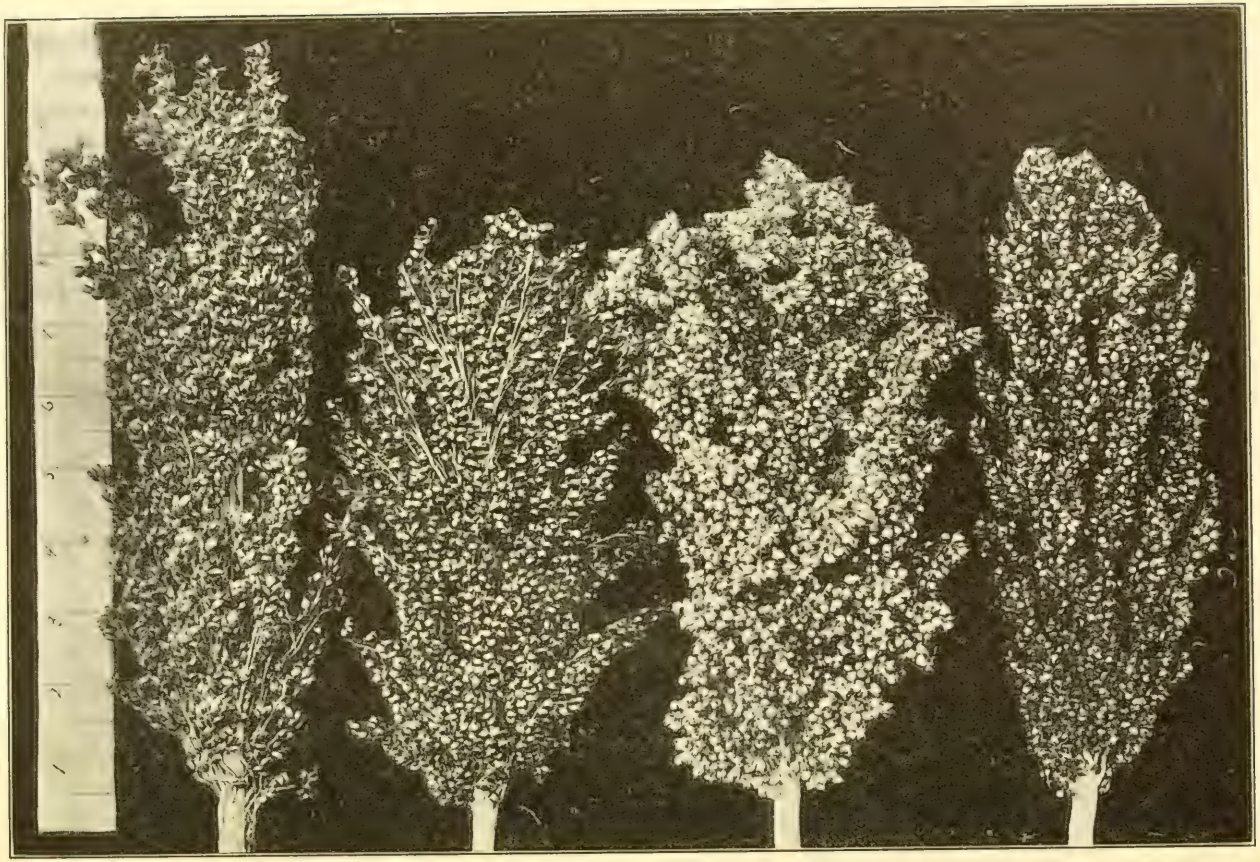

Fig. 28. Typical heads of different varieties of sweet sorghum. Reading from left to right, the varieties are: (1) Early Amber; (2) Black Dwarf; (3) Kansas Orange; (4) Coleman.

tons, well cultivated into the soil, should be followed by an application of 200 to 300 pounds per acre of a commercial fertilizer containing

Nitrogen	3 per cent
Phosphoric acid (available)	8 per cent
Potash	5 per cent

Yield and value

Sorghum is frequently allowed to grow to a height of five to six feet, and then cut and permitted to make a second crop. By this method, the largest yields of succulent forage are obtained, ranging from eight to thirty tons per acre, although the latter figures are exceptional. An average of ten tons may be regarded as good, and this should be secured under medium conditions of soil and in usual seasons.

Sorghum is a sugar-producing plant. It is very palatable, and is readily eaten by all farm stock. In their immature state, however, the plants do not contain a high content of dry matter, being similar in this respect to millet, although they are more palatable when mature.

The quantity fed may range from fifty to seventy-five pounds per day, in two feeds. The sugar forms very rapidly after the heads begin to appear, and this formation of sugar, while accompanied by a considerable increase in crude fiber as the plants

approach maturity, makes the forage sweet and encourages the animals to consume the coarser materials more readily than is the case with the millets or kafir corn, or even maize (except the sweet varieties).

Sorghum is not well suited for hay, although it can be used for the purpose if cut early. It can be used for silage with advantage. It can also be harvested and allowed to dry, and the seed threshed; the dry stalks are then practically as useful as corn-stalks, and the seed can be ground into a feed which is similar to corn-meal in its composition and feeding value.

COMPOSITION AND YIELD OF NUTRIENTS OF SORGHUM FORAGE

	Early Orange sugar-cane	Early Amber sugar-cane	One ton contains	An average acre-yield furnishes
	Per cent	Per cent	Lbs.	Lbs.
Water	83.19	85.19	. . .	. . .
Dry matter	16.81	14.81	336.2	3362.0
Ether extract	0.57	0.51	11.4	114.0
Fiber	5.51	3.96	110.2	1102.0
Protein	1.70	1.36	34.0	340.0
Ash	1.49	1.20	29.8	298.0
Nitrogen-free extract	7.54	7.78	150.8	1508.0

SORGHUM IN DRY REGIONS

Sweet sorghum is well adapted to the special climatic conditions of the semi-arid regions, although it is generally used in the eastern and southern states for green forage. The remainder

of this chapter is drawn largely from Kansas State Board of Agriculture Report for 1900. Figs. 28 and 29 are Kansan.

Varieties for Kansas

Of the large number of varieties, those found to be most desirable in the West are: Folger,

Fig. 29. Field of Orange sorghum in Kansas.

early; Coleman, medium; Collier, late. The Early Amber and Early Orange are very valuable for the East. The main points to consider in choosing varieties are (1) time of maturity, (2) proportion of foliage to stem, (3) sweetness.

Fig. 30. Sorghum at good stage of maturity for soiling.

Preparation of land

There is a prevailing opinion with farmers that sorghum does not require the care in the preparation of soil and its cultivation that is demanded for corn. This may be true in part, but the plant responds readily and profitably to good treatment, and it usually pays well thoroughly to prepare the soil before planting. This good preparation not only destroys weed seeds, but increases the water-storage capacity of the soil, insures quick germination and rapid early growth.

Seeding in Kansas

Sorghum may be seeded any time that is suitable for seeding corn; if planted from the first to the twentieth of May, it will ordinarily catch enough of the spring rains to secure a fine growth before the hot and usually dry weather of the western states begins.

When grown for the mature plant, it should be planted in rows, about three feet apart, and the seed distributed evenly in the row, at the rate of one peck to one-half bushel per acre. After planting, the land should be harrowed to keep the surface loose, and as soon as the plant is well started, the ground should be frequently cultivated until the plant is thoroughly established. While the

young plant is slower than corn to start, and thus difficult to keep clean, especially in moist warm weather, it grows quite as rapidly, if not more so, when well established, and later cultivation is not so important.

Sorghum is usually grown for the making of hay, and therefore a much thicker stand is wanted and broadcast seeding is practiced. The best method of seeding is to use a press drill, sowing from one and one-half to two bushels per acre, sufficient to have the stand thick, like wheat or rye, if the best hay is to be obtained.

Harvesting and curing sorghum

The crop may be cut for forage when two or three feet high, in which case it is possible to get a second crop quite as large as the first. For hay, however, it is better to let the plant reach a more mature stage, so the seeds begin to harden and the plants to turn yellow. At this stage, it will make more and better feed than if cut earlier or later. If the stalks are not more than six feet tall, the method commonly used for hay is to cut with a mower, allow it to wilt, and then, with self-dumping rakes, carry enough together to make small stacks of 800 to 1,200 pounds. By this method, experienced growers find that the least labor is involved, and that the product keeps green

and sweet. The time of cutting should be the same if planted thinner, except that it should be cut and put in shocks, as in the curing of corn-fodder.

For many sections, sorghum is one of the most useful crops of the farm; it is easily grown, resists drought, and makes a large quantity of forage that is relished by all farm animals. In the South it is grown largely for making syrup. It was formerly used somewhat for this purpose, even as far north as Michigan, before the days of cheap sugar.

As a special crop, sorghum cannot be recommended too highly. When properly grown it produces from four to six tons of dry feed per acre.

CHAPTER VIII

MAIZE OR INDIAN CORN

THERE is no one crop that is equal to corn for forage purposes. If it could be so grown as to supply green forage from May 1 to November 1, there would be no good reason for the introduction in soiling systems of any other plant of the same group. The reasons for this broad statement are, (1) that corn is adapted to a wide range of soils, and thus can be successfully grown for forage practically everywhere in the United States; (2) it makes the largest yield of digestible dry matter per acre, other things being equal, of any crop that is now grown; (3) in its immature state it is very palatable and is eaten practically clean by all classes of farm stock up to the time that the grain begins to harden; (4) it is one of the least expensive crops to grow, largely because of the cheapness of seed; (5) it can be completely utilized, either as a grain crop or winter forage crop, if not needed as green forage to supplement pastures, or if the yields are larger than needed for soiling; (6) it is the only wholly satisfactory silage crop; (7) it is a tilled crop, and its use may improve the land,

CORN FOR GREEN FORAGE OR SOILING

The choice of variety and method of growing should be modified to meet the special requirements of soiling. It should be remembered that the purpose in the growing of soiling crops is not nutriment alone, but rather a combination of succulence, palatability and nutrients. Those varieties that make most rapid growth and develop early are, all things considered, more desirable than those that give a larger proportion of stalk and ear to leaf, because the shorter period of growth enables the gathering of two crops of green forage in one season as far north as New Jersey. The Rural Thoroughbred White Flint represents a type that gives excellent satisfaction in the Middle States, as it possesses in marked degree the characteristics already recommended. The branching habit is also well developed; from three to four stalks will sucker from the main stem, thus gradually thickening and maintaining the succulent character of the forage for a longer period than those not possessing this habit. In New Jersey and points south, this variety, if planted by May 1, will be ready for harvesting by the middle of July; and if another crop is planted at this time, it will reach a good stage of development previous to killing frosts that occur as early as the first week in October. Notwithstanding the possibility of secur-

ing two crops, the yields of each are often as large as can be obtained from the larger-growing varieties.

There are many other good varieties that possess in varying degrees the characteristics mentioned for this one. As a rule, the flint varieties are superior to the dent in the northern parts of the country. The smaller, quicker-growing varieties of the dent sorts are also satisfactory, although requiring much thicker seeding and a longer period of growth.

Preparation of land

The yield of the crop depends to a very considerable extent on conditions that are favorable for complete germination and very early growth. The importance of this point cannot be emphasized too strongly. Naturally, the preparation of the land and its treatment will depend somewhat on its condition and character. In the first place, if either clover or grass sod is used, it is generally good practice not to plow too deep, which is likely to turn up parts of the soil not thoroughly mixed with vegetable matter, and not in good physical condition. This admixture of subsoil has an unfavorable effect on quick and satisfactory germination. Therefore, relatively shallow plowing,—five to six inches,—is preferable.

Plowing should be performed as early as it is

Fig. 31. Fodder corn. Thoroughbred White Flint in New Jersey, after a crop of oats-and-peas, yielding twelve tons of green forage to the acre.

possible to get on the land, that the soil may be suitably compacted before the drying winds of spring absorb the moisture. Following the plowing, the tillage should be deep and thorough, both to warm the soil and to make the surface as fine as possible. When soils are loose and porous, the necessity for deep and repeated tillings are not so great as when they are heavy and compact. If the soil is not plowed until immediately preceding planting, it is likely to be cold, preventing quick germination; and should dry weather follow, the surface rapidly dries out and the plants will not absorb sufficient moisture from the lower layers to cause rapid and continuous growth. When the crop is planted on land that has not had a cover-crop, the recommendations may be modified to some extent; a little deeper plowing may be made, and less tilling is required to get it into first-class condition.

Manures and fertilizers

When the aim is to secure as large a yield of succulent food as possible, and of superior quality, it is absolutely necessary that the plants have an abundant supply of plant-food throughout the entire season. Therefore, even on good soils, the fertilization should be liberal. Manure may be placed on the surface in the fall, in which case it serves as a mulch during winter, absorbing mois-

ture, preventing washing and ensuring a complete distribution in the surface layers of the soluble plant-food; or it may be applied after plowing in spring, providing it is fine and thoroughly incorporated in the surface soil. These methods will ensure the largest return of the constituents in the crop, and they are particularly desirable when manures are used that contain but little litter. When manure is used, ten tons per acre applied broadcast will afford abundance of organic material, containing sufficient nitrogen in available forms to supply the early needs of the plant.

It must be remembered, however, that no amount of manure or fertilizer can be substituted for early and thorough tillage, as tillage saves moisture. This is a matter of the highest importance, for without moisture the plant-food cannot be dissolved and circulated through the soil. Therefore, whatever the method of manuring, the soil after seeding should be tilled, preferably shallow and as frequently as possible, until the plants are too large to permit further work. The fact that the plant does not make its most rapid growth in any case until warm weather begins, makes the necessity for early and large applications of quickly available nitrogen not so great as in the case of such crops as rye or wheat, or even oats, that make their most rapid growth much earlier in the season. With corn, the conditions are gener-

ally favorable soon after planting for the change of organic nitrogen into available forms.

The corn plant, however, requires a liberal supply of the mineral constituents; and while the application of manure will carry relatively large quantities of these, it is obvious that they cannot be so completely distributed as in more soluble forms, nor, unless the manure is placed in the row, can they be concentrated in such a way as to permit the plant to supply its needs easily and rapidly. Therefore, in addition to manures, a fertilizer rich in minerals is generally desirable. A fertilizer carrying 1 per cent of nitrogen, 12 of phosphoric acid and 10 of potash (made by mixing 250 lbs. ground bone, 500 lbs. acid phosphate, 250 lbs. muriate of potash), applied at the rate of 400 pounds per acre, will meet the requirements for minerals even under unfavorable conditions. This fertilizing, while seemingly heavy, is not more than should be applied, because the object is to stimulate as far as possible a continuous and rapid growth.

The above remarks are made, of course, with eastern conditions in mind. In large parts of the West, these heavy applications will not commend themselves to farmers in general; but even there the question of fertilizing is coming to be an important one, although the main demand may be for but one of the constituents. In the long

run, the question of applying plant-food is not regional.

Seeding and tillage

Methods of seeding vary widely, although it is recognized in all cases that the thickness of seeding should be proportioned to the possible available plant-food in the soil. On soils that are naturally rich and supplemented with the fertility constituents in available forms, thicker seeding may be made than when conditions are not so good in respect to food.

A good method of seeding corn is to plant in drills, from two and one-half to three feet apart, and the plants from eight to ten inches apart in the drill. The quantity of seed necessary to plant thus thickly, will range from twelve to fourteen quarts per acre, depending on the size of the grain. In branching varieties, the plants will be as thick as it is desirable to have them with the lighter seeding. Seedings thicker than this, either in rows or broadcast, as is frequently practiced, are likely to cause the crop to suffer from lack of moisture, if short droughts occur, even under very favorable conditions for obtaining plant-food. The size of the stalks under this thick seeding will be such as to cause the forage to remain succulent and palatable until the grain begins to harden.

As already indicated, when large yields are to

be secured, great care should be observed in the conserving of the moisture, and therefore the cultivation should begin about as soon as the corn is planted. Shortly after planting, the surface should be stirred frequently, preferably with a light harrow or weeder, until the corn is well started, when shallow tilling should begin and be continued as frequently as possible during the early period of growth. This frequent tilling will prevent the undue escape of moisture into the atmosphere, as well as assist in the decomposition and nitrification of the organic matter in the soil and manure.

After the first crop is removed, a second one may be immediately planted, preferably without plowing but with a deep cultivation with a cutaway harrow. The corn stubs will interfere to some extent, but not seriously. The reasons for cultivating, rather than plowing, when the first crop is removed (say the middle or latter part of July), are, first, that quite as good tilth can be secured, and second, if the land is plowed at this season, it is frequently impossible to get the surface layers so thoroughly compacted and connected with the lower one as to permit free upward movement of water from the lower parts of the soil. It is essential, particularly in this second crop, that the germination should be quick and as complete as possible, and the early growth very rapid. The manures and fertilizers should be applied in the same way as for the

first crop, and the seeding and tilling should also be the same.

Time of harvesting, and yields

The time of harvesting maize for soiling purposes may begin as soon as the plant has fully tasseled, or even before, depending on the need for succulent forage. The largest amount of actual food or digestible nutrients will be secured if the harvesting is delayed until the ears have formed, and then continued until the glazing stage is reached. Therefore, the yields will vary widely, inasmuch as the proportion of dry matter in the early-cut forage is relatively very much less, and the water very much more than when the crop is nearly mature. Records obtained at some of the stations show that under normal conditions of season more digestible matter, and that which is quite as palatable, may be secured from twelve tons of corn cut at the glazing stage, than would be secured in fifteen tons or more harvested before or about the time the plant is coming in tassel. So the yields may vary by the common, though not proper, standards of reckoning; and the fact that a crop will yield fifteen or even twenty tons of forage, as is frequently stated, is no indication that such crop is superior in content and value of total nutrients to one that yields twelve tons.

It is not desirable to prolong the feeding of the

green forage until the ears have matured, as the tendency of the animals will be to eat the ears in preference to the other parts of the forage, and the master cows will appropriate an undue proportion and possibly be injured by an excessive supply, particularly if the forage is distributed in the field. For soiling, the forage should preferably be used before the grain has hardened.

Composition and value of crop

Corn in its best stage for green forage contains, on the average, and for all varieties, 20 per cent of dry matter. This dry matter is much richer in carbohydrates than wheat or rye forage. Therefore, so far as total nutriment is concerned, it is much superior to these crops, as well as to the millets, sorghums or kafir corn. That is to say, a larger proportion of feed in a succulent and digestible form is contained in a smaller amount of forage. Usually from forty-five to fifty pounds per day will supply the needs for roughage, as compared with fifty to seventy-five pounds of millet or either saccharine or non-saccharine sorghums.

Corn can be utilized through a longer period than any other crop. Therefore, the plantings should be made at different times; and as any one seeding can be used for a period of fifteen to

twenty-five days, the plantings should be made two or three weeks apart. Of course, a similar succession may be obtained by the use of the early-maturing and the late-maturing varieties, but the later varieties do not make so good green forage as the early ones.

COMPOSITION OF THOROUGHBRED WHITE FLINT CORN (GREEN)

	Per cent	One ton contains Lbs.	Average acre yield furnishes Lbs.	Fodder corn, all varieties Per cent	One ton contains Lbs.	Average acre yield furnishes Lbs.
Water . . .	80.27	. . .	. . .	79.30	. . .	. . .
Dry matter .	19.73	394.6	3946.0	20.70	414.0	414.0
Ether extract	0.62	12.4	124.0	0.50	10.0	100.0
Fiber . . .	3.78	75.6	756.0	5.00	100.0	1000.0
Protein . .	1.65	33.0	330.0	1.80	36.0	360.0
Ash	0.86	17.2	172.0	1.20	24.0	240.0
Nitrogen-free extract . .	12.82	256.4	2564.0	12.20	244.0	2440.0

The yield of the Thoroughbred White Flint has ranged, at the New Jersey Station, from ten to fifteen tons per acre, with an average of about ten tons, containing 20 per cent of dry matter. Two crops of ten tons each would yield about four tons of dry matter per acre of a highly digestible and very satisfactory forage.

SWEET CORN FOR GREEN FORAGE

Owing to the very palatable nature of sweet corn, it is frequently recommended for green forage. If suitable varieties are chosen and planted

at the proper time, it is a very useful crop, although the experience of careful experimenters shows that, on the whole, the yield of feed is relatively very much less than from the regular field varieties, the range being from four to ten tons per acre, with an average of about six tons. A variety of sweet corn that gives a satisfactory yield is rather slower in development than other corn, owing largely to the fact that the seed does not germinate quickly nor the young plants grow vigorously until the season is well advanced. Of the suitable varieties, Stowell Evergreen is one of the most generally satisfactory, since it is a large, rank grower, with abundant foliage. It should not be planted until the season is well advanced, say the latter part of May, for the Central States, and the land should be thoroughly well prepared, as pointed out for other kinds of maize. When used primarily for forage, sweet corn may be fertilized or manured, as indicated for the Thoroughbred White Flint, and cultivation should be practically the same.

A great advantage that many dairymen find in the growing of sweet corn is that they may sell a large proportion of the ears, when the prices are satisfactory, and still have a very good forage left, as the stalk remains palatable for a considerable time after the ears have been removed. There is no question as to the superiority of the

sweet varieties for forage, as the animals certainly are able to utilize the nutrients to the fullest extent; and because of their extreme palatability, they exert a very favorable effect on the system, encouraging, apparently, a larger and better use of the accompanying feeds, as an increased flow of milk usually follows when sweet corn forage is substituted for field varieties. Because of the greater palatability of the sweet varieties, however, animals are likely to overeat. From fifty to sixty pounds per head per day should be the limit of use; it is important that the distribution in the feeding lot should be so made as to prevent any one animal from securing a larger quantity than this.

The composition of sweet corn does not differ materially from that of the field varieties, although it is more palatable and undoubtedly more completely digested. Following are analyses:

COMPOSITION OF SWEET CORN

	Stowell's Evergreen Per cent	Average analyses Per cent	One ton contains Lbs.	Average acre yield furnishes Lbs.
Water	77.90	79.10	. . .	. . .
Dry matter	22.10	20.90	418.0	2508.0
Ether extract	0.60	0.50	10.0	60.0
Fiber	4.50	4.40	88.0	528.0
Protein	1.80	1.90	38.0	228.0
Ash	1.20	1.30	26.0	156.0
Nitrogen-free extract	14.00	12.80	256.0	1536.0

Comparison of the average yield of nutrients in regular field varieties and in sweet varieties, shows

the great superiority of the former, an average yield per acre of field varieties furnishing:

100 pounds of fat
360 pounds of protein
2,440 pounds of nitrogen-free extract

as against:

60 pounds of fat
228 pounds protein
1,536 pounds of nitrogen-free extract

for the sweet varieties, or a gain of nearly 60 per cent in all the different nutrients. The cost of the sweet corn forage is greater, owing to the much higher price of seed.

DRIED CORN FODDER

An advantage that corn possesses, and which makes it superior to practically every other plant, is the fact that, if the crop is not required in its green stage, it may be dried and used for fodder. While it contains a high content of dry matter, it cures readily, and for certain classes of feeding furnishes roughage that is unexcelled.

Seeding and harvesting

The varieties used for fodder may be practically the same as those recommended for green forage, although the seeding may be slightly thicker, as

the advantage of earing is not so important. In fact, a better quality of fodder will be secured when a minimum number of matured ears are formed.

The time of cutting will depend somewhat on the character of growth, but the largest amount of dry matter will be obtained when the maize plant is practically mature, and if the seeding has been thick enough the curing at this stage can be accomplished readily. When there is danger of shortage of other winter roughage, corn is often planted late to supplement the regular supplies, in which case the crop is not always sufficiently mature before it is time to harvest. This will result in giving a crop that is very rich in digestible dry matter, but that is difficult to cure. However, if it is placed in small shocks, it will soon dry out; it should be removed from small shocks to large stacks or to the barn before the heavy storms of winter begin.

Composition and value of dry corn fodder

The composition of well-cured corn fodder is such as to make it a most excellent and nutritious food, and it is readily eaten by all farm stock, especially if cut fine. The amount of dry matter in field-cured fodder is about 75 per cent, and it is nearly as rich in protein as timothy hay, and con-

tains very much less crude fiber. A good crop of corn should yield about three tons per acre. A mistaken idea is that the thicker the corn is seeded, the larger will be the yield of food per acre, and in many instances the corn is sown broadcast or planted exceedingly thick in the row with this notion in mind. While the forage will be a little more digestible and a little richer in protein under this treatment, the yield of total nutrients per acre is usually very much less than if planted in the ordinary way and tilled, since the thick-seeded crop will be likely to suffer from lack of moisture, and it is much more exhaustive per unit of dry matter on the fertilizer constituents of the land. It is not a desirable practice to broadcast corn unless for hog pasture, or as catch-crop, and even then the advantages are not always apparent.

Sweet corn dry fodder

As already pointed out, sweet corn is an excellent source of nutrients, because it does not grow quite so coarse as the ordinary field varieties, and because it is very palatable and contains a highly digestible form of carbohydrates. As in the case of other fodders, if grown primarily for dried fodder, the seeding should be relatively thick, so as not to permit too heavy earing, although the presence of ears is not so undesirable as in field

corn. Sweet corn fodder is more likely to mold than field corn, and greater care should be exercised in harvesting; it should be thoroughly cured in the field, and then stored in a dry place. If entirely freed from outside moisture, and thoroughly air-dried, it may be packed tightly in the barn without danger of injury. The necessity for cutting it fine, when fed, is not so great as for other corn, since animals will eat it readily without cutting, due to the softer stalk and its palatability.

CORN-STALKS OR STOVER

Stover is the stalks remaining after a corn crop has been harvested of its ears, the crop having been grown for the grain. There is great waste of stover throughout a large area of the country; it is certain that this waste would be saved if its food-values were better understood. The coarse stover has a high feeding-value, which will justify much greater care in its handling and storage. The feeding-value of a ton of stalks is more than half the value of a ton of timothy hay that is harvested in its best condition.

Methods of curing and handling corn-stalks

Methods of handling stover differ widely in different sections of the country. In the eastern

and northeastern states, the corn is usually cut and shocked, and when the ears are dry enough to crib, the corn is husked and the stalks are reshocked in the field until cured, and then either carted to large stacks or stored in the barn. This is an economical method of curing and saving the crop. In the South and parts of the West the practice is merely to "top" the stalk, and the leaves and stalk below the ear, with the husks, remain standing in the field. This practice results in a large waste of valuable material. In many of the western states, only the ears are removed from the standing corn and the stalks are not harvested; the only value gained from the stover is that which may be secured by the animals following the huskers, and even then probably not one-third of the food is utilized.

Another source of loss of fodder, even though the corn is husked and the stalks shocked, occurs when the shocks are left in the field until they are needed for food. By this method great losses occur, due to the mechanical removal of the leaves by weather, to changes in chemical composition, and to the removal of a large proportion of the best of the material by wind- and rain-storms; besides, the rain and snow soak the outer parts of the shocks, and these parts become frozen, not only rendering them unpalatable but making it impossible to remove the entire product to the barn.

Fig. 32. Corn-husker and shredder at work.

Methods of using; yield

The best method of using stover is to cut it fine, or to shred it and feed the animals liberally, allowing the unpalatable parts to be used as bedding. In this way the best of the feed is utilized and the manures are saved and improved.

The yield of stover will naturally vary according to the variety and the character of the crop. The ratio between ears and stover is not uniform, but with a yield of 100 bushels of ears there is usually about two tons of stover, which contains about 60 per cent of dry matter or feed per acre, equivalent in value practically to a ton of timothy hay.

CHAPTER IX

CORN FOR SILAGE

THE prime means of utilizing the green corn crop is in the form of silage, particularly in dairy districts. By this use the largest amount of digestible feed may be obtained per acre, and in a succulent and highly palatable form. Since the use of the silo became an important question there has been very great improvement in the growing of corn for silage and in its storage. In the early history of the silo it was recommended that corn of the larger varieties be planted very thickly, and be stored before it had nearly reached a stage of maturity. The consequence was, that, while large crop yields were secured, the high content of water and the consequently low content of dry matter were detrimental both in increasing the cost of handling and the difficulties of its preservation; the feed value was not increased, and wastes from decay in the silo were very serious. Investigations on the growing of corn and ensiling it have shown that the general principles involved in the growing of forage, as already pointed out, are quite as applicable in the growing of corn for silage as for soiling or for fodder.

Varieties of corn for silage

For the eastern, central west and southern states, the larger-growing varieties, as the Southern White, Horse Tooth, Mastodon, or those generally recommended by seedsmen, are preferable, giving a larger yield of actual dry matter per acre than the smaller-growing varieties, if only they mature sufficiently in average seasons before frost. Farther north, the flints, as Thoroughbred White, or the ordinary yellow varieties, and a number of the quick-growing dent varieties, are recommended, because the crop can be more completely matured before danger of frost.

Preparation of land, and seeding

As in the case of other forage crops, the preparation of soil is very important. Early plowing, and a deep and thorough preparation of land are important in securing a quick and complete germination and rapid early growth. Manuring should be liberal and supplemented by fertilizers. While all this is expensive when large areas are grown, nevertheless it is a paying procedure because of the very much larger quantity of feed material that may be grown per acre. It costs no more, for example, to buy land, to furnish seed, to plow, and to make the ordinary cultivations for a crop

of twelve tons than for a crop of eight tons; proper manuring will frequently make this difference in yield, other things being equal. It is recommended that manure be applied either in the fall or winter on sod, at the rate of eight to ten tons per acre, or in spring after the land is plowed and previous to planting. There is no crop that will utilize to such good advantage the coarse manures as corn; it is a great forager, and at the season of its greatest demands, when it makes its most rapid growth, the coarser organic manures are more readily changed and converted into active substances than would be the case with such crops as wheat or grass, that mature early and require a large proportion of their food before changes in the organic compounds can take place in the soil.

It is essential, also, in order that the nitrogenous material of the manure may be completely utilized, that abundance of minerals shall be at the disposal of the plant. Therefore, a liberal fertilization with available forms of phosphoric acid and potash, is also recommended. Usually, an application of 300 pounds of acid phosphate, or its equivalent of phosphoric acid from ground bone, when there is an abundance of organic matter, and 100 pounds of muriate of potash, broadcasted, will very materially increase the yield.

An old practice, which has many points in its

favor, is the dropping of fine manure in the hill at time of planting. The advantage of this method is, that the organic substances will ferment quickly and warm the soil, and thus encourage a quick germination; and a more rapid early growth is to be obtained, as the plant makes a quick start, gets away from insects and makes possible an earlier cultivation of the land.

Tillage

The methods of cultivation have been greatly improved in recent years, owing to a more careful study of the nature and the composition of the plant. While the old notion that cultivation previous to planting is the best, is true to some extent, tillage has for one of its primary purposes the destruction of weeds in addition to the conservation of moisture, and this is accomplished by frequent and deep tilling subsequent to planting as well as previous to it. Immediately after the crop is planted, the surface should be stirred to destroy the young weeds in the rows, and to prevent the rapid escape of moisture. This can be accomplished by harrow or weeder. As soon as the corn is three or four inches high, the ordinary cultivator should be run through the row, the first one or two cultivatings being three or four inches deep, then gradually shallower, as the plant grows,

to avoid cutting the roots, which soon ramify in every direction and fill the whole surface soil. These feeding roots should not be disturbed.

Seeding

The quantity of seed to sow will depend to some extent on the variety and the character of soil. On good lands, the large-growing varieties will probably give the largest yield if planted in rows from two and one-half to three feet apart, and the plants six to eight inches apart in the row. This will require about fourteen to twenty quarts of seed per acre, depending on the size of the grain. Seedings as thick as this will permit of a very considerable setting of ears, although not so large a proportion as to make the silage too rich in digestible carbohydrates.

Time of cutting, and yield

The best time of cutting is when the ears are beginning to harden, and while the lower leaves are still green. Of course, the season will influence this point to a considerable extent. In dry seasons, the lower leaves will become dry before the ears have reached the proper stage of development, although there will be appropriation of food by the plant so long as any green leaves remain;

therefore, the stage of maturity of the ear is the best guide as to time of cutting.

When cut at this stage, a good yield will reach twelve tons per acre. This does not seem large, yet the crop will carry about 25 to 28 per cent dry matter, or an equivalent of over 6,000 pounds of actual dry substance per acre, which is greater than can be produced by any other cereal crop. When much larger yields of dry matter than this are reported, the probabilities are that it is produced on a smaller area specially treated, or in an exceptional season, or under unusual conditions of soil and climate. The reported average yields of twenty, twenty-five and thirty tons per acre, which are often noted, are evidently based on forage containing very much less dry matter. When it is remembered that it is a question not of tonnage of silage corn, but of dry substance that is involved, the grower should not base his expectations of feed production on statements of extraordinary yields, as he will surely be disappointed.

If a crop has become too dry to go into the silo in the best condition, the wetting of it may help somewhat to preserve the silage, but it must be kept in mind that water cannot take the place of the natural juices and the activity of living cells. If leaves and stalks have become dry, the cells have become filled with air and the adding of water can only partly displace it. The chief help

of water is in softening the tissues, and in aiding it to pack more closely. This method is often used, however, and, if the conditions in other respects are favorable, good silage results.

Frosts often come earlier than usual, and the corn is frozen before it can be ensiled. When this happens, it is best to cut the corn as soon as possible thereafter, and before the leaves are entirely dry, cutting in rather large heaps, so that it will not dry out too rapidly in the field. By care in these respects, frozen corn can be fully utilized for silage.

Storage in the silo

In the ensiling of corn, great progress has been made, chiefly in the form and construction of the silo. It has been demonstrated that the one crucial point in the saving of corn in a silo, is that the product shall be put in a building or receptacle that is practically air-tight. A round structure is more easily made tight and it presents the least friction against proper settling and packing. It may be made of staves, or frame, or brick, or stone, or of any material that will accomplish the purpose, namely, the prevention of the access of air. Square silos cannot be so tightly constructed, and the penetration of air when the silo is open is greater. It is impossible to pack closely in the corners.

While the various styles of silos here mentioned may all be good, there are several objections to stave silos that are intended to be permanent buildings out-of-doors. The staves are liable to shrink and the hoops to loosen when the silo is empty. In many instances, they are blown down in high winds, and even if not blown down they are racked and get out of plumb. It is also difficult securely to anchor a permanent roof, and to connect permanently the staves with the foundation. It does not pay, in the long run, to make cheap staves silos. An all-wood frame round silo is a type that has given excellent satisfaction, especially when care has been given to securing a good lining, which can be accomplished only when it has a sufficient diameter to permit of "springing" the lining boards in place, rather than to have the lining perpendicular. There should be at least three layers of the wooden lining, with paper between, the first nailed on the studs, then a lining of tough building-paper; the second layer nailed so as to break joints, and another lining of paper; and the third nailed, breaking joints again. To prevent the decay of the inside lining, it should preferably be treated with a mixture of gasolene and coal tar, rather than paint. This preserves the wood, to some extent prevents the entrance of moisture, and is not brushed off by the pressure of the silage as paint is likely to be.

As to cutting and filling, there has also been considerable gain in our knowledge and practice. It is now thought that the finer the corn is cut or shredded, the better, primarily because there is more even distribution of the parts of the ears and stalks, and because the finer the material is cut the more readily and evenly will the settling take place, thus again preventing the ready access of air. It has been demonstrated, also, that the necessity of very rapid filling of the silo, and the subsequent pressure, are not such important considerations as was formerly supposed.

Corn may be ensiled at the convenience of the farmer, providing the fermentation does not proceed so far as to cause rotting between times of filling. The development of heat in the silo cannot be avoided, and does not necessarily occasion great loss of substance, although fermentation always results in more or less breaking down of substance, and in some loss; in the case of corn, this loss is chiefly in the carbohydrates.

When the work can proceed steadily, from eight to fifteen tons per day may be put in small and medium-sized silos, but, as already indicated, the silage should not stand more than two days between successive fillings. The importance of thoroughly compacting silage at the time of filling the silo is not usually sufficiently well understood. The thorough tramping not only enables a much

larger quantity of silage to be put in, but it expels at once a very large volume of air, which, if allowed to remain, prolongs the changes. It should be tramped well around the sides because the lateral pressure of the silage tends to develop friction against the walls, which prevents its settling.

In building a silo, it should be as deep as it is practicable to make it. The advantages of a deep silo are that the largest quantity of feed per cubic

*Table Giving the Approximate Capacity of Cylindrical Silos for Well-Matured Corn Silage, in Tons

Depth, feet	Inside diameter in feet											
	15	16	17	18	19	20	21	22	23	24	25	26
20..	58.84	66.95	75.58	84.74	94.41	104.6	115.3	126.6	138.3	150.6	163.4	176.8
21..	62.90	71.56	80.79	90.57	100.9	111.8	123.3	135.3	147.9	161.0	174.7	189.0
22..	67.35	76.52	86.38	96.84	107.9	119.6	131.8	144.7	158.1	172.2	186.8	202.1
23..	71.73	81.61	92.14	103.3	115.1	127.5	140.6	154.3	168.7	183.6	199.3	215.5
24..	76.12	86.61	97.78	109.6	122.1	135.3	149.2	163.7	179.0	194.9	211.5	228.7
25..	80.62	89.64	103.6	116.1	129.3	143.3	158.0	173.4	189.5	206.4	223.9	242.2
26..	85.45	97.23	109.8	123.0	137.1	151.9	167.5	183.8	200.9	218.8	237.4	256.7
27..	90.17	102.6	115.8	129.8	144.7	100.3	176.7	194.0	212.0	230.8	250.5	270.9
28..	94.99	108.1	122.0	136.8	154.4	168.9	186.2	204.3	223.3	243.2	263.9	285.4
29..	99.92	113.7	128.3	143.9	160.3	177.6	195.8	214.9	234.9	255.8	277.6	300.2
30..	105.0	119.4	134.8	151.1	168.4	186.6	205.7	225.8	246.8	268.7	291.6	315.3
31..	109.8	124.9	141.1	158.2	176.2	195.2	115.3	236.3	258.2	281.8	305.1	330.0
32..	115.1	135.9	147.8	165.7	184.6	204.6	225.5	247.5	270.5	294.6	319.6	345.7

In this table the horizontal lines give the number of tons of silage held by a silo having the depth given at the head of the column.

*Bulletin No. 83, of the Wisconsin Agricultural Experiment Station.

foot can be stored; the silage packs tighter and loss is prevented at the surface when feeding; and when closely tramped against the wall, air is excluded and the silage keeps better than when it is shallow.

The quantity of silage that may be stored in a silo increases in a higher ratio than the depth increases; a silo thirty-six feet deep will store nearly five times as much as one twelve feet deep.

Cutting corn for the silo may be done either by hand or by the "self-binder." When the crop is large enough, the latter is preferable, because a team may do the cutting late in the afternoon or early morning, and thus reduce the number of men needed. Besides, the binding of the corn makes it much easier to handle, both in loading and in feeding. There are a number of excellent silage cutters. The mistake commonly made by farmers is in getting those that are too small; it is better to have a cutter a little larger than is needed. Few should have cutting blades less than fourteen inches long. It is also very important that the power to drive the cutter should be considerably in excess of its guaranteed capacity; especially is this the case when blowers are used, instead of carriers, as it is important to have not only a high speed but a steady power.

After the silo is filled, the top should be covered with earth or other material, which will

pack tightly, so as to prevent the ingress of air. Many farmers recommend the thorough wetting of the surface, a light covering of soil, and the seeding of oats, as the cheapest and surest way to make the silo tight. While there is considerable loss under the very best methods of handling and packing the corn in the silo, chiefly falling on the carbohydrate group, these losses have been shown to be no greater than those which take place in the common handling of the corn after it has been cut and husked. The changes in the silo, other than direct losses of carbohydrates, are due chiefly to modifications in the nitrogenous nutrients, the albuminoids being changed into other forms, even though the feed value is not seriously reduced.

In the construction of the winter silo, the size should be so adjusted to the number of cattle as to allow a removal of about two inches of the surface per day. In the summer silo there should be a removal of three to four inches, otherwise the heating or fermentation which begins as soon as the surface layer is removed, will result in considerable changes, and consequent reduction in the food value of the silage. What is termed "sweet silage" is possibly a misnomer, although there is great difference in the composition of silage made and used under the conditions here outlined. The development of acid is very rapid, if the air is

allowed to come in contact with the silage for reasonably short periods.

The amount of silage to feed

The quantity of silage to feed should be regulated to some extent by the kind of silage and the size of the animals. It should never serve as the exclusive food, but mainly to supply carbohydrate roughage. From thirty to thirty-five pounds per day, containing say 28 to 30 per cent of dry matter, are sufficient for an animal of 1,000 pounds live weight. The feeding of silage should be accompanied, of course, by the use of the proper fine or concentrated feeds, and preferably with a little dry material, as cut corn-stalks or hay. When fed in this way, the results are altogether good.

There have been no genuine investigations showing that silage causes any injury, when properly fed, or is in any way deleterious to the health of the animals, or unfavorably affects milk, butter or cheese. On the contrary, the health of animals in winter is usually better under the use of the succulent food, and the returns per unit of dry matter for silage used in the dairy, compared with the dry fodder corn, are about 12 per cent greater. These results have been secured in actual experiments to determine the relative

value of the two kinds of forage. There is no question, therefore, of the value of this method of preserving corn for food. Whenever farmers have a sufficient number of dairy, beef or young cattle to warrant the building of a silo, there will be no question as to the advantage of the system.

The gains in the making of silage over the using of the grain and stover, are, (1) the prevention of mechanical losses in the harvesting of the corn; (2) the advantage of the removal of the entire crop at one time, so as to permit of a more rapid growth and development of cover-crops, which are so important in the conservation of fertility; (3) reduction in actual cost of labor per unit of feed obtained, which will result whenever farmers are equipped for the rapid handling of large quantities of material in a short time. The silo is as much a part of the equipment of dairy farms in the North and East, as the corn-crib is of the farms of the West.

COMPOSITION OF CORN FODDER AND SILAGE

	Dried fodder Per cent	One ton contains Lbs.	Stover Per cent	One ton contains Lbs.	Silage Per cent	One ton contains Lbs.
Water	42.20	. . .	40.50	. . .	79.10	. . .
Dry matter .	57.80	1,156	59.50	1,190	20.90	418
Ether extract.	1.60	32	1.10	22	0.80	16
Fiber	14.30	286	19.70	394	6.00	120
Protein . . .	4 50	90	3.80	76	1.70	34
Ash	2.70	56	3.40	68	1.40	28
Nitrogen-free extract . .	34.70	694	31.50	630	11.00	220

CHAPTER X

LEGUMINOUS FORAGE CROPS

EVERY farmer is now familiar with the group of leguminous crops. This group deserves even more attention than it is now receiving, because of the relations of the plants to nitrogen. The plants belonging to the legume family include the various clovers, peas and beans. All these plants have a source of supply of plant-food that is not accessible to most other plants, particularly not to the cereal plants. It is well known that after a crop of clover the land, as a rule, produces a better growth of corn, or other cereals, than when such a crop follows a grain or a grass crop. It was thought for a long time that this improvement in land was due to the greater proportion of root substance in the surface soil, because the plants root deep and gather food from the lower layers, storing it in the thickened roots. The soil improvement was not attributed to their power of gathering nitrogen from the air until careful experiments showed that the soil nitrogen was not consumed but rather increased by their growth. The fact that clover gives better returns as a stock feed than an equivalent weight of timothy was also known for a long

time, and investigation of the composition of the two showed that this difference was due to a larger proportion of nitrogenous substance in the clover than in the timothy.

It is now known that the individual members of this group of plants possess the peculiar property of being able to secure the important element nitrogen, in part, at least, from the air. Therefore, they may not need nitrogenous fertilizers after they are well established, and they may add to the nitrogen content of the soil when they are returned to the earth. The advantage of leguminous crops to the feeder lies in the fact that the plants themselves contain a larger proportion of nitrogenous matter than those of the grass family, and thereby may be used to supplement other foods and to reduce bills for purchased and concentrated feeds. One can more profitably utilize the carbohydrates usually contained in excess in other plants; and he is relieved of some of the necessity of purchasing nitrogenous fertilizers to increase the growth of the cereal crops.

Soil inoculation

While leguminous crops possess this superior advantage in the ability to appropriate nitrogen, it must be remembered that this power is not constant for all soils and under all conditions; but in order

that this peculiar function may be exercised, it is necessary that there shall be present in the soil certain organisms which attach themselves to the roots of the plants. The presence of these organisms is indicated by the formation of tubercles or nodules on the roots, which range in size on different kinds of plants from that of a pin-head to that of a pea. When these nodules are not present, it is usually an indication that the proper organisms are absent and that the legumes, in common with other plants, must derive their nitrogen from the soil; and thus, from the standpoint of accumulation of nitrogen, they are probably no more useful than the cereal or other crops.

Investigations of the life-history of these minute organisms show that there are certain conditions unfavorable for their growth and development, which explains why they are absent in many soils For example, it has been shown that they are likely not to be present in soils that are poorly drained, and when air cannot penetrate and circulate freely. It has also been found that an acid condition of soil is not favorable to their growth. They are also liable, even if originally present, to be destroyed at certain periods if soils are allowed to remain uncultivated for some time. In other words, in undrained, acid, and light sandy soils deficient in organic matter, the organisms are not so likely to be present as in those that are well supplied with

organic matter, are neutral in their reaction, and are well-drained; and these are the conditions, also, that are favorable for crops, providing sufficient food is present.

Methods of inoculation

In view of these facts, it becomes necessary, in order to secure the full benefit from the growth of leguminous crops, to see that the proper organisms are present. This may be readily accomplished by inoculation, or introducing the specific organism. Soils deficient in these organisms may be supplied by using earth from the fields in which they are known to be present. Experiments show that only a small quantity is necessary, if evenly distributed, to accomplish the purpose. From one to three hundred pounds of mixed soil, taken from different parts of the field, will be sufficient for one acre, if sown broadcast and harrowed in. The soil should be taken from a field in which the same kind of crop has been successfully grown. The organisms will multiply when legumes are grown, will distribute rapidly, and be prepared immediately to begin their helpful work. Once the organisms are present, there is little danger of their destruction under good farm practice. If the crops that are grown on this area are fed to farm stock, and the manure is used elsewhere on the farm,

the chances are that the organisms will soon be generally distributed. It is especially desirable that land be inoculated for alfalfa, if it has not grown alfalfa previously. Clover lands are not often inoculated.

It often happens that in the growing of such plants as cowpeas and soybeans, the first crop will not show the tubercles, but the second one will be well supplied with them, indicating that the organisms may be introduced by means of the seed or the dust that goes with it. Some seedsmen now make it a practice in harvesting soybeans and cowpeas to pull them instead of cutting them, thus mingling more or less of the soil with the seed in the threshing.

The organisms of different leguminous crops have recently been investigated by the United States Department of Agriculture,[1] and methods devised for providing suitable nutrients for them. As a result, cultures have been prepared and distributed, together with the food necessary for their early growth. The commercial cultures have not yet been successful in practice, however; but eventually good results may be obtained.

The grower should remember that inoculation of the soil is only one factor in the growth of these plants. Good crops cannot be grown on poor, wet, or acid soils, or under unfavorable culture condi-

[1] Bureau of Plant Industry, Bulletin No. 71, January, 1905.

tions by inoculation alone; the other conditions of growth must also be made favorable.

The amount of nitrogen gathered

It does not follow that even when these organisms are present and all other conditions are favorable, all of the nitrogen in the legume crop has been gathered from the air. It has been shown that the plants preferably take soil-nitrogen rather than air-nitrogen. On good soils containing much available nitrogen, or directly well supplied with this element, the proportionate amount of nitrogen appropriated from the air will be much less than when the crop is grown on soils poor in nitrogen, even if inoculation has been made. The amount of nitrogen gathered by a crop, therefore, cannot be exactly determined, although, as just indicated, it is thought that the usefulness of the legumes as a means of acquiring atmospheric nitrogen and adding to the stores in the soil, is greater when they are grown on soils rather poor in this element.

It has also been clearly demonstrated that the proportion of nitrogen gathered from the air, particularly on poor soils, even when the proper organisms are present, depends on the supply of the other necessary plant-food ingredients. Soils poor in nitrogen and uncongenial in physical character

will not produce a large crop of any leguminous plant unless well supplied with phosphoric acid and potash. Therefore, in attempts to increase the protein supply of the farm by means of leguminous plants, it is quite as necessary to fertilize with the minerals as it would be to grow any other crop. This is entirely reasonable, as the mineral constituents cannot be secured from any other source than the soil and these are quite as essential to leguminous crops as to any others, or as the nitrogen itself.

Kinds of leguminous crops

The family Leguminosæ, or pulse family, is very large and it is represented in the flora of all parts of the globe. Some of the legumes are trees, as locusts, red-bud, yellow-wood; others are bushes, as furze, broom, lead-plant; some are tall woody climbers, as wistaria; others are agricultural herbs, some of which are grown for forage, as alfalfa, clovers, cowpea, soybean, velvet-bean, vetches, pea, and these are to be considered further in the three chapters that follow.

Fig. 33. Oats-and-peas.

CHAPTER XI

COMBINATION CROPS WITH LEGUMES

VARIOUS crops may be grown in combination, in which leguminous plants occupy an important place. The combination crops with legumes afford a very perfect balancing of nutrients, they often increase the acre yield, and sometimes they afford the best means of utilizing land. These combinations are of three groups: (1) Hardy annual legumes (peas and vetches) grown with cool-season cereals; (2) tender annual legumes (cow-peas, soybeans, velvet beans) grown with warm-season cereals; (3) mixtures of clovers and grasses. When carefully managed, these combinations give the desirable results of each of the ingredients and afford another resource to the stock feeder.

OATS-AND-PEAS FOR FORAGE

The oats-and-pea crop is grown primarily for use as green forage, or for soiling, and it is one of the most serviceable in any forage crop rotation, supplying food when other crops are not usually available, and also making an excellent substitute for hay when it is not needed for green forage

purposes. The object of making a mixture of oats and Canada field peas is to improve the quality of the crops, as well as to increase the yield, making both the total quantity and the character of the nutrients superior to those that would be secured by using either of the crops alone. The variety of oats to be used should be a strong and vigorous grower, well adapted to the locality and to climatic conditions. Any variety that has proved itself superior as a grain-producer may be safely used for green forage. It is an advantage to select the best seed when planting for forage crops, — quite as important in the growing of forage as in the growing of grain or seed.

There is wide difference in the varieties of the Canada pea. For average purposes, probably the Golden Vine is as satisfactory as any, because it is more generally grown and the seed is cheap, and because a smaller quantity is required per acre. It is a medium-early variety. Early varieties that are very satisfactory are Canadian Beauty and Black-Eyed Marrowfat. Late varieties are Green-Scotch, Greenfield and Prussian Blue. These later varieties naturally produce a larger crop, as the period of growth is somewhat longer. Where hot weather comes on early, medium or medium-early varieties are superior. It is safer to plant a distinct variety than to depend on mixtures of various kinds, which are likely to mature unevenly.

Preparation of soil, and manuring

Oats-and-peas are usually grown on land on which a cultivated crop has immediately preceded, although good crops may be obtained on sod land if it has been plowed in the fall or very early spring and deeply cultivated. The land should be well and deeply prepared, in order to furnish a deep seed-bed for the peas. The areas best suited to the crop are cool, moist lands. When the weather is cool and moist, the season is much more favorable than when hot and dry.

This crop responds very favorably to applications of yard manures. In fact, there is no other manure that will so well or so completely meet the requirements; the organic matter contained in it aids materially in the development of the soil bacteria, and the soluble nitrogenous and mineral salts feed the plants abundantly in the early stages of growth. The manures should be broadcasted at the rate of eight to ten tons per acre after plowing, and thoroughly harrowed into the soil. When a smaller quantity of manure must be used, it may be fortified by an application of a good fertilizer mixture whose constituents have been derived from good sources and containing

Nitrogen	4 per cent
Phosphoric acid (available)	6 per cent
Potash	6 per cent

Fig. 34. Oats-and-peas for soiling or for hay.

This may be applied either broadcast, or drilled with the seed at the rate of 200 to 300 pounds per acre. Owing to the fact that the crop makes an early growth, the particular need is for an abundance of available nitrogen.

Quantity of seed, and methods of seeding

The quantity of seed used on good soils is generally about one and one-half bushels of oats and one and one-half bushels of peas each per acre, although as thick seeding as two bushels of each has been even more successful on well-enriched soils. Many variations may be made in the proportions, however, to suit the various conditions of cost of seed, kind of soil and time of seeding. Sometimes increasing the peas to two bushels or two and one-half bushels, and decreasing the oats to one bushel, is practiced.

The crop should be seeded as early in spring as it is possible thoroughly to prepare the soil. The earlier the crop is planted, the greater will be the likelihood of a perfect crop, as both oats and peas suffer in the hot dry days of summer. It is a common practice to sow the peas from five to eight days earlier than the oats. Many growers recommend that the peas be plowed-in from four to six inches, in order that they may root deeply, and thus be better able to resist heat and drought.

Many other successful growers prefer to use the ordinary grain-drill for the peas and plant them as deeply as possible, following with the oats a few days later, and before the peas have sprouted. The experience at the New Jersey Experiment Station, where this crop has been an important one for eight years and where different methods have been used in seeding, has shown that it is not a profitable practice there to expend the extra labor required in plowing-in the peas or in seeding the two plants at an interval of a few days. Quite as even distribution and as large yields have been secured when the oats-and-peas have been mixed in the grain-drill, and all seeded together. It is important in any case that the seed be distributed evenly.

Time of cutting oats-and-peas

When seeded as early as it is possible to prepare the land, the first cutting for green forage will be ready in about two and one-half months. Because of its good proportion of nutrients, it may be used as the exclusive source of food for dairy cows, although this is not a desirable practice when it is the purpose to keep the animals up to full standard of production, as it would require about 100 pounds of the forage per day.[1]

The best time for cutting is when the oat-grain

[1] New Jersey Experiment Station Bulletin, No. 130

Fig. 35. Oats-and-peas for soiling. A vigorous growth of both plants.

Fig. 36. Oats-and-peas, showing great vigor of the peas.

is in milk and the peas are forming pods; at this period, the largest amount of digestible matter may be secured. Because of the rather slow maturity of the crop, particularly if the weather is favorable, a single seeding of oats-and-peas may furnish supply for eight to ten days, providing cutting begins a little earlier than this, or when the oats are just headed out.

When it is desirable to continue the feeding longer, a second seeding is usually made about ten days after the first. In ordinary seasons this will be ready eight to ten days after the first planting. A third seeding made eight or ten days later than the second is likely to be ready for use relatively earlier, however, owing to the more rapid development of the crop as the hot and dry weather advances.

In recent years a plant-louse has made its appearance in the eastern and southern coast states, and has been a very serious pest, attacking the peas and practically ruining the crop. Where this pest is present, the later seedings should not be made, as it attacks the plants at the end of June or the first of July, when early seedings have reached the cutting stage, and before later seedings have reached full development. When an abundance of fertilizer has been used, the plants are better able to resist or outrun the attacks of the insect.

Yield, uses, and quality of crop

The yield varies widely, ranging from six to twelve tons per acre. The early cuttings are not rich in dry matter, although the average is higher than for some other forage crops. The oats-and-peas crop gives a relatively higher percentage of protein than is obtained in wheat, rye or grasses, and it serves a very good purpose as a balanced ration.

This crop also makes most excellent hay, palatable for all kinds of farm stock, and much richer in the digestible nutrients than timothy, though not so rich in protein as clover. It should be cut for hay when at its best for forage, namely, when the oats are in the milk stage, and when the peas are forming pods.

A larger yield of dry matter may be secured by allowing the two crops to ripen, harvesting and threshing the mixed grain crop, grinding the grain and using it for feed and using the straw as roughage. The expense of this practice is much greater than that of hay-making, and the yield of digestible matter has been found to be no greater. An experiment at the New Jersey Station[1] to test this point showed that while the cured grain crop gave a larger yield of total nutrients than the crop cured as hay, the expense of the former method was

[1]Annual Report for 1901, p. 278

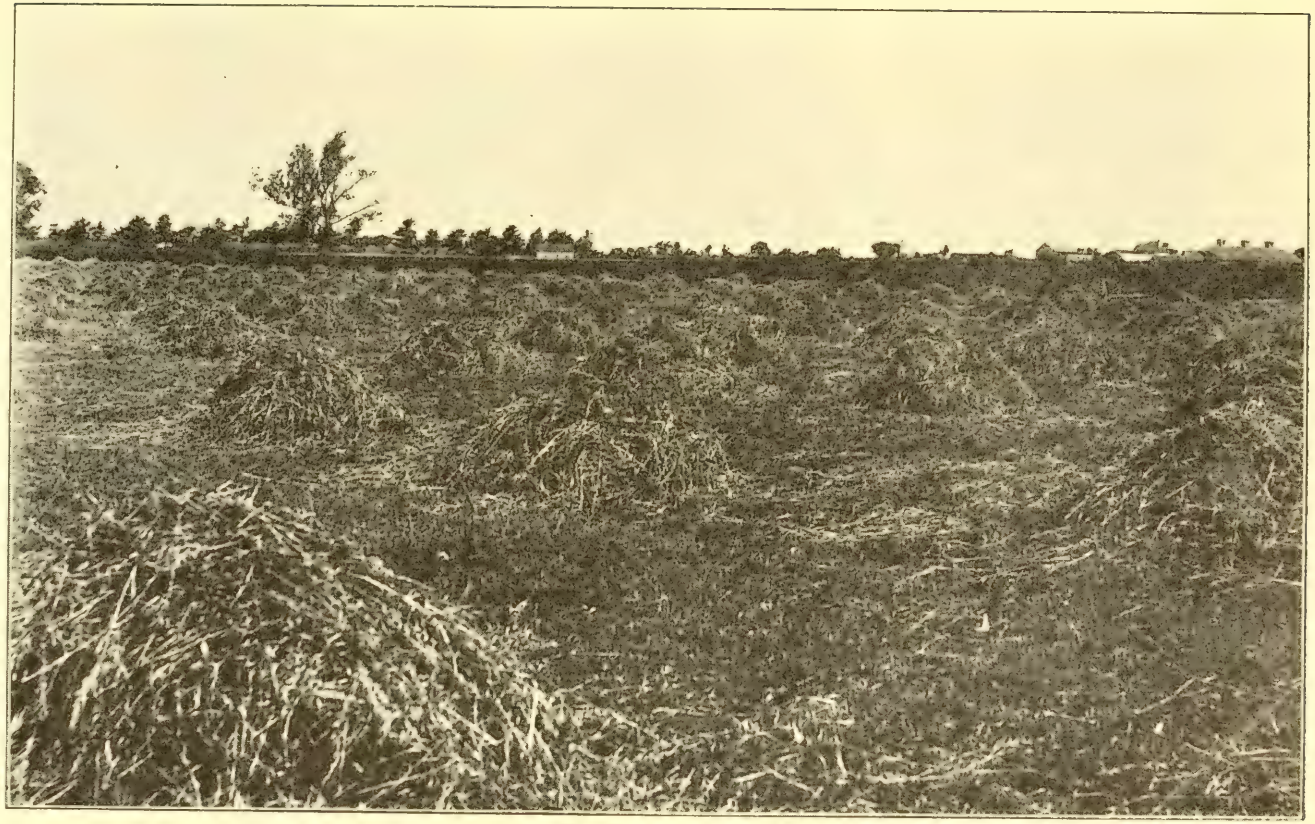

Fig. 37. Oats-and-pea hay.

much greater. The hay cost $8.24 per ton, and the oat-and-pea feed, $22.60, and the oat-and-pea straw, $6 per ton. The use of five pounds of the straw and seven pounds of the oat-and-pea feed resulted in 2.6 per cent larger yield of milk than fourteen pounds of the hay, although the feed cost of milk per hundred was 61.6 cents, when the oat-and-pea ration was fed, and 49.9 cents when the oat-and-pea hay ration was fed. The experiment showed clearly that both rations are palatable and digestible, and can be successfully used as partial substitutes for purchased feeds, although indicating the greater economy as a source of nutrients of the oat-and-pea hay. Allowing the crop to ripen, therefore, is not a profitable practice, excepting when labor is abundant and cheap, or when it is more desirable to produce fine feeds than to purchase them.

Composition of Oat-and-Pea Crops

	Water	Fat	Fiber	Protein	Ash	Nitrogen-free extract
	%	%	%	%	%	%
Oat-and pea-green forage	79.44	0.70	6.19	2.04	1.59	10.03
Oats and peas, matured	17.68	2.57	23.76	9.44	5.83	40.72
Oat-and-pea hay	31.27	1.96	22.80	7.00	5.80	30.50
Oat-and-pea straw	9.21	2.33	32.83	4.11	6.89	44.63
Oats and peas, ground	9.92	3.81	10.91	16.73	4.72	53.91

These analyses are the average of those made at the New Jersey Station, where the pea is used in larger proportion than is here given, or at the

rate of two bushels of peas to one or one and one-half bushels of oats. This proportion is frequently desirable, depending on the relative price of seed and adaptability of soil. The forage and hay will be much richer in protein than is given in these analyses.

When this crop is seeded primarily to supplement natural pastures, it is often used as pasture rather than as a soiling crop. This is a very wasteful practice, as under the best conditions of pasturage not more than one-third to one-half of the actual food will be used by the animals.

Observations of the effect of feeding of oat-and pea forage to dairy cows show that it exerts a very favorable influence on the physical quality of milk. When farmers are raising their own milk and selling it to special customers, there are very great advantages in using this crop, either as green forage or as hay.

OATS-AND-VETCH

The methods or practice used in the growing of oats-and-peas apply in the case of oats-and-spring-vetch (*Vicia sativa*). This crop is not so palatable as oats-and-peas and has not been so generally used. The chief difference in management is in the quantity of seed used per acre. Thus far, the seeding of one and one-half bushels of

Fig. 38. Oats-and-spring-vetch for soiling.

oats and three-fourths of a bushel of vetch has been very satisfactory. The vetch makes much more leaf, and is not so firm a grower as the pea, but under favorable conditions it will make a large yield. It is not open to the disadvantage of being attacked by the pea-louse, and thus will serve in combination with oats when later seedings of oats-and-peas are found to be undesirable. The method of harvesting and feeding are the same as for the oats-and-peas.

This crop also makes an excellent hay, the vetch contributing the protein in larger proportion and making a food rich in nitrogenous nutrients. When the vetch is allowed to mature, it shells rapidly, and unless care is used may prove a nuisance by volunteering as a weed.

BARLEY-AND-PEAS

For late feeding, a combination of barley and Canada field peas is desirable, as the pea makes a luxuriant growth in late fall and is not injured except by heavy freezing; and the pea-louse, which is so destructive to the spring-seeded Canada pea, usually does not attack the fall-sown crop. The quantity of seed should be about one and one-half bushels of barley and one and one-half bushels of the pea, seeded in the same way as oats-and-peas, preferably from the first to the middle of August.

The composition of this product does not differ materially from that of oats-and-peas, although, owing to the fact that it does not mature, it is naturally a little richer in protein than the oats-and-peas. It can be fed in the same way, except that a smaller quantity should be used,—from forty to fifty pounds per day. Where this crop can be successfully grown it is very useful, as it lengthens the soiling period by at least two weeks.

WARM-SEASON COMBINATIONS

In addition to such combinations of soiling crops as oats-and-peas, oats-and-vetch, rye-and-peas, there are others which at times at least are advantageous, although experiments have not yet been sufficient to determine whether under all circumstances it is advisable to use them. The leading crops that may be used for these combinations are: corn, sorghum, kafir corn and millet, seeded with cowpeas or soybeans. The advantages of the combining of these crops are (1) the production of a more nearly balanced ration; (2) the larger yield that may be secured per acre, when all conditions are favorable; (3) the greater certainty of a paying crop when conditions are unfavorable for one or the other alone.

For summer soiling, the advantages of growing kafir corn with cowpeas or soybeans, or of barn-

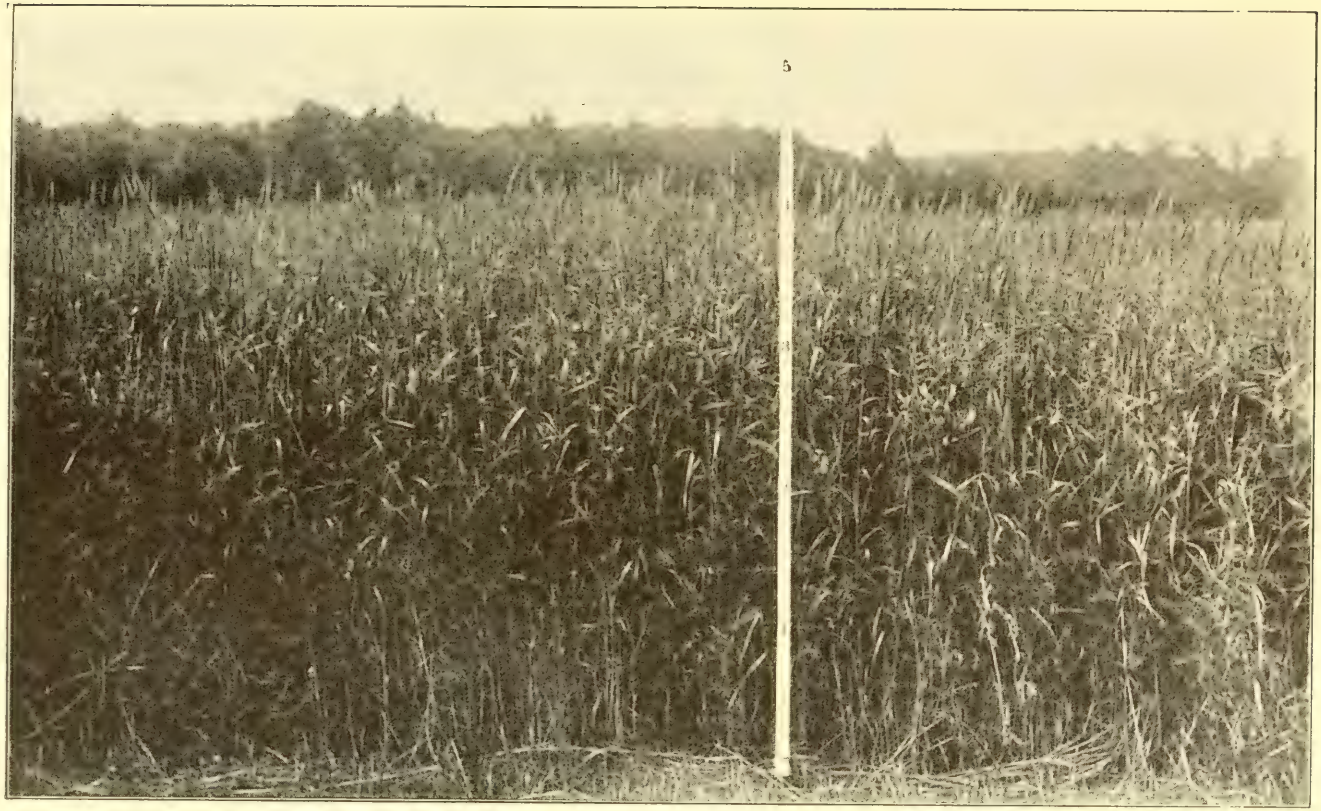

Fig. 39. Wheat-and-winter-vetch for soiling. A poor stand of vetch.

Fig. 40. Wheat-and-winter-vetch. A good stand of vetch.

yard millet with cowpeas, are usually abundantly apparent. With the latter combination, unless the season is very warm, the millet will mature earlier than the cowpeas, yet there is the advantage that the corn or millet supports the cowpea, making the cowpea easier to harvest, prolonging the period of profitable use, and providing a much better ration. Very excellent yields have been secured with these combinations. Kafir corn or millet may be utilized for a longer period than if either the kafir corn or millet were used alone, which is at times a matter of very considerable importance.

In the case of maize-and-cowpeas or soybeans, the advantages of the combination are usually not so apparent, although in certain regions the combinations have been found to be very desirable, and have been recommended particularly for silage, since the combined crop provides a practically balanced ration for winter feeding. The trouble is that if a sufficient quantity of nutrients is to be provided in a succulent ration made up of maize and cowpea silage, a too large quantity must be used in order that the animals may secure a sufficient amount of dry matter. A safer, although a slightly more expensive method, is to plant the maize-and-cowpeas separately, and make the cowpeas into hay. Silage and cowpea hay are not open to this objection, as the succulent ration need not exceed thirty to thirty-five pounds per day.

Sorghum-and-cowpeas, or sorghum-and-soybeans, make an excellent summer forage, providing the sorghum is seeded rather thickly and harvested before it has nearly reached maturity.

The quantity of seed recommended for all these combination crops is one-half that used when each of the crops is grown singly.

MIXED GRASSES AND CLOVERS

On most farms in the dairy sections of the country, timothy, red-top and clovers (both red and alsike), and timothy and clovers are two mixtures generally used for pasture and hay-making. When the purpose of growing forage crops is primarily to supplement natural pastures, this crop of mixed grasses and clovers serves a most excellent purpose in supplying the need in emergencies. In many localities, the grasses are seeded in the fall with field crops, as with wheat or rye, and the clovers are seeded in early spring, either without covering or with light harrowing.

When immediate and large returns are important, seedings may be made without cover-crop in the late summer or early fall. The best time of seeding has been found to be from the middle of August to the first of October, depending on the locality. At the New Jersey Experiment Station, many tests have been made as to methods and

times of seeding, and it has been found that for that locality (which would probably be true for a large part of the East) this method of seeding in late summer without nurse-crop is a very desirable one, as the seedings may be made after other crops are removed, as, for example, after potatoes, oats, or even after the same grass mixture when the land has been plowed immediately after the hay has been removed, and cultivated frequently before seeding. It is not necessary that the land shall have been planted with wheat or rye, as is the general custom; the seedings are more liable to take when this old practice is not followed.

The preparation of soil, and seeding

Frequent and thorough cultivation of land during the entire preceding summer, accompanied by heavy fertilization, is strongly recommended, although this is not found to be feasible by all growers; the principle is correct, however, and whenever the areas are not too large and when the farmer has abundant capital for the purchase of fertilizers, it may be profitably followed. In general, however, the conditions do not warrant such an expensive mode of preparation and seeding, and a system has been developed at the New Jersey Station which is entirely practicable under what may be regarded as more extensive condi-

Fig. 41. Corn-and-cowpeas for silage, the cowpeas planted five days after the corn.

tions, not requiring so large an outlay of labor and money. By this method the land from which crops are removed early enough, is plowed in July and thoroughly and frequently tilled until about the middle of August; this frequent tillage destroys many weed seeds, ensures a thorough division of the soil particles, and conduces to the unlocking of plant-food and encouraging the growth and development of soil bacteria. When the main purpose in the use of either of these mixtures of grasses and clovers is to secure hay, and to have the land remain in permanent meadow, the use of yard manures immediately before seeding is not generally desirable, owing to the danger of adding weed seed, although the thickness of the seeding of grasses and the treatment of the fields in respect to top-dressing will overcome this danger to some extent.

When it is found desirable to re-seed, it is not necessary that the sod be planted with other crops, but it may be at once re-seeded with the grasses, provided it is plowed immediately after the first cutting has been removed, and thoroughly tilled in the months of July and early August. This practice will permit a continuous growth of a crop that is suitable for green forage, although grown primarily for pasture and for hay.

The quantity of seed required will depend to some extent on the character of the land and its

preparation. When the land is naturally good and well prepared, the quantity of seed may be relatively large; but if it is poor and in bad condition, a large quantity of seed will not encourage a proportionately heavy growth, as a great number of young plants will perish because of the lack of a proper medium for their growth and nourishment. The following seed mixture has been used with very great success, and as a general grass and clover mixture for dairy farms can be strongly recommended, because it is one for which the seed can be readily obtained, is not expensive, and possesses a sufficient number of distinct plants to permit of complete occupation of the land:

Timothy	8 pounds
Red clover	4 pounds
Alsike	2 pounds
Cleaned red-top	2 pounds

This mixture should be sown at the rate of twenty to thirty pounds per acre,—not less than twenty pounds on medium soil, and as much as twenty-four to thirty pounds or even more on very good soil. If seeded in the middle states any time from the middle of August to not later than September 20, this mixture of grasses and clovers will make sufficient growth in fall to cover the ground completely, and prevent the starting of weeds, and under good climatic conditions will successfully survive the winter.

Fig. 42. Corn-and-cowpeas, planted after a soiling crop of wheat had been harvested.

Fig. 43. Cowpeas-and-kafir-corn, showing height and thickness.

Manures and fertilizers

It has been shown by experiments that a liberal supply of plant-food from artificial sources is quite as serviceable in supplying the plants with their needs as a supply from natural manures, provided there is sufficient organic matter in the soil. If the cost of actual plant-food is taken into consideration, the increase in crop may be secured at a lower cost with the artificial than with the natural manures. A primary consideration is that the land shall be in good tilth, and the preparation and cultivation made as previously recommended; and there should be an occasional application of lime,—at least once in five years,—at the rate of twenty-five bushels per acre. This general practice will greatly improve the soil in physical character, and prevent to a large extent the compacting which would be likely to follow a continuous use of chemical fertilizers, without the direct addition of vegetable matter. Under these conditions the following recommendations as to fertilizers are made. In summer, while the land is being prepared, a few days previous to seeding, apply broadcast a fertilizer rich in minerals, as

Ground bone	150 pounds
Acid phosphate	600 pounds
Muriate of potash	250 pounds

This mixture should be applied broadcast at the rate of 300 to 500 pounds per acre; and at time of

seeding a further application should be made of 300 pounds per acre of a commercial fertilizer, containing

Nitrogen	3 per cent
Phosphoric acid (available)	6 per cent
Potash	5 per cent

This will ensure an abundance of the mineral elements, and sufficient nitrogen to supply the immediate needs of the plant and to encourage a vigorous growth in the fall. If the land is in good condition, and the plants winter well, a top-dressing on the first cutting is not usually required, although, in order to ensure a good second crop or aftermath, it is desirable that the top-dressing be made after the first crop is removed, preferably of the formula mentioned for seeding down, at the rate of 300 to 400 pounds per acre. The second season, the crop is likely to be made up largely of timothy and red-top, the clovers having disappeared, and a top-dressing should then be made early in the spring, as soon as the grass has well started, of a fertilizer rich in available nitrogen, in order that the plant may have a nitrogenous food that it can appropriate rapidly when it needs. Therefore, a mixture of

Nitrate of soda	500 pounds
Ground bone	200 pounds
Acid phosphate	200 pounds
Muriate of potash	100 pounds

may be applied broadcast at the rate of 200 to 300 pounds per acre. This will stimulate and strengthen any weak plants, and provide all plants with the nitrates, so essential at this season of the year.

To ensure a large second crop of forage, immediately after the first crop is removed a further application of the top-dresser formula should be made, and at the same rate. It must be remembered that if a rapid and large growth of succulent food is to be secured, the plants must be abundantly supplied with all the essential constituent elements; and since the crop is one that does not have to be reseeded annually, a very considerable increase in the cost of the fertilizer may be allowed in lieu of the preparation and re-seeding that would be necessary if not abundantly fed and if weeds and foreign growths had encroached.

While the amount of fertilizer recommended may seem large to the farmer accustomed to extensive practice, trials at a number of Experiment Stations, notably, Rhode Island (Bulletin No. 99, "A Six-Year Rotation of Crops"), and the experience of growers, notably George E. Clark, Higganum, Conn., show that if large yields of hay or forage (from four to six tons of the former per acre per year) are to be secured, this liberal use of fertilizers is desirable, for the profits are greater. The Rhode Island Experiment Station

finds to be profitable an annual application of 1,050 pounds per acre of a mixture of

Nitrate of soda	350 pounds
Muriate of potash	200 pounds
Acid phosphate	500 pounds

Clark recommends, for seeding down, an annual application of 400 to 800 pounds per acre of a mixture of

Ground bone	1,000 pounds
Muriate of potash	800 pounds
Nitrate of soda	200 pounds

and two top-dressings of 200 to 300 pounds each of an equal mixture of ground bone, muriate of potash and nitrate of soda. These larger applications, however, assume a much more thorough preparation of land previous to seeding than is outlined here.

Values of mixed forage crops

A crop of mixed grasses and clovers is useful for green forage from about June 20 to July 10, according to the locality and season. It is one of the most palatable and useful of our forage crops, making a well-balanced ration in itself, and producing a relatively large yield of dry matter.

Fig. 44. Cowpeas-and-kafir-corn.

Fig. 45. Sorghum-and-cowpeas, in rows, ready for soiling. Sorghum alone at the left; sorghum-and-cowpeas at the right.

COMPOSITION AND YIELD OF NUTRIENTS OF MIXED GRASSES AND CLOVER FORAGE

	Per cent	One ton contains Lbs.	An average acre-yield contains Lbs.
Water	75.00	. . .	. . .
Dry matter	25.00	500.0	4,000.0
Ether extract	0.75	15.0	120.0
Crude fiber	7.95	159.0	1,272.0
Protein	2.89	57.8	462.4
Ash	1.57	31.4	251.2
Nitrogen-free extract	11.85	237.0	1,896.0

A good first crop of mixed grasses and clovers will yield, on the average, about eight tons per acre of a product relatively rich in protein, and of a highly digestible character. The second crop will range from four to six tons, depending on the season. If the clovers are abundant, the second crop will be richer in protein than the first cutting. The yield of digestible nutrients from an acre of this crop will compare favorably with that of any other crop of this class, and it will be well adapted to the purpose. Owing to the high content of dry matter in the various grasses, the usual quantity used,—fifty pounds per day,—will supply a larger portion of nutrients than is furnished by the same quantity of rye or wheat, and thus reduce the amounts of fine feeds required, a very important matter in most cases.

For hay suitable for the dairy, these mixtures

are very superior. Yields have been secured, under good conditions, ranging from three to four tons per acre from the first cutting, and frequently one ton and a half in the second cutting, making it also a very profitable crop from the standpoint of supply of nutrients. It is not recommended that fields that are intended to serve as hay should be pastured, although the pasture is of excellent quality.

If made into hay for use on the farm, the crop should be cut before it matures, if the largest quantity of highly palatable and digestible dry matter is to be obtained. When the plants are in blossom, or immediately after,—if there is a large proportion of the grasses,—may be regarded as the best time to cut under average conditions. The plants harden rapidly after this period, increasing proportionately the indigestible woody fiber and decreasing the digestible protein. Timothy grown for market purposes may be cut at a later period, for market conditions demand well-matured, though not over-ripe hay, and increased yields are secured if cut at this later period.

CHAPTER XII

ALFALFA

THE leguminous forage plants may be classed into three groups: perennials, biennials, annuals. Of the perennials, the plant most useful for forage, and the one that occupies the relative position among the legumes that corn does among the cereals, is alfalfa, although it differs from corn in having a more restricted habitat or adaptability, not so readily conforming to a wide range of soils, climate or conditions of growth. It should be said, however, that alfalfa has not yet received the careful attention that its merits warrant, and the chances are that a wider study of the plant will show that it is adapted to conditions which are not now thought to be satisfactory. The chief difficulty in the growing of the plant thus far, particularly in the eastern and middle western states, is in securing and maintaining a good "stand."

Alfalfa is not a new plant. It has been cultivated in Europe for nearly two thousand years, and is well known in both North and South America. It was introduced into California from Chili nearly fifty years ago, and its use has gradually spread eastward. Long before this, however,

it had been introduced into New York from Europe. It is now regarded as one of the most important forage-crop plants in those states where irrigation is practiced. About fifteen years ago, it was found that it could be successfully established in those states where there is shortage of rainfall, but where irrigation is not practiced, as, for example, in Kansas, in which state the area in alfalfa has rapidly increased and where it is now regarded as one of the most important forage crops. It has also been the subject of experiment in many of the eastern and middle states, notably New York, New Jersey and Maryland, and the results secured in recent years show that with proper care in the preparation of the land for seeding, and in subsequent management, it may be profitably grown. In many parts of the eastern states it is now an established forage crop.

Once well established the plant will last a number of years, from four to ten or more, depending on the character of the land, the treatment in reference to manuring, methods of cutting, and freedom from weeds and grass. The annual upright, branching stems do not sprout when cut, but die back to the crown, when new shoots start and grow rapidly. The roots extend much deeper than those of most plants, sometimes reaching a depth of twelve feet or more, under favorable conditions. For this reason alfalfa should not be grown per-

manently in orchards, as its deep roots are liable to injure those of the trees. It is often able to adapt itself, however, to soils in which the roots cannot extend very deep.

Land, and its preparation

Alfalfa grows well on varying kinds of land, providing the subsoil is open and porous. The most favorable land is a rich, somewhat sandy loam, warm and friable, with a deep and loose or gravelly subsoil, well supplied with lime. A dense clay or hardpan subsoil is most unfavorable. Although rich land is preferable, alfalfa does well on poor, well-drained gravelly soils if well provided with the mineral elements, as phosphoric acid, potash and lime. While the plant requires much water, it will not flourish where the water-level is too near the surface, say nearer than eighteen inches, or when the ground is saturated, or where, when flooded, the water stands more than two or three days. Acid lands are uncongenial.

The field intended for alfalfa should be treated the season preceding so as most effectually to subdue all weeds and cause the sprouting and destruction of any weed seed in the ground. Farmyard manure should preferably not be used for at least one year before seeding, as it favors the growth of weeds.

Owing to the practically permanent character of alfalfa, it will well repay the expense of careful and thorough preparation of the land. This is very important in order to secure a good "stand." If the subsoil is hard and compact, the subsoil plow should be used. If a piece of sod land is to be converted into an alfalfa field, it should be plowed and planted with some cultivated crop the first year or two, in order to put the soil into good physical condition as well as to destroy all tufts of grasses which may spread, as grass is the worst enemy of alfalfa. It is desirable to have the soil somewhat compact for the seed, and therefore, it is better not to sow alfalfa on new-plowed ground. Plowing should be completed as long before sowing as possible, and the land should be rolled to compact it, and afterward lightly harrowed to leave the surface finely pulverized, and to prevent loss of moisture.

Manures and fertilizers

Alfalfa is a heavy feeder, and will not thrive on lands deficient in plant-food. It is especially desirable that the soil contain abundance of lime, both in order to supply the needs of the plant and to correct any possible acidity, for, as already stated, acid soils are unfavorable for the growth and development of the organisms that are neces-

Fig. 46. Alfalfa in New Jersey, an acre yielding nineteen tons of green forage a year.

sary to enable the plant to gather the atmospheric soil nitrogen.

The fertilizers should contain chiefly potash and phosphoric acid, and, although alfalfa is capable of obtaining atmospheric nitrogen, it responds quickly to applications of nitrogenous manures, particularly in its early growth. The lime and fertilizers should be spread broadcast and harrowed in previous to seeding. The lime should be applied, when possible, to the preceding crop, in order to ensure its thorough distribution and incorporation with the soil. The following applications per acre are recommended in the East, even on good lands:

First year, before seeding, thirty-five bushels of stone lime and a mixture containing 3 per cent nitrogen, 10 per cent available phosphoric acid and 5 per cent potash, at the rate of 400 pounds per acre. When there is a known deficiency in mineral elements, as in sandy soils, these fertilizers may be reinforced with ground phosphate rock or bone, or kainit, and plowed in. In the fall or early winter a top-dressing with fine manure is good, if free from weed or grass seed. The latter point is important, as weeds will crowd out the alfalfa. The fertilizers should be applied just previous to seeding, and well worked into the surface. The manure should be applied late in the fall after cutting has ceased; it should be fine, and evenly

spread; it will prove serviceable both in protecting the plants and in furnishing plant-food that may be well distributed in the soil by fall and winter rains.

Second and succeeding years, a top-dressing is recommended of eight to ten tons of manure, and an application of fertilizers supplying about twenty pounds of available phosphoric acid and twenty-five pounds of potash, which may preferably be obtained from 150 pounds of acid phosphate and fifty pounds of muriate of potash per acre. The fertilizers may be broadcasted, preferably after the first cutting in spring, or previous to the last cutting in fall, and the manure applied as recommended for the first year.

In regions where alfalfa is new, the land should be inoculated. There is but one practical way to do this,—by the use of soil from an established alfalfa field, or from a patch of sweet clover (melilotus). The same bacteria inhabit each of these plants. It does not matter how much soil is used, so long as it is fine and is scattered over the field and harrowed in before sunlight destroys the germs. As little as 200 pounds will inoculate an acre, and a ton of earth has been used with good results. Even and thorough distribution of the inoculated soil is readily accomplished by sowing it on the land just after plowing, the tillage required in seeding ensuring the complete distribution.

Seed and seeding

Pure seed is essential,—only that which is bright, plump and clean. Dodder is a parasitic plant, that twines about the alfalfa and thrives on its juices. Dodder seed may come with alfalfa seed. The alfalfa seed ought always to be re-cleaned to free it from this parasite. There is no remedy for dodder when once established in a field except to plow up the infested patch. Alfalfa seed resembles that of red clover, but is larger and, when fresh, has a greenish yellow color.

It is sometimes recommended to sow clover with alfalfa; this is a doubtful practice as, when the clover disappears, it will leave an uneven and too thin stand of alfalfa, although it is good practice to seed a little alfalfa with clover and timothy, on land intended for alfalfa later.

Experience has demonstrated that, in order to secure a good stand, it is best to sow thirty to thirty-five pounds of seed per acre. The seed should be sown broadcast, and covered by a very light harrow or weeder, and lightly rolled. If seeded in spring, the last of April or the first of May is preferable in the northern states, and without any protecting or nurse-crop.

In the North, notably in Wisconsin, alfalfa is seeded in spring, using a nurse-crop of oats or barley. The best nurse-crop is beardless spring

barley. This is not the heaviest-yielding barley, but it is the best nurse-crop yet found for alfalfa, because it usually does not lodge, does not stool very much, nor shade the land too much, and it comes off early in the season. The purpose of using a nurse-crop is to discourage the growth of fox-tail and other annual grasses until the alfalfa can get a start. It is very unsafe to sow alfalfa alone early in spring, because of the danger of its being choked with grasses. One can get a much more satisfactory stand with the barley than when sown alone. A bushel to the acre will be enough barley, although more may be used. It is best to sow with a drill, sowing the alfalfa seed at the rate of about fifteen to twenty pounds per acre in front of the drill. The land should have been first deeply plowed, and early enough in the season, if possible, to let it settle together, then worked to a good seed-bed just before sowing. The time of sowing should be as early as the danger of hard freezing is past, say the middle of April for the 40th parallel, earlier to the south, and later to the north.

Oats as a nurse-crop are not nearly so safe as barley, yet they may be used. No more than a bushel of seed should be sown to the acre. The oats must be cut for hay just when coming in bloom. If cutting is postponed until grain is formed, half or more of the alfalfa will be killed.

If the oats lodge, cut them for hay the next day. Oat hay is a good thing to have, if it is properly cured. When barley seed is not available, oats may be used with good results, if care is taken to mow on time.

After the nurse-crop is cut away, let the alfalfa alone. It will start into growth promptly, and if the soil is fertile and well inoculated, the crop will make rapid growth for a time, usually for about fifty days. As long as it continues to grow thriftily, do not cut. If a rust appears, it should be clipped close, which will check or destroy the disease.

Unless seeded, early alfalfa ordinarily will not make sufficient growth before midsummer to withstand the weeds and drought. Where the winters are not too severe, the trouble with weeds may be avoided by seeding the last of August or after danger of crab-grass is passed; when seeded at this season the weeds are not likely to take possession during the fall and sufficient growth will be made to enable the plants to withstand the winter. The crop from late summer seeding should not be cut the first fall, even though a considerable stand is secured, but left as a protection in winter. There will be no danger of smothering, as the plants will usually stand erect rather than go down.

Care should be taken that the seed is not put in too deep — this is very important and is often

the cause of failure. The depth may vary somewhat with the kind of soil, but in general, if planted more than three inches deep, there is danger that the germinating plant will not be able to reach the surface. One-half to two inches are about the extremes.

Another point of importance, as already stated, is that the soil should be packed around the seed. Many failures to secure a stand of alfalfa are traceable to sowing the seed broadcast on new-plowed ground, and then to harrow, mixing the seed loosely with the surface soil, but not compacting it thereafter by means of a roller. Under favorable conditions of soil and moisture the plant might survive, but it is safer to compact the soil and then go over it with a light harrow or weeder, loosening the immediate surface.

Subsequent treatment

The growth of weeds in spring seedings should be checked early by mowing, and as soon as the weeds are large enough to be clipped. By slightly raising the cutter-bar, the mowing machine can be used. If the crop of clippings is not too heavy, it may be left on the field and will serve as a mulch for the dry weather. This destruction of weeds in the early growth is very important, and frequent cutting is helpful, also, in establishing the young plants.

Fig 47. Alfalfa; first cutting in the season. Three feet tall and very thick.

Before clipping, however, examine the little alfalfa plants to see whether buds have started near the ground. If these buds are just bursting into leaf, clip the alfalfa at once. Do not clip it before the buds start. Do not cut the alfalfa for hay or any other purpose before these buds have formed close to the earth. To cut it before the buds appear may very seriously set it back, and may possibly kill young alfalfa. To leave alfalfa uncut will also very seriously weaken it, and may result in its death. However, the first season it should be permitted to grow as long as it is vigorous. There should always be left a growth of at least a foot to protect the crowns in winter.

Alfalfa should be cut when about one-quarter of the plants are in blossom, whether the growth is short or tall, unless a seed-crop is desired. If left until fully blossomed, the quality of the product is reduced; besides, the plants are injured and subsequent crops are smaller. On rich lands, two crops are sometimes secured the first summer from spring seeding, but on poor lands or in a dry season, no crop can be expected until the second year.

Yield of alfalfa

The yield on established fields will vary according to the character of the land, thickness of

stand and method of treatment. It ranges from ten to twenty-six tons per acre green forage for all cuttings, or an equivalent in dry hay of two to six or more tons. The larger yield is readily obtained on good lands.

Alfalfa is a gross feeder, particularly on the mineral elements, and a large producer, and is sometimes considered as an exhausting crop. This is a mistaken idea; it should rather be looked on as a crop fulfilling the proper aim of rational agriculture, which is most perfectly to transform into products the raw materials at disposal in atmosphere and soil.

The chemical composition of alfalfa

The following table shows the composition of five different cuttings from established fields at the New Jersey Experiment Station farm, as well as the composition of the hay when ready to put in the barn to be fed. These analyses, which are representative, show the variations in the composition of the different cuttings in the green state, all samples representing the crop cut when first blossoms appeared or just before blossoming, as well as the changes that were caused by handling, curing and storing. The composition of the different cuts will vary with the time of cutting and character of season. The crude fiber increases with maturity:

COMPOSITION OF THE CROPS OF THE DIFFERENT CUTTINGS OF ALFALFA

	Pounds per hundred of						
	Water	Ether extract	Crude fiber	Crude protein	Crude ash	Nitrogen-free extract	Albuminoids
First cut	83.00	0.67	4.56	3.65	1.92	6.20	2.62
Second cut	76.63	1.02	7.83	4.07	2.25	8 20	2.85
Third cut	74.10	1.07	6.58	4.52	2.17	11.56	3.60
Fourth cut	69.71	1.10	7.07	5.43	2.67	14.02	4.06
Fifth cut	81.77	1.13	3.20	4.50	2.07	7.33	3.27
Hay, when stored	18.66	3.19	24.11	13.87	7.44	32.73	11.45
Hay, after storage	9.56	3.36	31.07	13.24	8.64	34.13	10.78
WATER-FREE BASIS							
First cut		3.94	26.81	21.46	11.29	36.35	15.14
Second cut		4.36	33.51	17.42	9 63	35.10	12 20
Third cut		4.13	25.40	17.45	8.38	44.62	13.90
Fourth cut		3.63	23.33	17.92	8 81	46.27	13.40
Fifth cut		6.19	17.54	24.66	11.34	40.17	17.92
Hay		3.92	29.63	17.05	9.14	40.23	14.07
Hay		3.71	34.33	14.63	9.55	37.71	11.91

The chief point of difference between the composition of the samples of the green forage is in percentage of moisture, the samples representing the first and last cuttings showing a much higher content of water than those of the cuttings made in midsummer. The composition of the dry matter, however, shows the true differences. The first and fifth cuttings show a much higher percentage of protein and ash, indicating a higher feeding value and that they were not so fully matured as the others, although the different cuttings

were made when the crop had apparently reached the same stage of growth.

The exact amount of nutrients contained in each cutting has been calculated in the accompanying table, together with the yields per acre:

THE NUTRIENTS CONTAINED IN THE YIELDS OBTAINED IN THE DIFFERENT CUTTINGS ON ONE ACRE

	In Tons	Dry matter Lbs.	Ether extract Lbs.	Crude fiber Lbs.	Crude protein Lbs.	Crude ash Lbs.	Nitrogen-free extract Lbs.
First cut .	9.00	3,060	120.6	820.4	657.0	345.6	1,116.0
Second cut	7.73	3,613	134.5	1,113.1	629.2	347.9	1,388.3
Third cut .	4.89	2,533	104.6	642.5	442.1	212.2	1,130.6
Fourth cut	2.75	1,666	60.5	388.9	298.7	146.9	771.1
Fifth cut .	2.23	913	50.4	142.7	300.7	92.3	326.9
Total . .	26.60	11,785	470.6	3,107.6	2,327.7	1,144.9	4,732.9
Hay from second cut	2.21	3,595	141.0	1,065.7	613.1	328.8	1,446.7
Hay after storage .	2.00	3,617	134.4	1,242.8	529.6	345.6	1,365.2

It will be observed that the largest quantity of dry matter was secured in the second cutting, although the largest amount of protein was secured in the first cutting. There was a loss of moisture and a change in relative composition of the hay in curing, although the changes were not serious, and were rather evenly distributed throughout the various groups of nutrients; whereas the losses incurred in storing were considerable, aside from the moisture, and were particularly noticeable in

the loss of protein, which resulted in a considerable relative gain in the amount of fiber. This storage loss was to be expected, as the chief losses were probably mechanical, due to the shattering of the leaves, which are richer in protein and poorer in fiber than the stems. The chief point of interest is the very large quantity of dry matter obtained in the year's growth, nearly six tons, and the large proportion of nitrogenous substance, or crude protein, contained in it (2,327.7 pounds) equivalent to that in about 7.5 tons of wheat bran.

Variations will occur in samples from different fields and in different years, but it is thought that the analyses given here fairly represent what may be expected as to variations in the composition of the different cuttings, and the losses that occur in handling when made and stored as hay.

Alfalfa as a soiling crop

Alfalfa is one of the most useful of the soiling crops, because it is ready for use early in the year, and because three to four cuttings may be had each year. In the East, the first cutting is ready about the latter part of May or first of June, the second, usually within a month or five weeks, and the third and fourth usually four to six weeks after cutting the preceding crop. It possesses more nearly than any other crop the very great

advantage of furnishing a practically continuous supply of forage during the growing season. That this may be accomplished, it is necessary that a large part of the crop shall be cut either too early or too late; therefore it is desirable to have other forage crops if the very best results are to be reached. Care should be exercised when using it for soiling, particularly in the early cuttings, as animals are very fond of it and are likely to eat so much as to cause bloating. Animals have been soiled, with success, at the New Jersey Experiment Station for the past eight years, and no trouble has been encountered, probably due to the fact that the animals, previous to feeding on alfalfa, have been supplied with other succulent forage, and the quantities have been adjusted so that there should not be an excess for any one animal. In the early cuttings, from thirty-five to forty pounds per day usually are fed, gradually increasing to fifty pounds on the third day after beginning. After once started in this way, there is no danger, and only favorable results are likely to follow.

Another peculiar advantage of the soiling forage is its richness in digestible protein; fifty pounds of the green forage will furnish very nearly two pounds of digestible protein. Therefore, the feeds used with alfalfa should contain more carbohydrates than are usually fed with forage. A mixture of feeds that would make a good ration

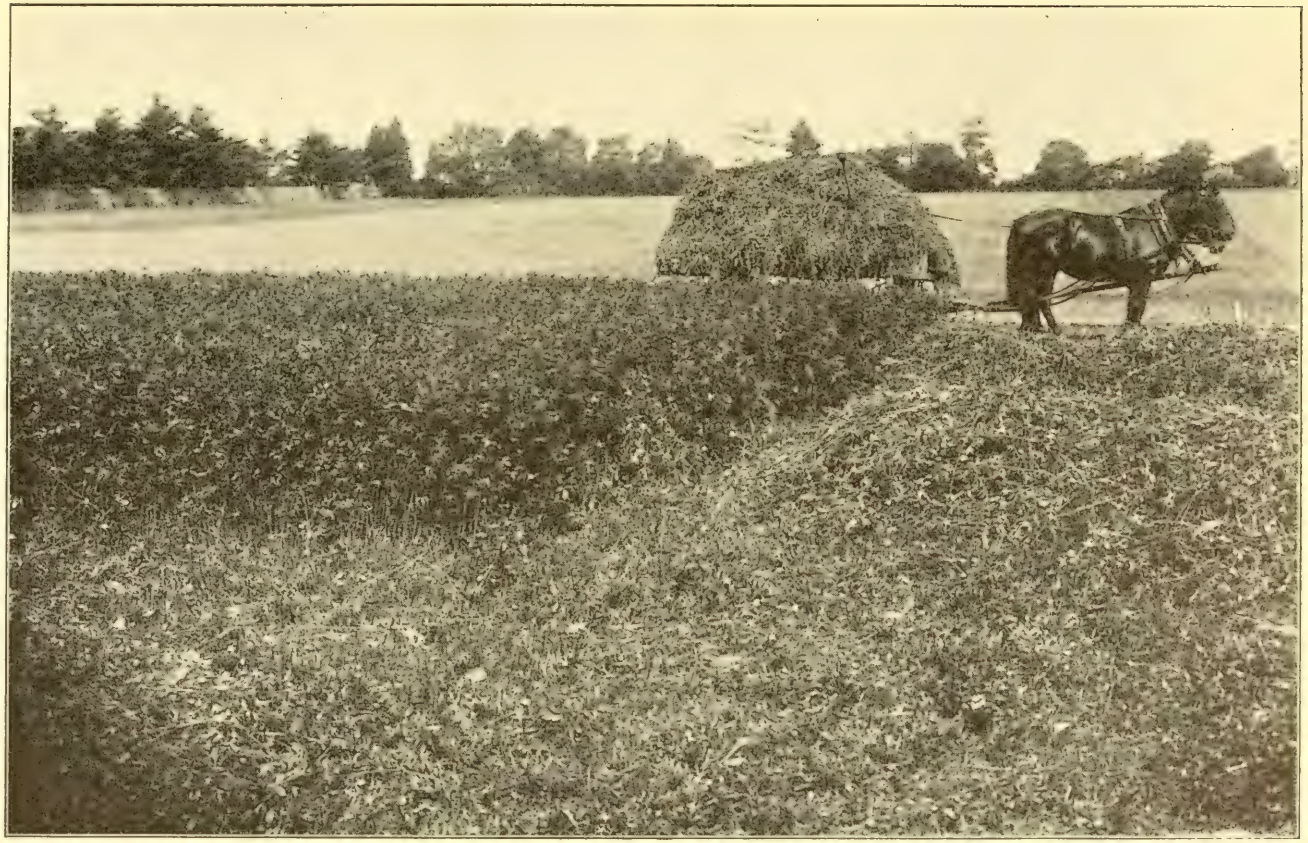

Fig. 48. First cutting of alfalfa. Ready for soiling May 27. New Jersey.

with fifty pounds of alfalfa per day may consist of about six pounds per day of a mixture of three pounds each of wheat bran, dried brewers' grains and corn meal. When large quantities of alfalfa are available as forage, the quantity used per day may be increased, thus reducing the necessity for feeds; and such feeds as are used may be richer in carbohydrates, as, for example, corn meal.

Alfalfa as a hay crop

When desired for hay, alfalfa should be cut when budded, or just before full bloom, as it contains more nutriment at this time; besides, it is better for the subsequent crops to cut the plant before it is in full bloom.

The value of the hay depends much on the method or care used in curing it. Alfalfa cannot be cured as hay is usually handled. After cutting, it should be allowed to lie in the swath only long enough to become well wilted, when it should be raked into windrows, where it may be left a few hours before putting into cocks. The hay should be allowed to remain in the cocks until practically cured, which usually requires two or three days. Then it may be thrown out, dried with three or four hours' sun, and hauled to the barn without further handling. It is desirable to use hay caps in unfavorable weather, as water

penetrates alfalfa cocks very readily, which injures the feeding value and causes mechanical losses. In good weather, alfalfa that is cut in the morning may be raked in the afternoon of the same day. It should not be left long enough to become dry and brittle, or many of the leaves will shatter in raking, much reducing the value of the hay.

In experiments at the New Jersey Experiment Station, it was shown that alfalfa hay may be substituted for the protein feeds generally used, without interfering with the health of the animals, and at considerable saving in the cost of the ration, although the yield of milk was not quite so high. In other experiments, when cowpea silage and alfalfa hay were used as the source of roughage as well as for the protein, and corn meal used to supply the carbohydrates, the yield of milk was greater and the cost per quart much lower than from the regular barn ration, in which the source of protein was such feed products as dried brewers' grains and wheat bran. In other words, it has been demonstrated that it is quite possible, with the judicious use of such leguminous crops as alfalfa and cowpeas, to produce all the needed nutrients on the farm, thus saving expensive feed bills and at the same time enriching the soil in nitrogen. It is important that dairy farmers should grow, if possible, a few acres of alfalfa to supply part of the green

forage needed for summer feeding, and as much as possible of the protein needed to balance the silage or other fodder rations of the winter.

Alfalfa as pasture

Alfalfa may also be safely used as pasture for horses and swine, and the careful farmer who gives the subject intelligent personal attention may also pasture cattle and sheep on alfalfa with success. There is always danger, however, of losing animals with bloat, and pasturing, especially with sheep, is injurious to the alfalfa because they eat away the young buds, which would soon develop into new branches. The younger plants are not strong enough to withstand long-continued pasturing the first year after sowing, and much tramping is injurious at any time.

Alfalfa silage

Alfalfa can be successfully made into silage, although, in common with other plants of a highly nitrogenous character, it is not so desirable as corn. The losses are likely to be considerable, and the product seems to be less palatable than corn silage. Nevertheless, there are many circumstances when its preservation and use as silage are to be recommended.

CHAPTER XIII

THE CLOVERS

THE true clovers all belong to the genus or group Trifolium, of which there are many species and varieties in many parts of the world. The sweet or Bokhara clover is a Melilotus, not sufficiently grown to warrant discussion in a brief popular book like this. The bur clover is a Medicago, allied to alfalfa. Other related plants of the legume family are sometimes known as clover, but they need not be described here.

There are four types of true clover that must be discussed in any American book on forage plants: (1) red clover (*Trifolium pratense*), and mammoth red clover (variety *perenne*, formerly but improperly called *Trifolium medium*); (2) alsike clover (*T. hybridum*); (3) crimson clover (*T. incarnatum*); (4) white clover (*T. repens*). All these clovers are natives of the Old World.

THE RED CLOVERS

It has been well said that red clover is more valuable among fodder plants than wheat is among cereals. As a forage crop, it has no

superior, all things considered. Like corn, it is adapted to a wide variety of soils, and, because of its habit of growth, is always beneficial when introduced into a rotation, aside from its particular value as a forage crop. While its best use for most purposes is in connection with other clovers and grasses, it is excellent as a green forage plant, since it is very palatable and contains the nutrients in such proportions as to make it a well-balanced ration in itself, thus serving to supplement pastures, as well as to provide an excellent dry forage.

While it may persist for three years, in practice it must be regarded as a biennial, the length of life depending largely on its treatment and the nature of the soil. It thrives best on deep loamy lands, rich in humus, where, as a rule, it stands longer than on light lands, although it is well adapted to them and large crops are obtained when well fertilized.

Soils and manures

Stiff clays, when properly tilled, are suitable for red clover, although they should be well drained to avoid any standing water. Dry, sandy or hot lands are unfavorable, although they may be very materially improved by liming or by the use of marl. On loose lands and heavy clays,

clover is liable to be uprooted by the alternate freezing and thawing, and on sandy lands it suffers from drought. Like alfalfa, the soil must be either rich in lime, or this substance must be applied, for it is a heavy feeder on lime, as well as on the other mineral constituents. The very beneficial effects that were observed from the former use of gypsum, when it was thought that plaster or gypsum was a specific fertilizer for clover in the eastern states, is now considered to be due to the power that gypsum possesses of setting free the dormant potash of the soil. Therefore, on old soils from which the potash has been to some extent exhausted, the element potassium should be applied in considerable excess. The very beneficial effect of wood ashes, following the use of gypsum, also verifies this conclusion, as ashes is rich in both of the constituents, potash and lime.

As clover is a legume, it is not usually benefited by the addition of nitrogenous manures, except in the early stages of growth. On soils not well supplied with vegetable matter, manures are very beneficial, primarily in correcting the deficiencies, and in providing a more favorable medium for the development of the specific bacteria. The size of the crop will be measured to some extent, also, by the abundance of mineral elements, thus enabling the plant to employ to

full advantage its capability of gathering nitrogen. In many cases, particularly on soils that are likely to heave, a mulch of manure is very advantageous as a protection.

Methods of seeding red clover

The method of seeding most generally practiced is to sow in March or April, on wheat or rye (which was seeded the fall previous), when the ground is still moist, and danger of very heavy freezing is past. By this practice, the light freezing and subsequent drying of the soil causes the seed to be covered, and it will then germinate and make a light growth previous to harvesting. It is also seeded in spring with oats or barley; this is a common practice in regions which are cool and moist, as in many of the western states.

The quantity of seed ranges from eight to twelve pounds per acre. The plants grow rather feebly until the grain is removed, when they usually come forward rapidly, sometimes permitting a fall cutting, but in any case they make a crop the following year.

Recently, however,—especially where the plant is grown primarily for forage purposes,—the seeding is made in the latter part of August or early September, without nurse-crop, usually following

potatoes or some other hoed crop. When seeded in this way, the land should be very carefully prepared, and the surface made as fine as possible, in order that germination may be rapid and complete, as well as to provide abundant food near the surface.

The quantity of seed in this case is about sixteen pounds per acre on the average. On poor lands, more seed must be used. If seeding is too thick, the plants are liable to lodge and thus be badly injured for either forage or hay. When seeded in this way, the seed should be lightly covered, preferably with a weeder, and on light lands rolled with a light roller. In ordinary seasons, the plants will make considerable growth and become well rooted before winter, and the crop usually will be ready to harvest as early in the next season as in the second year if seeded in the old way with grain.

In many sections, red clover is used as a catch-crop in corn, mainly to serve as a spring pasture and in preparation of the land for wheat. This practice is generally not suitable when the primary purpose is to make soiling crops or hay. In the eastern and central western states, the crop will be ready to harvest about the middle of June, although the time will vary, depending on the season; if dry and warm the crop will mature earlier than if cold and wet.

Harvest, yields and value

If used primarily for soiling, harvest should begin when the plant is fully in head, and it may continue until many of the heads become brown. This period will range from ten days to two weeks, depending on the soil and season.

As a soiling crop, red clover should be fed with care at first, unless the animals have been accustomed to green forage of other kinds, as they are extremely fond of it, and there is danger that there will be a tendency to bloat. When they have been regularly fed on green forage, and the quantity is regulated, no danger need be apprehended from this source, and the usual amount of fifty to sixty pounds per day may be used.

With a good stand and sufficient moisture, the yields of red clover will range from six to ten tons per acre. It usually pays to allow it to stand for the second crop, which is also quite as serviceable for forage as the first, although the yield is smaller, —four to six tons per acre. The second cutting is usually ready in early August.

Red clover varies in its composition according to the time of harvesting, although either when cut young, or allowed practically to mature, it is much richer in the nitrogenous compounds than are the grasses, but not so rich as alfalfa. The

average composition of red clover forage in full blossom is as follows:

	Clover, green forage	One ton contains	An average acre-yield furnishes	Clover hay
	Per cent	Lbs.	Lbs.	Per cent
Water	70.80	. . .	. . .	20.80
Dry matter	29.20	584	4,672	79.20
Ether extract	1.10	22	176	4.50
Fiber	8.10	162	1,296	21.90
Protein	4.40	88	704	12 40
Ash	2.10	42	336	6.60
Nitrogen-free extract	13.50	270	2,160	33.80

Red clover hay

The one very great advantage of clover as forage is that, if not needed as a supplementary green food, it makes good hay. Clover hay is one of the best kinds for dairy purposes. However, it is liable to considerable loss in harvesting, unless great care is used, owing to the rapidity with which the leaves dry and to their tendency to fall in curing and housing. If cut when about one-third of the bloom has disappeared, it will contain very much less moisture than when cut earlier, and still retain a large proportion of leaves if carefully handled.

Clover should be cut when free from dew or other moisture, and allowed to wilt, then raked into windrows, and put up into cocks and cured in this way, rather than be allowed to lie in the

swath until dry. Light rains, or even heavy dews, will change the green leaves to dark brown, and make them crisp and readily removed by handling; they will also extract the aroma arising from the essential oils, which is so important in making the hay palatable and attractive. When properly cured, the hay will have about the composition noted above, and, as a roughage to use with silage in winter feeding, it cannot be surpassed except perhaps by alfalfa.

The high content of protein makes clover one of the best plants for forage purposes. It is possible with clover alone to supply all the needed nutrients in good proportions for dairy animals. It is usually better, however, to feed from fifty to sixty pounds and to supply the remainder of the nutrients from other sources, to give variety to the ration.

Pasturing red clover

When the purpose is to secure the best yield of forage, it is not desirable to pasture red clover, although it is an excellent pasture plant, and is well liked by all farm stock. The tramping of animals will soon kill many of the stools, injuring the stand, and causing a smaller yield in later cuttings. Red clover is an important constituent of permanent pastures, generally insuring a larger yield the first season than grass alone.

Mammoth red clover

This resembles the common red clover, but is larger, later and more truly perennial. It is a great forager. The stems are stout and coarse, and, therefore, it is not so desirable for hay; but these characteristics do not impair it as a soiling crop. The preparation of soil and the seeding may be similar to the practice recommended for common red clover. The quantity of seed should be twelve to fifteen pounds per acre, according to the character of soil. When seeded in the fall, the crops should be ready for the first cutting by June 15. Yields are usually heavier than those of the common red clover. A good average yield is ten tons of forage per acre.

Mammoth clover may be fed as recommended for red clover, the composition not materially differing, although, unless the plant has reached the full blossom stage, it is likely to carry less dry matter; therefore, a slightly larger proportion should be fed. All animals are fond of this forage, and the results of feeding are exceedingly satisfactory.

If the land is good, and well drained, the crop will make a rapid second growth, to serve for forage, or for pasture, it being excellent for grazing.

The great foraging powers of this plant make it exceedingly valuable as a soil-enricher. The

large amounts of mineral matter from the lower layers of soil, being stored in the roots and stems, will greatly improve the soil for subsequent crops.

ALSIKE CLOVER

Alsike clover is more perennial than red clover, and can be left frequently for three to five years. It is little affected by extreme seasons, and lands on which other varieties do not grow may produce an abundant harvest. It thrives on damp, moist loams and clays, on lands too wet for other clovers. It is very hardy, and not liable to be uprooted by late frosts, which frequently injure the red clover.

Alsike clover has a rather superficial root system; therefore, the preparation of land should be very thorough, and the surface layers well enriched, particularly with the mineral elements. Owing to its somewhat creeping habit, it is not well adapted to seeding alone; as the stems lie along the ground, without rooting, the remainder of the stem ascending, in wet seasons it is liable to lodge badly, and the lower stems to rot.

Seeding alsike clover

Alsike may be seeded with wheat or rye, in the same way as red clover. When used for forage, the best time for seeding is in late

summer or early fall. The quantity of seed will be about one-half that recommended for red clover, as the seeds are about half as large. A pure sowing of alsike, however, is not usually advisable, because of the tendency to lodge, as already pointed out; although, where it grows well, it may be used in a soiling-crop rotation with great advantage.

Value and yield

Mixtures of red and alsike clovers and timothy make a most excellent forage, the timothy supporting the clover and preventing lodging. The alsike will mature about a week later than the red clover. It makes a very rapid and usually a large second growth. The best time for cutting is when the plant is in flower, as at this period it is richest in digestible nutritive matter. It contains more water, as a rule, than red clover, thus causing the same tonnage weight to carry less nutriment. The yield will range from eight to twelve tons per acre, depending on the character of the soil. The composition of this clover is similar to that of red clover.

Alsike hay and pasture

Alsike clover makes very palatable and useful hay, its fineness of stem and large proportion of

leaf giving a larger percentage of digestible matter than the red clover at the same period of growth. However, it is more difficult to cure, and suffers great loss in handling if care is not exercised.

It also makes excellent pasture, starting quickly after the first cutting, and being less readily destroyed by the tramping of animals than red clovers.

COMPOSITION OF ALSIKE CLOVER

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	74.80	. . .	. . .
Dry matter	25.20	504	4,032
Ether extract	0.90	18	144
Crude fiber	7.40	148	1,184
Protein	3.90	78	624
Ash	2.00	40	320
Nitrogen-free extract	11.00	220	1,760

CRIMSON CLOVER

Crimson clover is an annual. Because of its adaptabilities, it has quickly made a place for itself in American agricultural practice. Its habits of growth are not so well known as those of the other kinds described, and for this reason, among others, is not so generally distributed, even in those sections in which it thrives. Its habits are such as to make it undesirable to substitute for red clover, although it may well supplement it.

It is essentially a cool-weather plant, thriving well in late fall and early spring, and maturing seed in the middle states about June 1. These characteristics make it especially suitable for a

Fig. 49. Field of crimson clover, grown as a catch-crop seeded in corn at last cultivation.

catch-crop or cover-crop, to be used without interference with regular rotations. It has proved to be hardy in the eastern and middle states, although many failures are reported, which are probably due in large part to failure to understand its peculiar habits. The impression that it will grow well on poor soils with other crops, under all conditions of season and climate and without particular care in seeding, is very erroneous. It must have abundant food; it is affected by drought and cold and severe weather; it can not subsist with other crops which rob it of moisture and plant-food; it must be carefully seeded in order to insure against adverse conditions, although when conditions are favorable it will catch and grow from a mere scattering of the seed on raw ground.

Method of seeding

Crimson clover should preferably be seeded at the rate of twelve to fifteen pounds per acre, on a well-prepared seed-bed, and covered lightly with harrow or weeder. It is not suited for spring seeding, as it ceases to grow as soon as hot weather comes. The best period for seeding ranges in the eastern and middle states from July 15 to September 1. Therefore, it may be used as a catch-crop, seeded in corn, after the regular cultivation has

ceased, and also after early potatoes, tomatoes and other crops harvested early enough in the season to enable its roots to get hold of the soil and to make considerable top before cold weather.

While it requires good land for its best development, it is well adapted to light sandy lands if well supplied with mineral food. It will grow later in the fall than red clover, because it is not injured by light freezing, and it also makes more rapid spring growth than any of the other clovers when seeded in the late summer. When land is light and poor, a dressing of acid phosphate, say at the rate of 150 pounds per acre, will aid in securing a catch and insuring a crop.

Crimson clover as green forage

Early maturity is one of the most valuable characteristics of crimson clover, from the standpoint of its use as green forage, making it particularly useful in rotations. In the middle states it will begin to head about May 15, thus following directly after wheat. Cutting should begin as soon as the heads begin to form, and may be continued until the plant is completely headed out. This period ranges from ten days to two weeks. The dry matter is richer in protein than red clover; and the plant has more moisture at the same stage of growth than the red. Therefore, larger quantities,

as usually cut, will be required to furnish the same amount of total nutritive matter.

Crimson clover is an exceedingly palatable forage, and serves good purpose for soiling, for hay, or for pasturage. The composition at different periods of growth is shown in the following tabulation:

COMPOSITION OF CRIMSON CLOVER

Pounds per hundred of	May 12, before blossoming	May 24, in blossom	May 31, mature
Water	89.17	84.23	83.26
Dry matter	10.83	15.77	16.74
Crude fat	0.43	0.53	0.53
Crude fiber	1.78	4.37	4.78
Crude ash	1.21	1.31	1.47
Crude protein	2.53	3.00	2.95
Nitrogen-free extract	4.90	6.57	7.01
Albuminoid protein	1.80	2.09	2.13

The samples taken on May 12, before blooming, show a high content of water. The samples representing full bloom, on May 24, and the fully matured plant, on May 31, show a much higher content of dry matter, although still much less than is contained in other green forage crops. The samples at this time also show a much higher percentage of crude fiber than on the earlier dates.

In the earlier stages of growth, crimson clover is too watery to give the best satisfaction as an exclusive feed, although in actual practice the forage would be much drier than is indicated by the analyses.

"There has been much discussion at farmers' institutes and in the columns of the agricultural press," write Roberts and Clinton (Cornell Bulletin No. 135), "as to the value of crimson clover in this state [central New York] as a forage crop and as an improver of the soil. To answer these questions in part and to determine the relative value of the

Fig. 50 Crimson clover ready for soiling, May 20. New Jersey.

different clovers, there were planted side by side on August 1, 1896, three plats of clover, one of crimson, one of common red and one of mammoth. The soil was gravelly and porous. All varieties of clover came up quickly and made good growth. The crimson clover, however, made far more rapid growth in the fall than did the others. One object of these experiments was to determine the amount of nitrogen stored up by the different varieties of clover. On November 2, samples were taken of each kind of clover, the roots and tops of each being taken as the sample. The chemical analysis shows the following amount of nitrogen stored up in each per acre:

Kind of clover	Nitrogen in tops (pounds)	Nitrogen in roots (pounds)	Total pounds of nitrogen per acre
Crimson	125.28	30.66	155.94
Red	63.11	40.25	103.36
Mammoth	67.57	78.39	145.96

"All clovers wintered well, but in the spring the freezing and thawing killed nearly all of the crimson clover. It had, however, served its purpose as a cover-crop and for late fall pasture would have been valuable, leaving in the ground enough fertilizing material to pay for the expense of the seeding."

Yield of crimson clover

The yield varies widely, but from good seeding the average of green forage should be about eight

tons per acre. In experiments at the New Jersey Experiment Station, crimson clover was the cheapest forage crop grown. This was due both to the low cost of seed and to the fact that it was grown without extra expense of manure or fertilizer; besides, it was generally grown as a catch-crop and did not interfere with regular rotations.

Its advantages as a soil-improver are also worthy of careful consideration by the dairy farmer. If seeded in corn at the last cultivation, it may be harvested in time to permit of planting corn the next season, and besides forage, the humus-forming material remaining in stubble and roots improves the land.

AVERAGE COMPOSITION OF CRIMSON CLOVER

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	84.00	. . .	. . .
Dry matter	16.00	320	2,560
Ether extract	0.50	10	80
Crude fiber	4.10	82	656
Protein	3.00	60	480
Ash	1.40	28	224
Nitrogen-free extract	7.00	140	1,120

Crimson clover hay

Crimson clover is in no sense a substitute for red clover, either as a green forage or hay, but it makes hay of excellent quality, and is not so

much injured by light rains and dews, owing to the smaller proportion of leaf. The stems are finer and are readily eaten and digested. The difficulty in making hay arises from the fact that it is ready for hay-making at a period when the season is still cool, and bright sunshiny days are less frequent. Stock is said sometimes to suffer from eating crimson clover hay from the formation of hair-balls in the stomach, due to the hairs on the plant.

Crimson clover as pasture

Crimson clover is very highly regarded as a pasture plant, particularly for late fall and early spring. When seeding has been made in July, on lands not otherwise occupied, it makes rapid growth and serves as late fall pasture, not being injured by frost in the same degree that red clover is. Fall pasturing frequently benefits the plant, as a thick, heavy crop is not so liable to be carried safely through winter. It makes earlier pastures than any other clover. It is very useful for sheep or cattle. As a pasture clover, it is a very desirable plant in the rotation, inasmuch as it is adaptable, easily grown, matures quickly in a cool season and possesses the characteristics of other clovers in contributing directly to the increase of nitrogen in the soil.

WHITE CLOVER

White clover is not suitable for soiling forage or hay, but is very useful in the formation of pastures, especially on low-lying lands. On good land it lasts from four to five years. It is superior to red clover in thriving on lands of inferior quality, standing pasturing well, and possessing higher nutritive value. Sometimes the creeping stems and foliage become too luxuriant, when it may act injuriously in suppressing other plants.

White clover is less sensitive to climate than red clover. It bears drought very well, although its roots confine themselves mainly to the superficial layer of the soil. In dry seasons the old branches do not lengthen, and growth is confined almost entirely to the principal stem. White clover succeeds best in a moist soil, containing lime and an abundance of humus. It can also adapt itself to sandy soils, which are not too loose and dry, providing the surface contains sufficient nutriment.

The parent stem sends out creeping branches; these in turn branch and at intervals give off shoots. If conditions are favorable, the branches become long and extend in all directions; in this way a large surface is soon covered.

If the plant has not been sown with a cereal crop, full development is made the first year, flowering early in spring, but rather later than red

clover. As pasture it is better than any other kind of clover, being readily eaten by all kinds of live-stock. Pasturing is begun in the spring, as soon as animals can get a good bite, and it remains good until late autumn.

Because of its higher content of water, white clover is more difficult to cure than red clover, but not so wasteful in curing, as the leaves do not fall away so readily.

When seeded alone, ten pounds of seed per acre should be used. But a pure sowing of white clover is neither so good nor so healthful for stock as a mixture. It may be mixed with other clovers and with grasses, either for temporary or permanent meadows. It is much benefited by top-dressings of lime, marl, ashes or mixtures of bone and potash.

CHAPTER XIV

OTHER LEGUMINOUS FORAGE CROPS

MUCH attention has been given to leguminous forage crops in recent years because of their soil-enriching propensities and their supply of protein substances to animals. Many of these plants are now being experimented with in different parts of the country; some of the remaining kinds that have now thoroughly proved themselves may be discussed here.

COWPEA

The cowpea is an annual viny plant, more a bean than a pea. Its origin is authoritatively stated to be in the Orient, where it has been cultivated for thousands of years; it is thought to have been introduced into this country in the early part of the eighteenth century. Its best development occurs in warm climates; in this country it has found a congenial home in the southern states, where it reaches its maximum development. A number of varieties have been developed, however, that are adapted to cooler conditions, so that now it is well distributed even in parts of the North, where its adaptation to

various uses and the rapid and large development of plant make it one of the most useful of the annual summer legumes for forage purposes.

Varieties of cowpea

The natural tendency of the plant toward variation has resulted in many varieties, although the permanent and distinct kinds are comparatively few. The same variety is likely to be given a new name in different parts of the country, as, for example, the one variety that goes under the name of Unknown, Wonderful and Quadroon. In addition to the confusion arising from this practice, the same name is frequently given to a number of varieties, as, for example, the name Crowder, which is applied to any variety in which the seeds are closely packed or crowded in the pod. The further fact that season and climate exert such an influence on the plant as to make a variety in one place very different from what it is in another place, renders it difficult to give positive advice as to the choice of kinds for specific purposes. The varieties range from a bush a foot or so high, without runners, to those having distinct vining or trailing habits, the vines sometimes reaching a length of ten to twenty feet. The pods range from four to eighteen inches in length, giving seed of every possible

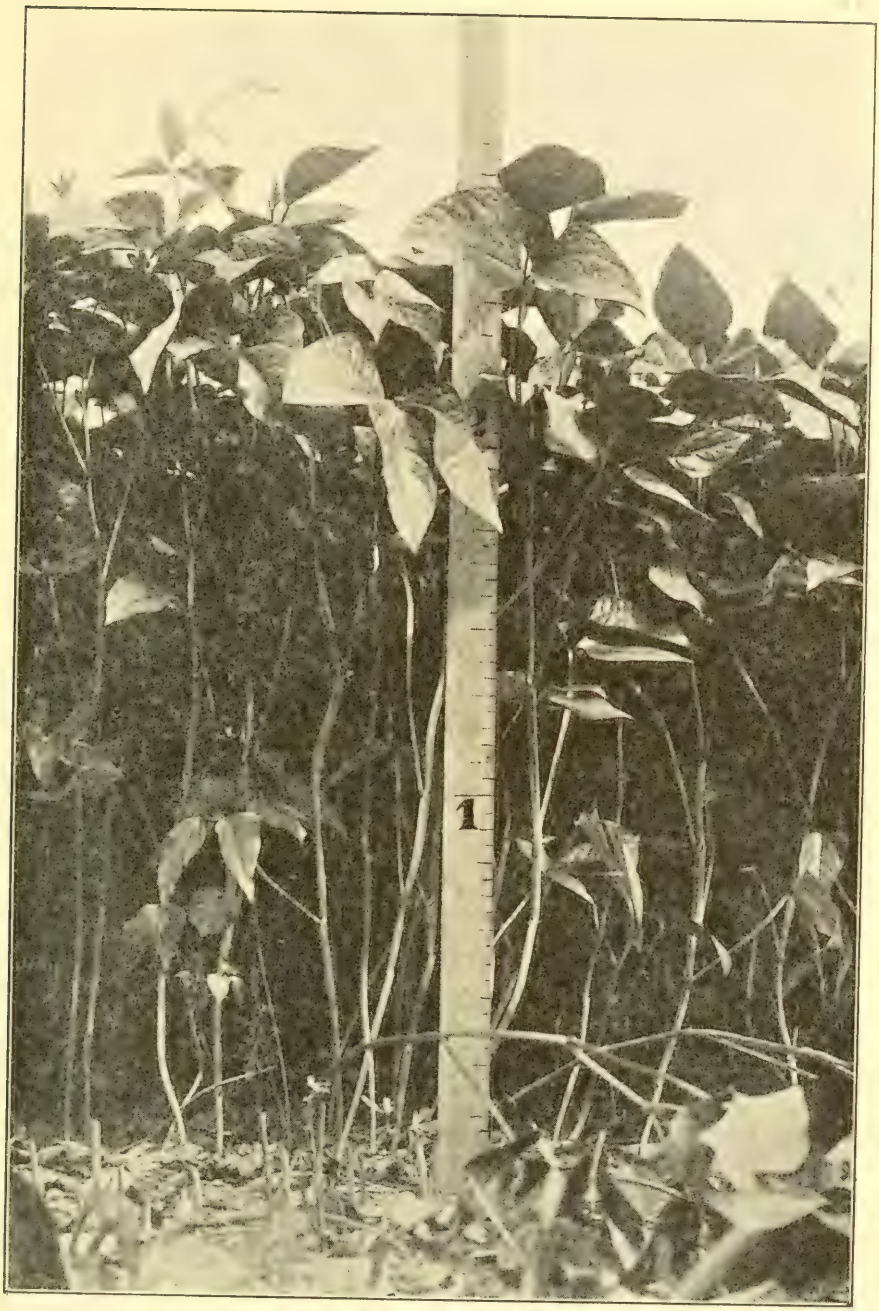

Fig. 51. The cowpea.

shape and form. The period of mature growth also varies, the varieties ranging in time of maturity from two to six months, although the habit of plant bears some relation to the period, for the more nearly the plant approaches the bush form, the shorter the time required for maturity.

In order to choose the proper variety, the object of its cultivation should be clearly established. When short, quick growth and maturity are required, then the bush varieties should be chosen, particularly in the North; whereas, if the purpose is to produce much forage and the period of growth can be extended, the vining varieties are likely to be more useful. When grown primarily for green forage, the period in which they must grow should determine the variety. It is more difficult to choose varieties for the North than for the South, as the plant has not been so carefully studied in this section. In the more northern sections, the Early Black, Small Black, Black Eye, Mt. Olive, Southdown, Red Ripper, Whippoorwill, Wonderful, Clay, New Era, and Iron have proved excellent for the various purposes for which cowpeas are grown. Early Black, Black Eye, New Era and Mt. Olive are superior when the seed crop is desired, as they mature quickly; the others are better adapted for forage and green manure. The cowpea varies so widely in its habits of growth that it is possible to select varieties suitable to all conditions.

Time and method of seeding

The time for seeding the cowpea depends on the weather. The crop should not be sown until danger of frost is past, and the soil is thoroughly warm. In cold, backward springs many failures have been recorded because of too early seeding; the seed is then liable to rot, and if uniform and quick germination does take place, the crop is retarded and is likely to be unsatisfactory even if warm weather follows. This is particularly true when cowpeas are grown for green forage or hay. Neither should they be sown for forage later than two months before the average date of frost, as the first heavy frost will destroy the plants and no variety that is now known will reach a satisfactory stage of growth within this period except as green-manure.

For forage and green manure, the crop may be sown broadcast at the rate of one to one and one-half bushels per acre, or it may be drilled in with an ordinary grain-drill. If the seeding is not made too early, broadcasting is very satisfactory. If early growth is retarded, weeds get a foothold, and the crop is likely to be choked out. When the crop is grown for seed, planting should preferably be in drills, from two to three feet apart, or a little closer than corn, and the quantity of seed may be reduced to three pecks per acre. When

the seed is expensive, it pays even for forage to use the smaller quantity and cultivate, rather than to broadcast the larger quantity.

Seed should be covered one to two inches deep, and on very light soils a little deeper. The season, to some extent, governs the depth; in a dry season, the deeper the seed the better. The difficulty in too late summer broadcast seeding is that crab-grass or other growth is likely to choke out the plants.

Value of the cowpea crop

Perhaps there is no other annual leguminous forage crop that is so generally useful as the cowpea. In the first place, it grows in hot weather, when it is desirable to have the ground covered; (2) its long tap-root penetrates the subsoil, loosening it and making it more porous; (3) the absorption and assimilation of the free nitrogen makes it of great service; (4) it provides good forage; (5) it may be used as a cover-crop; (6) the roots and stubble are left as additions to the soil, always causing considerable improvement.

Manures and fertilizers

While the cowpea is well adapted to light soils, nevertheless, if the best results are to be had, the soil must be well supplied with phosphoric acid

Fig. 52. Cowpeas planted in rows and cultivated.

Fig. 53. Crop of cowpeas for soiling.

and potash. On lands that are capable of producing fair crops, the fertilizers may be limited to an application of these minerals, and a mixture of

Acid phosphate	300 pounds
Muriate of potash	100 pounds

applied at the rate of 200 pounds per acre is recommended. This should be broadcasted, and well cultivated into the soil previous to planting.

Harvesting cowpeas

For soiling purposes the crop may be harvested in its immature state, although a larger amount of dry matter will be secured if it is not cut until the pods are turning yellow. It is often necessary to have the crop ready in two to two and one-half months; when the early varieties are sown, and the season is favorable, profitable crops may be harvested as early as this after seeding. If the cowpea is not harvested promptly it does not suffer serious loss, as is the case with many other crops. The leaves remain green and the stems succulent until growth ceases. When the entire season can be used for the crop, the trailing varieties will give the larger yield, although they are more difficult to harvest, owing to the intertwining of the vines. If cut in a very immature stage, the forage shows a higher content of water, and the dry matter is

relatively richer in nitrogenous substance than when more nearly mature.

Cowpea hay is more difficult to cure than clover, owing to the very succulent stems and large leaves. Therefore, it must be handled carefully, in order to prevent losses in the field, or molding in the mow. In the southern states, the practice of "ricking" is quite general. That is, the crop is mown, allowed to wilt in the swath, then raked into windrows and allowed to dry until it can be readily handled, then carted and placed in rather large stacks on ricks that are placed a foot or so from the ground, enabling the plants to cure thoroughly. There is no special need for this extra labor in the northern states, providing it is cut as early as September, as it will cure readily in the windrow if the weather is good.

Yield and composition of cowpeas

The yield of forage under the various conditions of soil, season and time of harvesting, will naturally vary widely, ranging from four to twelve tons per acre, with a probable average of eight tons on good soils. The yield of dry matter and actual nutrients increase as the plant approaches maturity. On the average, the green forage will contain about 16 per cent of dry matter. Following is an average analysis:

	Forage	One ton contains	An average acre-yield furnishes	Hay
	Per cent	Lbs.	Lbs.	Per cent
Water	83.60	. . .	. . .	10.70
Dry matter	16.40	328	2,624	89.30
Ether extract	0.40	8	64	2.20
Crude fiber	4.80	96	768	20.10
Crude protein	2.40	48	384	16.60
Ash	1.70	34	272	7.50
Nitrogen-free extract	7.10	142	1,136	42.90

Cowpea pasture and hay

When the crop is not needed for soiling, it may be used for pasture or hay. It makes excellent pasture, and, if the animals are not allowed to feed it too closely in the beginning, it will furnish good grazing for six to eight weeks, as the tendency of the plant is to throw out new runners when the main stems are removed. Pasturing is wasteful, however, as the animals tramp much of the herbage into the earth, besides killing some of the plants. It is better practice to make the crop into hay, as it makes a very palatable and highly digestible product, and one which, because of its high content of protein, can be used to substitute for concentrated feeds.

The cowpea is one of the most useful forms of winter forage, as it can be fed in considerable quantity, and because it possesses characteristics which make it a good substitute for purchased protein feeds. Experiments at the New Jersey,

Tennessee and Alabama Stations show that cowpea hay can be very profitably substituted in part for concentrated feeds for dairy animals, although it was shown to be advisable to use a little feed in the ration.

SOYBEANS

The soybean is from Japan, where it is one of the staple crops. It is now generally grown in the southern coast and middle states. Soybeans are also grown successfully in Illinois, Michigan and Wisconsin, being better adapted to the climatic conditions of those states than cowpeas. The soybean has a strong central root, stiff stems, broad leaves, and somewhat resembles the ordinary bean, although it is larger and bushier in form. The plants may be dwarf and early maturing, or late and tall, but in no case do they have the vining and trailing characteristics of cowpeas. They are strictly upright plants. There are a number of varieties. The Green seems to be the variety most generally used.

Seeding, growth and use

The plant resembles the cowpea in many of its characteristics; namely, that it should not be seeded until the soil is warm, and when grown

for forage it should preferably be planted in rows in order that it may be tilled, although it may be seeded broadcast. The quantity of seed per acre varies from one to one and one-quarter bushels broadcast, depending on how well the seeds are covered. When seeded in rows, the quantity may be reduced to one-half bushel or three pecks per acre. The land should be put in good condition, and fertilized as advised for cowpeas, that the germination may be prompt.

For forage purposes it does not possess characteristics very different from those mentioned for cowpeas. Experience thus far shows that the soybean is slightly more difficult to handle, and that the yields are not so heavy, but the plant contains more nitrogen in the dry matter than the cowpea. It has been grown for forage when there has been a scarcity of cowpea seed, and many prefer it to the cowpea because it is easier to harvest. Its period of growth is about the same as for cowpeas, reaching its best condition in two and one-half to three months. The stems are stiff and hard, and the entire plant is not so palatable as the cowpea, although, owing to the abundance of large leaves, the feeding value is quite as high as that of the cowpea; in fact, at the stage of growth best for forage, it is richer in dry matter and protein than the cowpea. Yields of forage on good soils average lower than the cowpea,—about

seven tons per acre. The average composition is as follows:

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	75.10	. . .	. . .
Dry matter	24.90	498	3,486
Ether extract	1.00	20	140
Crude fiber	6.70	134	938
Crude protein	4.00	80	560
Ash	2.60	52	364
Nitrogen-free extract	10.60	212	1,484

The soybean is not so well adapted to pasture as the cowpea, but it is quite as good for hay and less difficult to cure. The crop is well worthy of wider use.

VELVET BEAN

The velvet bean has attracted much attention lately in the southern states. In Florida it has been one of the most useful of the forage plants. It grows well on light, sandy land, and the yield is ordinarily larger than that of the cowpea.

Under favorable conditions the vines reach a length of twenty to thirty feet. The season of growth is much longer, and for that reason the seed cannot be matured except in the most southern states. Experiments in the middle and eastern states show that it is not well adapted to those sections, and does not make as satisfactory crop for any purpose as the cowpea. It is used as a green-manure and cover-crop in the South.

Fig. 54. Field of cowpeas, seeded after oats-and-peas and to be followed by rye.

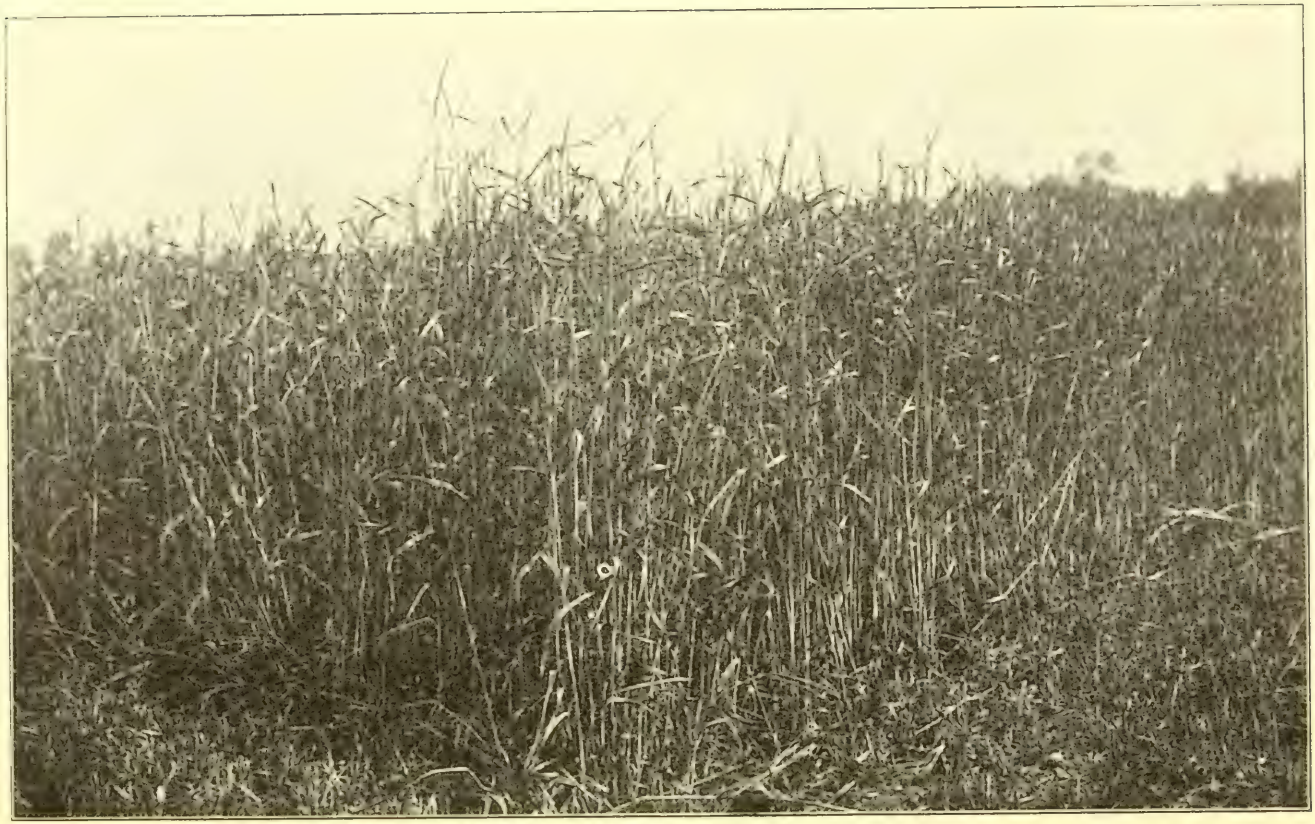

Fig. 55. Rye after cowpeas, without fertilizer.

VETCHES

There are two species of vetch that have recently come into considerable use. In the use of vetches for any of the purposes mentioned, care should be used to prevent the plant from ripening and re-seeding the land. In some states, notably Michigan, vetch has become a nuisance as a weed, and is said to have made profitable wheat-growing impossible in certain sections. Since it is not possible to separate the vetch readily from wheat, the latter is ruined for milling purposes. When grown only for green forage purposes, the danger is not formidable.

Spring vetch

The spring vetch or tare (*Vicia sativa*) may be substituted for Canada field peas, in a mixture with oats; and in the northern states, where the pea-louse has been very destructive, it serves an excellent purpose. It is sown in spring or early summer, and does not survive the winter. The preparation of soil should be practically the same as that recommended for oats and peas. Fertilizers should also be of the same character. Experiments indicate that one bushel of seed, with one to one and one-half bushels of oats per acre makes a good mixture, although the smaller quantity of oats will be better on good land, as

too large seeding of oats prevents a large growth of the vetch. The plant is trailing in habit. If conditions are favorable, it will make a very much thicker growth than the Canada field pea, and provide excellent forage, being very palatable and highly digestible when in the best stage for feeding. It requires a longer period for maturing, and this extends the time during which the forage may be used,—a very important advantage, particularly in dry seasons.

The composition of the oat-and-vetch forage does not differ greatly from that of the oats-and-peas. The crop may also be made into hay of an excellent quality, and it is readily cured.

Hairy or winter vetch

The sand, winter or hairy vetch (*Vicia villosa*) is another species that thrives on poor soils, and is useful as an early spring forage, withstanding the winter and growing in spring. Owing to its trailing habit, it should not be seeded alone (except as a green-manure or cover-crop), but with rye or wheat, preferably wheat for the central states, in August or September. It is desirable to have the soil well prepared in order to encourage an early and rapid fall growth, as well as to ensure a large crop in spring. It should be seeded at the rate of about one-half to one bushel

per acre, with the wheat or rye, the former being sown at the rate of one bushel per acre and the latter at the rate of three-fourths of a bushel per acre. It will be one of the first crops ready for use in spring, as it matures with the cereal.

The chief advantage of the use of hairy vetch with rye or wheat lies in the fact that a larger crop of forage may be secured than when the cereal is grown alone. The chief disadvantage of this crop is the expensiveness of the seed, but this difficulty will doubtless be overcome as soon as the value of the crop is known and larger areas are grown. Owing to its very early growth it may be pastured to advantage when not convenient to use as a soiling crop, usually coming earlier than ordinary pastures are ready. Of course the quantity of forage will be less when used as pasture than when cut and carried to the barn. It is not so desirable for hay as the spring vetch, because good hay weather does not usually prevail.

COMPOSITION OF HAIRY VETCH

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	88.10	. . .	. . .
Dry matter	11.90	238	1,190
Ether extract	0.50	10	50
Crude fiber	2.60	52	260
Protein	3.50	70	350
Ash	1.50	30	150
Nitrogen-free extract	3.80	76	380

BROAD OR HORSE BEAN

This plant (*Vicia Faba*, or *Faba vulgaris*), probably native to northern Africa and southwest Asia, is often mentioned in American writings, but it has never made much headway here. It is a stiff, erect-growing plant, wholly unlike the common bean in appearance. It grows two to four feet high. It produces large pods and big usually flat or flattish seeds. It is more like the pea than the bean in its relation to climate, as it withstands some frost. It has been cultivated from prehistoric times and its nativity is in doubt. It is much grown in Europe, primarily for forage purposes, although the seed may be used, both full grown and immature, for human food. It demands a cool climate and a long growing season and does not do well under the hot, dry summers of the United States. It is grown successfully in parts of Canada, where it has been used somewhat with corn and sunflower to make silage; this combination is known as the "Robertson mixture." This mixture does not seem to have made much headway. Frequently the plants are grown to full maturity and a meal made from the bean.

Planting may be made early in spring in clay loams. The seed is sown in rows, twenty to twenty-eight inches apart, so as to allow for

cultivation, which is especially important with this crop for conserving the moisture. Cultivation is discontinued in the latter part of July. If the crop is in early enough, it will stand up well under the snow when used as a winter cover-crop, but will winter-kill. Seeding is done at the rate of six to eight pecks per acre. A good yield of beans is thirty bushels per acre.

JAPAN CLOVER

Japan clover (*Lespedeza striata*) is a native of Japan and China, introduced into the southern part of the United States about 1840, since which time it has spread throughout the southern states, where it has proved of great value as pasture, although it is frequently used also for hay when grown on good land. Japan clover is also a valuable cover-crop and green-manure crop, as it is well adapted to light and poor lands and withstands drought well, growing and spreading when other plants die for lack of moisture. The plant thrives as far west as Kansas, and as far north as Maryland, although it does best from Virginia southward, where it has spread naturally. Under ordinary conditions of growth, it does not reach a height of more than ten to twelve inches, and on very poor land it simply spreads over the ground. Until recently, it was allowed to seed naturally, or

was seeded alone, especially on the poorer lands, the custom being simply to harrow the land and broadcast about twelve pounds of seed per acre, without covering. The seed should not be sown until all danger of freezing is past, as the young plants are tender and will be destroyed by a light frost. Where its advantages as a forage plant are appreciated, it is now often made a part of a mixture with grass, and four to five pounds of seed are used per acre.

On good land and well cared for, Japan clover will reach a height of two feet or more, and can be readily used for soiling or for hay. It is ready for use about the middle of June as far north as Virginia, and earlier in the more southern states, and makes good pasture as late as November. As with white clover, it should be kept pastured closely for best results, and when so managed is relished by all grazing stock.

When grown for hay, the common practice is not to cut until some of the seeds on the lower part of the plant are ripe, which permits it to reseed. While more easily cured than the red clover, it should be handled in practically the same way in order to prevent losses of leaves, which are richer in protein than the stems. As a soil renovator alone, it is well worthy greater attention than is now given it, though valuable, also, as pasture, hay and seed crop.

CHAPTER XV

ROOT-CROPS

English agriculture is noted for its root-crops. These crops become a regular part of rotation systems. They thrive in the cool moist seasons of that country. In America they have not received the attention that they deserve, particularly in the northern states and Canada, although in the latter country they are better appreciated than in the United States. They afford good nutrient materials in most wholesome and digestible forms, and because of their succulence they become a good adjunct to dry and concentrated feeds.

"The reason why the production of roots is of special interest in the north Atlantic states," as expressed in a recent Cornell bulletin (Root-crops for Stock-feeding, Bulletin 243), is "that these states raise a comparatively large amount of roughage and a small amount of concentrates, while the north central states raise a large amount of cereals or concentrates in proportion to hay and forage, as shown in the following table of the ratio of concentrates to roughage in the north

Atlantic and north central states, according to the census of 1900:

	North Atlantic	North Central
All cereals except wheat, million tons . .	4.4	69.2
All hay and forage, million tons	15.6	49.0
Per cent of cereals, except wheat	22.0	58.5
Tons cereals except wheat, per animal unit	.55	1.55
Tons hay and forage, per animal unit . .	1.95	1.10
Total tons of food per animal unit (of about 1,000 lbs. live weight) . . .	2.50	2.65

"The significance of this table is further emphasized when the superior feeding value of concentrates is fully understood. For example, experiments made by Zuntz, of Germany, show that when clover hay was fed to horses, forty-one pounds were digested out of each hundred pounds of hay fed, while, when oats were fed, sixty-two pounds were digested, or 50 per cent more. It was found, however, that it required the energy of twenty-four pounds of the forty-one pounds of hay digested to chew and digest the hay, leaving the net nutritive value at seventeen pounds. On the other hand, it required only twelve pounds of the sixty-two pounds of oats to masticate and digest the oats, leaving fifty pounds of oats available for producing energy or work. In other words, the oats had three times the value of the clover hay for the production of work in horses. The energy used up in chewing and digesting

food is manifested in heat and helps to keep the animal warm, and is therefore not entirely lost when the ration is merely for maintenance. But since, in any liberal feeding for the production of work, the production of meat, or of milk, the amount of heat thus produced is sufficient to keep the animal warm, the figures given above may be taken as representing their true food value.

"One of the objections to roots as a food product lies in the fact of their high water content. This limits the amount which may be fed and becomes of special importance where they are fed in connection with silage. On account of this high water content it will not be practicable to feed a sufficient amount entirely to take the place of the cereals, even should this be desirable for other reasons. The trend of experimental evidence is that the feeding value of the different types and varieties of root-crops depends more largely on the percentage of dry matter than on any other factor; for example, the percentage of dry matter apparently modifies their feeding value more largely than the percentage of sugar.

"The problem in New York state is whether we can afford to raise roots, and, if so, what kind. The following table shows the minimum average and maximum number of pounds of dry matter per acre which was obtained at the Cornell Experi-

ment Station in 1904, 1905 and 1906 from sowings made during May:

	Minimum	Average	Maximum
Mangels	2,168	5,155	8,453
Half-sugar mangels .	5,480	5,880	6,440
Sugar-beets	6,014	7,090	8,090
Rutabagas	3,537	4,331	5,079
Hybrid turnips . . .	2,584	3,694	5,111
Common turnips . .	1,710	2,680	3,500
Kohlrabi	3,570	4,070	4,540
Cabbages	4,076	4,662	5,588
Carrots	1,878	3,134	4,379
Parsnips	2,080	3,130	3,680

"The estimated yield of grain from flint corn, the same seasons, at this station, was approximately 2,000 pounds; while the yield of dry matter in silage from dent corn was about 4,000 pounds. It is probable that the season of 1904 was relatively favorable to the production of roots as compared to Indian corn, but this was not true of 1905 and 1906. During the latter years the average yields from roots were better than in 1904, although the land used was conceded by all interested to be less favorable than that used in 1904.

"The present high price of cereals is a factor in favor of the production of root-crops. If corn meal continues to be worth twenty dollars a ton, or more, in New York state, economy in the production of roots would be indicated, while, if the price should fall to ten dollars a ton, corn meal would probably be the cheaper source of concen-

trates. The serious handicap to the raising of root-crops is the fact that, with present cultural methods, a large amount of hand-labor is required. The point of view that it is desired here to emphasize is that, while roots may not be economically raised as a substitute for silage or other coarse fodders, it may be economical to raise them in New York state as a partial substitute for concentrates, particularly the cereal grains."

MANGELS

Perhaps there is no other one crop that has had so wide use as succulent winter forage as mangels, although they have had less popularity since the general introduction of the silo. It is a crop that can be grown to advantage, however, and it possesses many characteristics that make it an extremely valuable product, even when silage is also used.

Varieties of mangels

There are many varieties differing but slightly, as, for example, the Golden Tankard, Mammoth Long Red, Red Globe and Yellow Globe, any of which will answer for forage purposes.

Cornell experiments[1] give the following indica-

[1] Culture and Varieties of Roots for Stock-feeding, Bulletin 244.

tions of varieties: "Among the mangels, all of the long varieties seem to be able to produce good yields but have various defects. The Globe and Tankard varieties usually contain a higher percentage of water and are low in dry matter content. Two half-sugar mangels, Vilmorin Half-sugar Rosy and Carter Half-sugar, are recommended as suitable stock to use for breeding American strains. Sugar-beets, although rich in dry matter, are generally so much more expensive to harvest that the writers are not prepared to advocate their extensive use for stock-feeding."

Land, manures and fertilizers

In the culture of this crop, particular pains should be taken to provide a deep surface soil, as the deeper the soil the greater will be the proportion of root grown under the ground. Besides, the crop requires a large area of soil, in order to supply the rather exorbitant demands for plant-food. When the best yields are obtained, it is frequently recommended to subsoil at least eighteen inches, in order that the fine rootlets may penetrate to lower depths. In order to ensure a large yield, the crop should be well supplied with all the constituents of plant-food in available forms. When the land is heavy, it should preferably be plowed deep in the fall, and

covered with manure at the rate of eight to ten tons per acre. This should be worked into the soil early in the spring, and the whole surface thoroughly cultivated, and fertilizers applied containing a high content of nitrogen. A good formula should carry nitrogen, 4 per cent; phosphoric acid (available), 10 per cent; potash, 6 per cent. If manure is used as recommended, a dressing of 400 pounds per acre of this fertilizer at time of seeding may be made with advantage, even on good soils.

Seeding and handling

The quantity of seed is five to eight pounds per acre. The seed does not germinate quickly, and early growth is slow and, as a consequence, early cultivation is not possible, because the rows cannot be readily followed; therefore weeds take possession and make hand-labor necessary. It has been suggested that a little buckwheat be added to the seed; this plant germinates quickly, and the broad leaves clearly mark the row, making earlier cultivation possible.

Mangels should be sown in rows two to two and one-half feet apart in May or early June, and, after well started, the plants should be thinned to eight to ten inches apart in the row. The cultivation should be frequent, and, early in the season, relatively deep, in order that the soil may be in

the very best condition for absorbing and retaining moisture, as well as to remove all weeds.

The beets should be harvested as soon as frost occurs. In order to preserve them for winter, they may be stored in the field by placing in covered heaps from five to seven feet high, although the better plan is to remove after thoroughly dry to a root-cellar in which they are not liable to freeze and the temperature is not too high.

Composition and use of mangels

As with all root-crops, the content of dry matter is relatively low, usually not more than 8 to 10 per cent. The nutrients are highly digestible, however, and when associated with so large an amount of water they possess a very high value, particularly in furnishing food in a wholesome form. They are extremely palatable, and when otherwise only dry feeds would be used, they answer a good purpose in keeping animals in condition, as well as stimulating the milk flow and the laying on of fat. They are very useful for cows, hogs, chickens and practically for all other kinds of farm stock. Because of their adaptability, the use of mangels is increasing in many parts of the country, especially on small farms where but few animals are kept and where the labor is performed by members of the family.

AVERAGE COMPOSITION OF MANGELS

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	90.90	. . .	. . .
Dry matter	9.10	182	3,640
Ether extract	0.20	4	80
Crude fiber	.90	18	360
Protein	1.40	28	560
Ash	1.10	22	440
Nitrogen-free extract	5.50	110	2,200

A recent Cornell bulletin (No. 243) quotes the following experiments on the value of mangels for milk: "Rather extensive Danish experiments indicate that a pound of dry matter in roots is about equal to one pound of the cereal grains, or to three-fourths of a pound of cotton-seed meal, when fed to milch cows. In these trials no silage was fed, the basal ration in each case consisting of six and one-half pounds of hay and ten pounds of straw per cow. The experiment was so conducted as to eliminate, apparently, the factor of succulence, as shown by the following table of average of six experiments including about 150 cows during several months. Basal ration six and one-half pounds hay, ten pounds straw:

	Cereal grains Lbs.	Cotton-seed meal Lbs.	Dry matter in root mangels Lbs.	Nutritive ratio	Daily yield of milk Lbs,
Lot A	7	1.5	4.5	1:8–9	22.4
Lot B	4	4.5	4.5	1:5–5.5	23.7
Lot C	4	1.5	7.5	1:8–9	22.5
Lot D	1	4.5	7.5	1:5–5.5	24.2

"It will be noted that all the cows were fed roots, but two lots were fed roots containing seven and one-half pounds of dry matter, equal to about sixty-five pounds of fresh roots, instead of four and one-half pounds of dry matter, equal to about forty pounds of fresh roots. The additional three pounds of dry matter in the first-mentioned cases gave as good results as an equal amount of cereal grains, the cereals consisting either of Indian corn or of a mixture of barley, oats and rye. Roots, like the cereals, are highly digestible, perhaps even more digestible than the cereal grains, and herein probably lies their high value. From the standpoint of the results which they produce, the roots may be looked on as watered concentrates. They have, apparently, a high net available energy."

Yield of mangels per acre

When conditions are favorable, the tonnage yield is very much greater than can be secured from corn or other forage crops, frequently reaching as high as twenty-five to thirty tons per acre, although the total dry matter is much less than for a smaller tonnage of corn, cowpeas, or other succulent forage, and the labor involved is relatively greater per unit of dry matter. The greater expense of the mangel crop is due in large part to the extra cost of cultivation.

Mangels versus corn

The relative production of dry matter in a crop of fodder corn and in mangels is well shown by an experiment made by the New Jersey Station in 1894. The soil was good, and the plots on which the crops were grown similar in character. The tonnage yield and yield of nutrients per acre were as follows:

Containing pounds of	Mangels	Corn forage	Mangels increase	Corn forage increase
Weight of green crop . .	56,600	20,000	36,600	. . .
Dry matter	4,684	6,130	. . .	1,446
Crude fat	33.9	152.2	. . .	118.3
Crude fiber	379.2	1,484.7	. . .	1,105.5
Crude protein	684.9	468.9	216.0	. . .
Crude ash	503.7	243.8	259.9	. . .
Carbohydrates	3,112.6	3,780.2	. . .	667.6

The first point of importance shown by this comparison is that the total dry matter contained in the crop of mangels was nearly 25 per cent less than in the fodder corn; and for every pound of dry matter contained in the crop it was necessary to handle twelve pounds of water, while in the corn fodder the proportion of dry matter to water was as 1 to 3.2. It is shown, also, that in feed constituents the corn fodder furnished nearly five times as much crude fat, and four times as much crude fiber as the mangels and 20 per cent more carbohydrates. The feed constituent furnished in greatest amount by the mangels is crude pro-

tein, of which more than 50 per cent was shown by analysis to exist in the form of amides, compounds less valuable than true albuminoids.

It must be remembered, however, that mangels possess a value in addition to the actual food constituents contained in them, due to succulence and physical character, which it is impossible to measure in definite terms, particularly for winter feeding in connection with dry fodders. Under certain circumstances their production is desirable, even though the cost of dry matter exceeds that in corn or clover, mainly because of their dietetic effect and of the greater digestibility of the dry matter.

SUGAR-BEET

Sugar-beets are often recommended in place of mangels, largely because they contain a much higher percentage of dry matter, consisting largely of sugar. Varieties highly recommended by seedsmen are Queen of Denmark, White Rose Top and White Green Top, although those ordinarily grown for sugar are quite as useful. The preparation of land and fertilization should be practically the same as for the mangels. The seeding should be somewhat different, as at least twenty pounds of seed is required per acre. Cultivation and harvesting and storing

may be practically the same as recommended for mangels.

Yields range from ten to twenty-five tons per acre. They contain on the average 18 per cent of dry matter, thus getting in one ton nearly twice as much nutriment as is contained in two tons of mangels. They may be fed with dry foods at the rate of fifty to sixty pounds per cow. They are a good source of carbohydrates, aside from the dietetic value that they possess in quite as great degree as mangels. When only a few animals are kept, or when conditions of growth are most favorable and labor abundant, the growing of either sugar-beets or mangels is recommended as a source of succulent winter forage.

COMPOSITION OF SUGAR-BEETS

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	82.00	. . .	. . .
Dry matter	18.00	360	4,320
Ether extract	0.10	2	24
Crude fiber	1.10	22	264
Protein	1.60	32	384
Ash	1.20	24	288
Nitrogen-free extract	14.00	280	3,360

CARROT

The carrot is frequently grown for succulent winter food, particularly for horses, for which purpose it is excellent. As for other root-crops,

the soil should be deep and well fertilized, as it is impossible to grow a good crop on poor soil. The main varieties for stock-feeding are Long Orange, Long White and Short White. These may be planted from the middle of May to the middle of June, at the rate of about one and one-half pounds of seed per acre, in rows eighteen inches to two feet apart. The early culture requires considerable care, as the growth is slow, which usually makes it necessary to hoe between the rows. They should be thinned to about six to eight inches in the row.

Carrots are useful chiefly as an appetizer, and are not fed in large quantities. They should be harvested before freezing weather, and stored in a dry, cool place.

TURNIP AND RUTABAGA

Turnips may be used as a catch-crop late in the season, and they are useful both for late fall and for winter feeding. They are particularly useful for sheep, and also, if carefully used, for dairy cows. They are very watery, and do not contribute a large amount of actual nutriment. They stimulate milk flow, and their action in this respect is responsible in large degree for the belief that they possess superior nutrient qualities.

The varieties mainly grown for feeding are the

Purple-top and Yellow Globe. The Cow Horn is highly recommended as a catch-crop, because it roots more deeply, thus bringing to the surface plant-food from lower layers.

As a catch-crop, turnips may be sown after potatoes, tomatoes or other early crop, or seeded in corn at the last cultivation, serving both to conserve plant-food and provide a succulent feed. The yield varies widely. When grown primarily for forage and the soil liberally fertilized, as high as thirty tons per acre are recorded. The turnip does not seem to be able to obtain the necessary phosphates so readily as some other crops; therefore it is especially benefited by applications of superphosphates. Lands in good condition in other respects may grow a maximum crop of turnips with additions of phosphate alone, applied at the rate of 250 pounds per acre of acid phosphate. Under average conditions, however, an application of nitrogen and potash should accompany the phosphate.

Turnips may be sown either broadcast or in drills; when seeded as catch-crops the broadcast method is practiced and seed used at the rate of two to three pounds per acre. Where grown for forage, they should be in drills, seeded at the rate of one pound per acre, and thinned to six inches in the row, and cultivated as other crops.

The feeding of turnips to dairy cows, should be

made after the milking, as they are likely to add distasteful flavors if fed at other times.

COMPOSITION OF TURNIPS

	Per cent	One ton contains Lbs.	An average acre-yield furnishes Lbs.
Water	90.50	. . .	. . .
Dry matter	9.50	190	2,850
Ether extract	0.20	4	60
Crude fiber	1.20	24	360
Protein	1.10	22	330
Ash	0.80	16	240
Nitrogen-free extract	6.20	124	1,860

POTATO

It is not frequent that it pays to grow potatoes for stock-feeding; still it often happens that a large proportion of the crop is not marketable because of the small size of the tubers, when they can then be utilized for cattle or pig feeding.

Potatoes contain about 28 per cent of dry matter, are very succulent and palatable, and exercise a very marked effect on milk production. They may be fed raw or steamed; if raw, they should be cut, to avoid danger from choking. They should be fed, at first, in small quantities, although the amount may be gradually increased to forty to sixty pounds per day. They should be washed and thoroughly cleansed before feeding. Potatoes should always be mixed with dry feed, the amount added being in proportion to the needs of the

animal, and the potatoes not in such excess as to cause the animals to scour, which frequently occurs if too large quantities are used.

SWEET POTATO

Sweet potatoes are also an excellent food for cattle and hogs. In wet seasons, and on heavy soils, the crop is liable to be "rooty," that is, the potatoes are not merchantable, although of good size. These imperfect roots may be fed in the same way as the white potato, although they usually contain a little more dry matter and need not be fed in such large quantities. In the absence of other succulent feed they contribute very materially to the improvement of the ration.

CHAPTER XVI

THE CABBAGE TRIBE

Several members of the mustard family (Cruciferæ) of the cabbage kind are useful forage plants, and their cultivation seems to be increasing. In general feeding practice they may be compared with root-crops. In fact, kohlrabi is often classed with root-crops, and well it may be, since it is very closely allied to the turnips and rutabagas, differing chiefly in having the thickened part above ground rather than below ground. The leading cabbage-like forage plants are rape, cabbage and kohlrabi. The kales are not much grown for forage in North America. Their culture does not differ greatly from that of rape. Thousand-headed kale is the kind mostly recommended, but it does not appear to have any advantage over rape for forage.

RAPE

As a forage plant rape is a recent introduction into the United States. Several varieties have long been grown in Europe and other countries for forage purposes. Of the various kinds, but two are generally grown,—Dwarf (Dwarf Essex)

and Giant. The former is more generally useful, especially on the light, chalky lands of England, and it is the only one that has given satisfaction in this country. The other is grown on strong lands, and occupies a full place in the rotation. Rape has taken the place of turnips to some extent, and is very similar in its management. All varieties are annual, but in England they sometimes do not mature seeds the first season. The advantages of rape are: (1) it is well adapted to most soils; (2) it can be seeded either in spring or summer, serving an excellent purpose as a catch-crop and for green-forage; (3) the expense of seed and seeding is low; (4) it is especially useful for sheep and swine, although with care it may be profitably fed to dairy cattle.

Preparation of land, and seeding

The seed of rape is small, and the preparation of land is therefore very important. The land should be deeply plowed, covering all vegetable matter, thoroughly pulverized, and the surface soil made extremely fine previous to seeding.

Although rape does well on soils of medium fertility, the best results are secured when they are naturally rich, or have been well fertilized. When grown for forage, an application of barnyard manure at the rate of eight tons per acre,

well worked into the surface soil, is desirable, as the plant is a voracious feeder. For its best growth it must have abundance of available nitrogen. Hence, if manures are not readily obtainable, an application of fertilizers rich in nitrogen should be applied. Experience has shown that a fertilizer containing

Nitrogen	5 per cent
Phosphoric acid (available)	8 per cent
Potash	9 per cent

applied at the rate of 600 pounds per acre, will supply the food in good proportions. Should the season be unfavorable for rapid growth, an additional application of 100 pounds per acre of nitrate of soda when plants have well started will stimulate growth and help to ensure a large crop. This top-dressing of nitrate should be made when the plants are dry.

The rape may be seeded either in drills or broadcast any time from early in May for pasturing in July or August, or as late as July or August for late summer and fall pasture and also for cover-crops. When used for a cover-crop, the broadcast method is probably the better. When a large yield of succulent forage is desired, it is better to plant in drills two to two and one-half feet apart, as this permits early and thorough cultivation. The quantity of seed to be used is to be determined by the condition of soil and weather.

The quantity should be increased in dry weather and on poor lands. When sown broadcast, three to five pounds per acre will be sufficient, and when sown in drills from one to two pounds is recommended. For soiling purposes, it should preferably be seeded in drills and about the time that corn is seeded, or when time of severe freezing is past. Machinery adapted for planting small seeds can be successfully used for this purpose.

Tillage should begin as soon as the plants are well started, and repeated as frequently as possible until the plants have arrived at such stage of growth as will not permit of further cultivation without injury. Ordinary cultivators will answer for the work, but one that will cut close to the line of the row, without covering the plants, is the best, especially in the earlier stages of growth. As with corn, the first cultivation should be deep and gradually become shallow as the roots take possession of the soil.

Feeding value of rape crop

The value of rape as forage is chiefly as a soiling crop or for pasture; that is, it cannot be harvested and preserved with advantage. When used as a soiling crop, it may be cut with a mower and placed in heaps, which will remain good for two or three days. The following description of

rape as a pasture for sheep is in Farmers' Bulletin No. 11, of the United States Department of Agriculture:

"Rape is unrivaled as a pasture for sheep in autumn in those parts of this continent where it can be successfully grown. As a fattening food in the field it is without a rival in point of cheapness or effectiveness. The sheep that pasture upon it do the harvesting in a most effective manner, and with but little cost to the owner; and the manure made from it is distributed over the field which produced the crop, and in a form which is readily available for the plants of the succeeding crops. While rape thus grown and fed does not add fertility to the soil, unless in the plant-food it brings up from the subsoil, it does not detract from the fertility when the sheep which eat it off are inclosed upon it. When rape can be successfully grown as a pasture, the necessity for sending sheep and lambs to the market in a lean condition will be removed, and the numbers that may yet be fattened upon it in this country will only be limited probably by the inclination of the farmers and the demands of the market. Four to five millions of acres of arable land would suffice to grow rape enough to fatten all the sheep at present in the United States.

"The manner of feeding off the rape when pastured by sheep and lambs is in outline as follows:

"They should be tagged before being turned in upon the rape, or soon after, as they are liable to become purged to some extent at the first. They should not be turned in upon the rape when hungry at any time, as they may so gorge themselves that bloating, followed by death, may ensue. When they have access to an old grass pasture at the same time, the grass eaten by them is usually very effective in preventing scours and other disorders arising from impaired digestion. When the animals are once turned in upon the rape it is not necessary to remove them, unless in time of severe and prolonged storms of rain or sleet. At such times they may be given the protection of sheds when these are available, otherwise the shelter of a grove may prove of some service. After they have fed upon rape from two to two and a half months they will be ready for market. When it is desired to carry on the lambs into the winter months after the season for pasturing is over, they will go on improving in fine form where the management is judicious. In other words, pasturing on rape is an excellent preparation for winter feeding.

"The sheep or lambs should be visited two or three times a day by the shepherd. This may be done on foot when the flocks are small, but when feeding over large areas the aid of a saddle horse should be called in. When sheep get fat and

heavy they are somewhat liable to roll over on the back and so perish. They do not require any water when feeding upon rape, but should have access to salt at will.

"There is no limit to the numbers that may be put upon one field except its capacity to sustain them. The labor of hurdling does not seem necessary, as the sheep waste very little of the rape. When it has grown strong and rank, they feed around the borders. Like an invading army of crawling insects, they make clean work as they go, but when the crop is light and thin they feed in any portion of it."

Rape is also good forage for cattle, although, when fed to dairy cows, it is liable to contribute undesirable flavors to milk and its products, even though fed after milking, as recommended for turnips or other members of this family of plants.

In experiments at the Wisconsin Agricultural Experiment Station (Bulletin No. 115) to determine the quality of cheese as affected by the feeding of rape and other forage plants, it was found that whenever the rape was fed before milking, there was, in most cases, a very pronounced rape flavor; when fed just after milking, there was also a very noticeable flavor. In no case was the amount fed larger than ten pounds per day, although it was all consumed between the morning and night milking. In fairness to the rape, it is

stated that other green crops, as cabbage, corn and clover, also unfavorably influenced the flavor of cheese.

To avoid danger of over-eating when pastured, cattle should be allowed to feed in the rape for a short time at first, gradually extending the period until they may be left with reasonable safety. When fed as a soiling crop, this danger is avoided, as the quantity given is entirely under the control of the feeder. In feeding sheep or lambs on rape, they should preferably receive in addition a small ration of oats in the morning, although in many cases they may be fed exclusively on this plant.

As a cover-crop

Rape also possesses great advantages as a cover-crop, as it may be sown thickly as late as August for late fall pasture, and that which has not been used as forage will serve as cover in winter, preventing blowing and washing of the soil, and maintaining much better condition of soil in spring than if the land is left bare. It is destroyed by the cold in the northern and central states, and for this reason is not so advantageous as winter leguminous crops for this purpose. Nevertheless, because it can be seeded later and makes a large fall growth, it possesses very superior advantages as a cover-crop.

Yield and composition of rape

Owing to the fact that rape is usually fed from the field, data in reference to yields are somewhat limited. At the Wisconsin and New Jersey Stations, the yields have ranged, in round numbers, from twenty-three to twenty-seven tons per acre. When mature, rape contains more dry matter than most root-crops, as, for example, mangels and turnips and the total yield of nutrients is much greater. The average composition and yield of nutrients per acre are as follows:

	Per cent	One ton contains Lbs.	Average acre-yield furnishes Lbs.
Water	86.2	. . .	. . .
Dry matter	13.8	276	6,900
Ether extract	0.5	10	250
Crude fiber	1.9	38	950
Protein	2.4	48	1,200
Ash	1.8	36	900
Nitrogen-free extract	7.2	144	3,600

At the New Jersey Experiment Station, rape when at the best stage for soiling showed the following composition:

Composition of Dwarf Essex Rape	Per cent	One ton contains Lbs.
Water	84.50	. . .
Dry matter	15.50	310
Ether extract	0.50	10
Crude fiber	2.60	52
Protein	2.30	46
Ash	2.00	40
Nitrogen-free extract	8.20	164

CABBAGE

Cabbage has not been largely used in this country for feeding live-stock, although knowledge as to its value for this purpose is undoubtedly extending. That cabbage possesses a very distinct value as a succulent forage crop is well understood by those who grow the crop for the markets and use the refuse for feeding. The extra cost of growing cabbage beyond that of growing turnips, rape or other similar plants has probably been the cause of a lack of attention to it. The disadvantages of cabbage as compared with the other better-known crops mentioned, are (1) the expense of planting; (2) the large plant-food requirements; (3) the difficulty of storing for winter use; (4) the low percentage of dry matter contained in the crop. Farmers with small areas for growing forage will find cabbage a useful green crop, as it is excellent feed for all farm animals, and it is a fairly well balanced ration for milch cows.

The crop is adapted to a wide range of conditions, although its best growth may be obtained in cool, moist climates, as are found in the more northern states and in Canada, or in certain regions along the shore, as on Long Island, where the atmospheric conditions seem to be peculiarly favorable. The crop may be planted in a rotation, taking the place of oats in a rotation of corn, oats,

wheat and grass, as it is a good preparatory crop for wheat.

Preparation of land for cabbage, and seeding

As with rape, the land should be deeply plowed and thoroughly cultivated, the surface well compacted and made fine, in order that the plants may not suffer for lack of food as soon as set. If seed is used in the field, the germination should be prompt and the early growth rapid. Farmyard manures are excellent, and, as the cabbage is a gross feeder, applications of ten tons or more per acre should be made even on good soils, and this dressing supplemented with nitrate of soda. The fertilizers recommended for rape, both in kind and quantity, will answer for cabbage. Attempts should not be made to grow cabbage unless there is an abundance of available food.

As a rule, cabbage is not grown from seed planted directly in the field, and it is doubtful whether its successful and profitable use as a forage crop will warrant the extra labor required in transplanting. Of course, more seed should be used when the seed is planted directly in the rows, thus permitting the removal of extra plants when they have reached such size as to determine their vitality. The seed, in this case, may be sown with the ordinary grain drill. The rows should be about two and one-half to three feet

apart, and the plants thinned to about two feet apart in the row. The wider rows are preferable, because of the greater ease of using machinery. The depth at which the seed should be planted is preferably from one to two inches, according to the nature of the soil. Light lands should be rolled

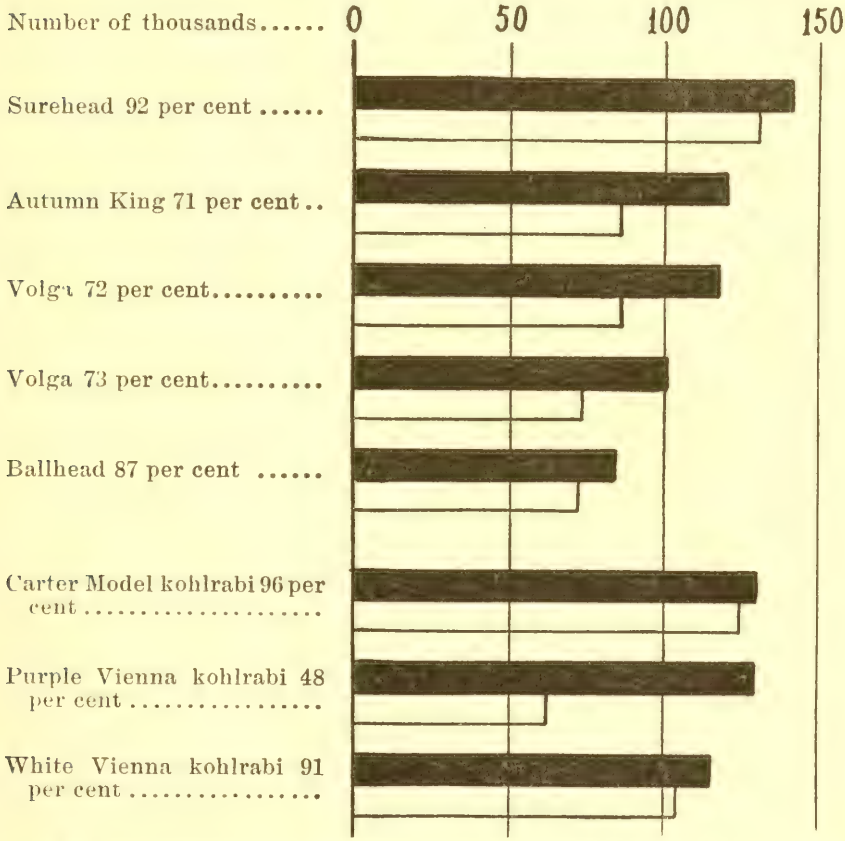

Fig. 56. Germination of commercial cabbage and kohlrabi seed and number of seeds in a pound (Cornell Experiment Station). The black bars show the number of thousand seeds in a pound; the light bars show the number of thousand that germinated.

immediately afterward, in order to draw the moisture to the surface and cause quick germination. From one to two pounds of seed per acre will be sufficient.

The time of seeding will depend on the place it is given in the rotation. The young plants are tender, and should not in any case be planted in spring until all danger of freezing is past, although light frosts will do no injury. It is better to sow either early or late, since, if the cabbage is not seeded until late in the spring, the heads will not form so well, but, if sown very late, the plants will be hindered from making heads before cold weather sets in.

In recent experiments at the Cornell University Experiment Station (Bulletin No. 242), the following statements in reference to soil and seeding are made:

"The soil considered best adapted is one rich in organic matter. Good crops can be raised on almost all types of soil, provided they contain the above requisite, are in good physical condition and contain an adequate although not excessive supply of water. Cabbages differ from almost any other farm crop in that their successful production is little influenced by the type of soil on which they are grown, or, in other words, they show a wide range of adaptability, so far as this factor is concerned. Undoubtedly, this power of adaptability

to varying soils was an important factor in leading the primitive people of northern and central Europe to cultivate the cabbage, and, having been grown by the common people of these regions under all sorts of conditions of soil and climate, with more or less success, from prehistoric times until the present, this power of adaptability has been preserved.

"The soil should be loose, friable and well prepared, deep fall-plowing being advised. An ap-

Fig. 57. Solid (at the left) and loose heads of cabbage.

plication of ten to twenty tons of manure per acre may be made before plowing. In spring, after harrowing, an application of well-slaked lime, at the rate of 1,000 pounds of quick-lime per acre, may be made, and harrowed in. The harrowing should be done before rain falls, otherwise the lime cannot be so readily incorporated with the soil. The advantages of lime for cabbage are recognized by many growers, and one of its benefits is its action

in destroying the fungus that causes clubroot. After the lime is harrowed in or before liming, it may be advisable to apply part of the fertilizers. Amounts frequently used are 400 to 800 pounds of acid phosphate, 15 to 16 per cent available, or its equivalent, i. e., 60 to 120 pounds of phosphoric acid; 100 to 150 pounds of muriate of potash, and fifty pounds of nitrate of soda per acre. Manure, lime and fertilizers should be uniformly applied. This important matter should not be neglected. If the seed is sown where the plants are to grow, the last harrowing should be done with the Meeker harrow or some tool which will fit the surface equally well."

The bulletin also gives the yields of varieties for 1904, 1905 and 1906, and states that the following are essentials of a high yield:

"First, rotation. It matters little what crops be grown, provided they are in accordance with rational practice, the main point being that when cabbage crops follow each other in succession the soil is likely to become infested with the clubroot fungus, which will render it unfit for growing cabbage for a number of years. Second, early planting. This gives time for full growth and development of the heads. Third, uniform stand. The number of plants per acre may vary between seven and ten thousand. As with many other tilled crops, however, it is more essential to have the

largest number of plants possible in the rows, and the rows wide enough apart to permit free use of horse implements in tillage. This may cut down the number of plants per acre, but it will be economical in the end."

The points clearly brought out by these experiments are: (1) that the tonnage per acre of all varieties is large; (2) that the percentage of dry matter in all varieties is low; (3) that, as a rule, the larger the yield the lower the percentage of dry matter; (4) of the varieties usually grown, the

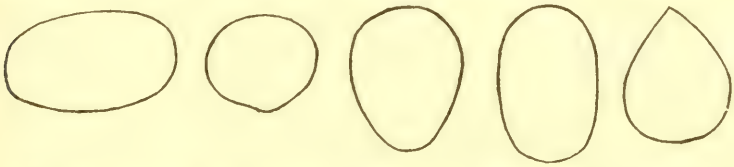

Fig. 58. Forms of cabbage heads. In order: flat, spherical, obovate, oblong, conical.

Surehead gave the largest yields in all the years, whether seeded in May and afterwards thinned, or whether grown as plants and transplanted in June; (5) the early planting produces the best yield of both fresh substance and dry matter. The most important points shown by these data is that cabbage does not compare favorably in yield of dry matter with many forage crops that require but two or three months for maturity, and which permits of two or three crops per year. With cabbage, one crop is practically all that can be grown, as it requires a long season.

The average composition and yield of nutrients per acre of cabbage are as follows:

	Per cent	One ton contains Lbs.	Average acre-yield furnishes Lbs.
Water	90.5	. . .	. . .
Dry matter	9.5	195	4,800
Ether extract	0.4	8	200
Crude fiber	1.5	30	750
Protein	2.4	48	1,200
Ash	1.4	28	700
Nitrogen-free extract	3.8	76	1,900

The average analysis of cabbage, which is here given, shows a much higher content of dry matter than is recorded in the Cornell bulletin; and the average yield per acre, with this analysis, would doubtless be much lower than is recorded in the bulletin, probably nearer twenty-five tons per acre, the average here assumed.

KOHLRABI

Kohlrabi is another valuable member of the cabbage family, and one that may be fed without risk at any period of growth. It requires a rich soil in order to attain its best development. If the land has been well prepared, it produces very heavy crops. There are a number of varieties, both bronze and green, but the green is almost exclusively grown. There are hardy, or big-topped varieties, and small-topped kinds, which come to

quick maturity, but are not able to withstand the severity of winter, and are, therefore, useful only for autumn food. Kohlrabi is particularly suited for filling in gaps between other forage crops.

A recent Cornell publication (Bulletin No. 244) speaks as follows of kohlrabi as a forage crop: "It

Fig. 59. White Vienna kohlrabi. It is a heavy yielder of both tubers and leaves. Background of six-inch squares. (Cornell Station.)

can be grown wherever rutabagas are grown, and will thrive if treated as described for the latter crop. In the middle West where rutabagas have a tendency to run to necks and form little root, this crop is a very good substitute. So far as now known, in New York the yields of the two crops are about the same, but both yielded less than mangels on the experiment station grounds. In addition to being quite a free-growing crop, it has the following advantages over rutabagas:

"1. It is not so subject to clubroot or finger-and-toe (*Plasmodiophora brassicæ*), and some other diseases.

"2. It withstands drought better.

"3. It can be grown on heavier soil, as clays, and does admirably on muck land.

"4. It stands well out of the ground and can be readily pastured by sheep if desired.

"5. It has not been known to cause taint of milk when fed to dairy cows.

"6. It is rather better than the rutabaga in withstanding frost.

"7. It may be grown where the climate is too warm for the best development of the rutabaga.

"8. The leaves are as valuable as the stem.

"Among well-known varieties are the White Vienna (Fig. 59), Purple Vienna, Short-top White, Goliath, Carter Model."

CHAPTER XVII

PERMANENT MEADOWS AND PASTURES

THE raising of hay forms a very important part of the farming interests of the eastern and central western states. The aggregate area in hay is greater than in any other crop. While in parts of the eastern states the hay crop is deemed worthy of the best attention of the farmer, this is the exception rather than the rule; therefore, while there may be profit from its growth, the yield and value are much less than should be secured were the crop given the same attention as the other crops in the rotation. In most instances, the hay is seeded rather as a catch-crop with wheat, rye or oats, and, while good catches are frequently secured, more often the stand is thin, thus reducing the yield, besides permitting the growth of natural grasses and weeds, and very materially reducing the quality of the product. Modern conditions would seem to warrant greater attention being given to this crop, and experiments show clearly that the hay crop will respond quite as profitably to good care, and the use of manures and fertilizers, as any other field crop.

MEADOWS

The main market hay is timothy, and market quality is reduced in proportion to the quantity of other kinds of grass mixed with it. Other grasses are of value, however, and these will undoubtedly be a feature in the hay markets, and exercise an influence in grading for market, when their value is generally known. From the standpoint of the grower, it is desirable to have more than one variety of grass, as it permits of thicker seeding and larger yield, for, when conditions are unfavorable for one grass, they may be favorable for another. Besides, the conditions that are unfavorable for the permanency of one grass may be favorable for the permanency of another, thus lengthening the period during which meadows may be profitably mown. Therefore, mixtures containing timothy, blue-grass, red-top, and other grasses of known value, in addition to the ordinary mixture of timothy and clover, are to be recommended. It is desirable that the varieties of grasses used in a mixture should mature practically at the same time; otherwise, the mixture would contain over-ripe and under-ripe grasses, which would unfavorably affect the quality of hay.

To insure permanency of meadows, it is not good practice to pasture them, as the tramping of the animals, especially should the land be wet, will

destroy many plants, and the vacant places will be occupied by weeds. It is much better to utilize the second crop as hay or green forage. If pasturing is practiced, care must be exercised to see that it is not carried too far.

Lands and their preparation

Lands suitable for hay-growing range from sandy loams to heavy clays, although, on the lighter soils, more difficulty is experienced in getting a stand and in securing its permanence. On heavier lands, the grasses are more likely to secure their needed food, and to grow without deterioration for a longer period.

The main point, particularly on the heavier lands, is to have the soil suitably prepared, if a good crop is to be guaranteed. The preparation usually given for the seeding of wheat or rye is generally very good for timothy and red-top, sown at the time of seeding the grain. As already pointed out, such seedings are not to be regarded as the best, as the purpose in the seeding is to secure the grain crop rather than the grass, and the grass crop is assured only when the conditions are all favorable for germination and subsequent growth. It has been demonstrated that, in order to secure the best results, the land intended for permanent meadows should be specially prepared,

not only plowed deep, but frequently and thoroughly cultivated, both to destroy weed seeds and to put the soil in an exceedingly fine tilth, which promotes the solubility of plant-food and permits the easy penetration of the roots of the young plants. It has been shown, also, that grass thus seeded does not usually require a nurse-crop, and that such seedings will give a larger yield of hay, the following season, than can be expected when seeded with grain in the customary way.

Seed and seeding

When seeded for permanent timothy meadow and for market, hay is the object sought; hence, if land is well prepared and clean, twenty to thirty pounds of seed should be used, although it follows that with this thick seeding abundance of available food should be present. The common practice of mixing timothy and clover is a good one, as generally a larger crop is obtained the first season—a sufficient increase to pay, although the selling price is lower for mixed hay. In this case, the following mixture of seed has been found to be good (using twenty to twenty-four pounds of seed per acre):

Timothy	12 pounds
Red clover	4 pounds
Alsike	2 pounds

Fig. 60. Meadow of mixed grasses: timothy, red-top and Kentucky blue-grass.

This mixture makes an excellent hay for home feeding, especially for cattle. The following mixture of seed has been found to be most excellent for lands well adapted to grass, the finer grasses making a thick sward, and insuring a larger yield:

Timothy	8 pounds
Red clover	4 pounds
Alsike	2 pounds
Kentucky blue-grass	2 pounds
Red-top	2 pounds

On clay loam lands that are naturally moist, the red-top and blue-grass are likely to crowd out the timothy, leaving a practically pure seeding of the red-top and the blue-grass. These make hay that is not readily salable, although, if cut when in full head and before the seeds have ripened, it is readily eaten by cattle. If allowed to ripen, the quality is much reduced, as it is not only unpalatable but is less digestible. Timothy for market should be cut as soon as the blossoms have dropped and the seeds formed, but not hardened; the leaves are still bright, while the yield has practically reached its maximum.

Whatever the mixture, the seeding may be made in the early fall, during a period ranging in southern sections from the latter part of August to early in October. The main point is to have the seeding made early enough to ensure a good growth before winter, and late enough to avoid

such summer weeds as crab-grass. Unless too large growth is made the first fall, it should not be removed nor pastured, but allowed to remain on the land. If heavy growth is made, it is better to mow, rather than to pasture it off before winter.

Manures and fertilizers

In seeding down meadows for permanent mowing, it is very important that the land, even though naturally fertile, be well supplied with available plant-food. This may be either barnyard manure or commercial fertilizer; in the absence of barnyard manure, commercial fertilizers can be depended on exclusively. In the use of barnyard manure, the quantity applied should range from six to eight tons per acre, preferably in fine condition, distributed evenly, and thoroughly cultivated into the surface soil. This should be supplemented at time of seeding by a fertilizer mixture made up largely of phosphates and potash salts, as the manure will supply an abundance of nitrogen to give the plant a start and insure its growth the first season. A good formula or mixture for application at time of seeding is the following:

Nitrate of soda	50 pounds
Ground tankage or bone	200 pounds
Acid phosphate	600 pounds
Muriate of potash	150 pounds

This application, when used without manure, may be 300 to 600 pounds per acre; with manure, about 200 to 350 pounds per acre. This should be applied previous to seeding and well harrowed in.

If the stand on young meadows is good, no top-dressing is needed the first year, on good lands. In spring, after the first year, the meadow should be top-dressed with a commercial fertilizer, or with finely divided manure early in the season, in order to supply the food needed for the rapid growth, as well as to encourage the deep rooting of the grasses, and a thickening of the sward. The mixtures for spring top-dressing should contain a large proportion of nitrate of soda, as this is the one form of nitrogen that is soluble and readily diffusible in the soil; this will penetrate deeply and encourage a deeper rooting of the plant. A formula made up as follows is one of the best:

Nitrate of soda	500 pounds
Ground bone	200 pounds
Acid phosphate	200 pounds
Muriate of potash	100 pounds

The summer or fall applications may contain a larger proportion of the minerals, and a formula made up of

Nitrate of soda	200 pounds
Ground bone	200 pounds
Acid phosphate	500 pounds
Muriate of potash	100 pounds

may be used in order to encourage the growth of the second crop, or aftermath. For this purpose, an application of 150 to 300 pounds of the mixture per acre may be made. Experiments to determine the most useful quantity show that, for the spring top-dressing, as high as 450 pounds of a mixture rich in nitrate, as the one above, will pay better than smaller applications, although in many instances, where the areas are large, farmers are not prepared to provide so large an allowance. These top-dressings, as already pointed out, may be either manure or fertilizer, but they should be applied every year, if permanence and good crops are expected; and, while the proportions of the different grasses may change somewhat, experience shows that the yields will be more profitable and will gradually increase, owing to the improved fertility of the land.

Experiments at the West Virginia Experiment Station show that the use of manure alone, when applied to a soil not highly fertile, caused an increase in yield from less than two tons per acre in the first year to over five tons per acre in the sixth year, and with nitrate of soda alone to about four tons. The average for the six years was four tons and over, for the manure, and three tons and over for the nitrate. "The entire meadow produced hay during the six years of the test to the value of more than thirty-six

dollars per acre per year, in addition to paying for all the fertilizer applied, while the land at the close of the five years was more valuable than at the beginning of the test. This plan of growing hay would not only result in increasing the value per acre to the farmer, but largely improved his soil for other crops."

Recent experiments at Cornell (Bulletins 232, 241) did not give very encouraging results on timothy with fertilizers alone (muriate potash, acid phosphate, nitrate of soda, and combinations) as compared with good stable manure: "It is perfectly obvious from these experiments that, on the Dunkirk clay loam on which this experiment was conducted and in this climate and under the conditions of this experiment, stable manure, at fifty cents a load,[1] brought much better financial results than any application of commercial fertilizer at current prices for the same. It also demonstrates that on this soil, which has been under cultivation for two or three generations, when stable manure is available, excellent crops of timothy hay may be produced. Where stable manure can be procured in sufficient quantity, the use of commercial fertilizers is not necessary.

[1] In making such comparisons as this, everything depends on the value placed on the manure. It is possible that fifty cents a load for manure is a comparable price on some farms, but farmers cannot buy manure and haul it at this figure. One dollar a load is probably a fairer price; and for city manures even this figure must be at least doubled.

On the other hand, these experiments give reason to believe that, when stable manure is lacking or not sufficiently abundant, commercial fertilizers may be used, if used judiciously, with good results.

"For the New York farmer, especially those who wish to raise the maximum amount of hay, a judicious blending of stable manure, leguminous crops and commercial fertilizers will probably bring both the maximum yield and the most economic returns. For the farmer who wishes to raise a larger proportion of hay on Dunkirk clay loam, an eight-year rotation may be suggested: hay, five years; an intertilled crop, such as corn, potatoes, beans, mangels, rutabagas or cabbages, one year; oats, one year; winter wheat or rye, one year. Timothy would be seeded in the fall with the wheat or rye and a mixture of red and alsike clover the following spring. In this rotation stable manure should be applied to the grass land before plowing for the cultivated crop. No fertilizer of any sort need be applied for oats. To the wheat apply commercial fertilizer relatively high in phosphoric acid and potash and low in nitrogen. Apply in the spring to each grass crop, just as soon as the grass starts, commercial fertilizers relatively high in nitrogen and low in phosphoric acid and potash. Mixed fertilizers usually contain too

high a proportion of phosphoric acid and too low a proportion of nitrogen for the production of timothy hay upon the soil and in the climate under consideration. It would probably be best for the farmer to buy the separate ingredients and mix them himself. The following mixture or its equivalent is recommended, nitrate of soda, 200 pounds; 16 per cent acid phosphate, 100 pounds, and muriate of potash, 80 per cent purity, 50 pounds. Whether this quantity should be applied per acre, or a greater or less quantity, can best be determined from the history of the land and the appearance of the meadow from year to year. In the experiments under consideration, only acid phosphate has been used as a source of phosphoric acid, although experiments at the Pennsylvania and Illinois Stations indicate that finely ground phosphate rock may, in the course of a rotation, be equally useful."

PERMANENT PASTURES

The treatment of permanent pastures follows the same general procedure as for permanent meadows. In many parts of the country, pastures occupy the rougher areas of the farm. In some instances they are too wet, in others too rough, and in practically all cases no attention is given to their improvement, either in the way

Fig. 61. Harvesting scene in meadow of mixed grasses: timothy, red-top and blue-grass.

of added fertility, or of drainage, or in cleaning the land of foreign growths. Experience has shown that pastures may be very materially improved, and at slight expense, if careful plans are made and a definite system of treatment is laid out and practiced. In the preparation of the land, and seeding, the suggestions already made for meadows may follow, except that many grasses will serve as pasture that are not so well adapted for hay; besides, the objections made to mixtures for hay do not hold good for pastures, as the farmer uses them for his own stock rather than offers them for sale.

Seed mixture

The following mixture of grasses and clovers will probably answer quite as well as any other, in the seeding down of pastures, as the variety of grasses is such as to insure a thick sward, as well as to provide for both early and late grazing:

Timothy	3 pounds
Orchard grass	2 pounds
Red-top	2 pounds
Kentucky blue-grass	2 pounds
Italian rye-grass	1 pound
Meadow fescue	2 pounds
Red clover	4 pounds
White clover	2 pounds

Preparation of land and top-dressing

In the preparation of the land and in seeding, great care should be exercised to remove all weeds, by allowing the land to lie bare for a time previous to seeding, and frequently to cultivate it. Since the pasture is to remain for a long period, it is usually important that the land be well limed, using from forty to fifty bushels per acre, and thoroughly harrowing it into the soil in the summer before the seeding. This will not only sweeten the soil, but will encourage the growth of clovers and other valuable legumes, which are always desirable.

Top-dressings should then be made at least once each year, preferably early in spring before the animals are turned on. The mixture may be similar to that recommended for meadows, applied at the rate of 200 to 300 pounds per acre. If applied in the fall, after the pasturage has ceased for the season, one not containing nitrates is preferable. An equal mixture of kainit, ground bone and acid phosphate has been found to be very useful, at the rate of about three hundred pounds per acre. This top-dressing not only causes a thicker growth of the nutritious grasses, but encourages a tendency to deep rooting, and thus a greater resistance to drought, besides improving the soil from year to year and preventing running out of

the grasses, which is so common on neglected pasture.

Weeds and brambles which are not consumed by stock should be removed each year, preferably in August, at which season the destruction of the plant is likely to result. Systematic management and treatment of pastures will result in many instances in increasing the yield more than two-fold; this should be a part of the practice of every farmer. On rough lands, where it is not possible to plow and prepare the soil and where grasses come in naturally, the permanency of the pastures may be increased, and the quality improved, simply by dressing with commercial fertilizers, using mainly ground bone, acid phosphate and muriate of potash, and liming once in about four years. Many hill pastures, that furnish scanty herbage, may be very quickly improved by this method, and the yield of forage very largely increased. In these cases, the soil is frequently dry and poor, and it requires only that the minerals should be applied, in order that the plants may develop more rapidly, and continue for a longer time.

Renewing old pastures

Old pastures that have become sod-bound and mossy may be greatly improved by scarifying with any suitable tool; a spike-tooth harrow will answer

the purpose, as it will do greater service among stones and stumps than most others. Lime the land at the rate of twenty-five bushels per acre, and fertilize with the mixture of ground bone, acid phosphate and kainit at the rate of 200 to 500 pounds per acre. The stirring of the soil will let in the air, the lime will sweeten it, and the fertilizer will provide additional food. Seed should then be sown and lightly covered. The expense is not great, while the value of the pasture is manifestly improved, and its greater permanence assured.

CHAPTER XVIII

BERMUDA-GRASS AND RUSSIAN BROME GRASS

TIMOTHY, red-top and June-grass are the staple meadow and pasture grasses of the older parts of the United States. The remarks in the preceding chapter apply specially to them and to combinations with clovers. There remain very many grasses of recent introduction, or which have lately come into notice, but a discussion of them is scarcely called for in a brief popular work of this kind. Two other grasses, however, need to be specially considered, and a discussion of them now follows.

BERMUDA-GRASS

Bermuda-grass is now regarded as one of the most valuable grasses for the southern states, particularly for pasture. It is perennial, the creeping stems of which produce nodes at short intervals; each joint is capable of producing a new plant, even though it is cut off and completely separated from the main stem. It is because of this characteristic, although valuable from the standpoint of securing a thick stand, that many farmers object to its introduction, as, after it is once seeded, the

cleaning of the land is very difficult. Many growers now think that, when rotations are desired, it is not necessary completely to clean the land of Bermuda-grass, since, if a few joints are left, these serve to bind the land and to hold moisture; then, when the grass crop is wanted again, enough joints remain alive quickly to form a complete cover. The plant makes a thick, leafy growth with branches of five to ten inches in height. It is the common lawn grass of the South.

Bermuda-grass is a hot-weather plant, and thrives only in those regions in which the winters are short, and the frost does not penetrate deep or persist for a long time. It grows through the entire summer. While it will make a much better yield on good lands, it is also well adapted for pasture on poor lands, and on those liable to wash and gulley; and its power of withstanding heat and drought, and to revive quickly when moisture comes, are among its valuable characteristics. It grows best on light soils, river-bottoms and at the foot of hills, where the soil has been washed from the higher levels. Its habit of throwing out underground stems, makes it better adapted to sandy lands than to stiff heavy clays; nevertheless, when once well established on the heavier soils, it is serviceable. It has rendered great service in the South in preventing the washing of lands, a danger that is common in the southern states.

Preparation of the land

As with other grass plants, the better the preparation of land, and the cleaner, the quicker will the stand of grass be secured. The conditions which result from the planting and care of corn, cotton and tobacco, provide a suitable preparation for Bermuda-grass. Owing to the high price of seed and its low vitality, the method now generally used to secure a stand, is to plant pieces of root-stocks rather than to seed in the ordinary way, although it is necessary to have a small area seeded to use as a cutting nursery for enlarging the area. For this purpose, the seed should be sown broadcast, on clean, moist land, and covered with a rake or light harrow. Five pounds of seed is sufficient for an acre.

This plant responds well to fertilizers, and top-dressings with nitrate of soda, where the soils have been suitably fertilized with minerals at time of seeding, are very profitable.

Bermuda-grass for pasture or meadow

The following methods of securing a pasture or meadow of Bermuda-grass are described by Prof. F. Lamson-Scribner[1]:—

"On account of the high price of seed, and the

[1]Circular 31, Div. of Agrostology, Dept. of Agr., Washington, D. C.

necessity of a thorough preparation of the soil, pastures and meadows are more often started from cuttings. To prepare cuttings, the sod is gathered and cut into small pieces with a feed cutter or other similar machine, or a wooden block and hatchet can be used if only a small quantity is needed. Since most of the propagating stems are near the surface, it is necessary to shave off a layer of sod only an inch or two thick. If cuttings are wanted in large quantities, the sod can be plowed and the roots harrowed into windrows or piles. In all cases care should be taken not to allow the roots to get dry. The cuttings may be planted at any time of the year in the South, except the coldest winter months, but the work is usually done in March. If a meadow is desired, more care should be taken in the planting of the cuttings to insure a level surface for the mowing machine. The cuttings are planted by dropping them at intervals of a foot or two in shallow furrows, and covering with the next round of the plow. This can be done when the field is plowed, the cuttings being dropped every other round or every third round. Or the field can be prepared first and the cuttings dropped upon the surface and pressed in with the foot as they are planted. For meadows it is best to go over the land with a roller after planting. For pastures, when a smooth surface

is not necessary, it is sufficient to plow shallow furrows every two to four feet and drop the cuttings therein, covering them with the foot or by turning the soil back over them with the plow.

"Professor Tracy remarks:—'So easily may Bermuda-grass be propagated that good stands can be secured by scattering a dozen or more sods to the acre and cultivating the land in corn or cotton two or three years, when the grass becomes distributed in the field.'"

Yield and value of crop

Bermuda-grass is relished by all kinds of livestock, and in all stages of growth, making a palatable and nutritious pasture and hay. Owing to its drought-resisting qualities, it provides pasture throughout the entire summer season, which ranges from seven months, in North Carolina, to nearly the entire year in the far South. It is not desirable, however, to graze throughout the entire year, as grazing naturally reduces the vitality of the plant. Neither should it be grazed too closely soon after planting, as this has a tendency to destroy the runners, thus preventing the formation of new plants. On established pastures, however, close grazing is desirable, because the pasture is more palatable,—the stems not becoming hard and wiry and less digestible.

For use as hay, the crop should be harvested when a large proportion of the stems are in bloom. The number of cuttings in a season must depend on soil and season, ranging from one to four per year, with a total yield of one to three tons per acre.

The following reports[1] from the states indicated show that Bermuda-grass is highly regarded and likely to prove one of the most valuable forage crops:

"*Alabama.*—This grass will grow under the most flagrant neglect; while care and cultivation will bring out its characteristics to a marked degree, and will repay the cultivator for all his expense and trouble. It is an excellent grass to prevent the washing of the land, for filling up gullies and preserving terraces. It makes one of the best lawns on account of its smooth and regular growth, and its power to withstand the heat of the sun. The Bermuda-grass is not so difficult to eradicate from the field as most farmers seem to think. Close cultivation in cotton for two or three years, and thorough pulverization of the soil will destroy this plant.

"*Arkansas.*—Bermuda-grass is the best summer pasture grass we have for the sandy soils of south Arkansas, and is one of the best hay grasses for all parts of the state, except the northwestern

[1] Bulletin No. 55, Oklahoma Experiment Station.

part. It is not generally regarded with much favor, but, where it has established itself and is being utilized, it is regarded with great favor. On the barren soils it does not succeed, but it succeeds on all other soils whether wet or dry. It makes hay of superior quality that is highly relished by live-stock. When the value of Bermuda-grass for hay, pasture and a soil-renovator is appreciated, and the proper methods for cultivating and controlling it are understood, it will be a highly appreciated grass. Shade is fatal to the grass, and by using the harrow, then oats, then cowpeas and cotton, the grass can be subdued and eradicated. To start the grass by seed is uncertain. The cheapest and best way is to start to turn up a Bermuda sod and harrow the roots into piles, then chop them into short pieces with a hatchet and sow them on freshly broken soil and plow them in. The roots must not get dry while out of the ground.

"*California.*—This grass has introduced itself in a bold and uninvited manner. Its perfect adaptability to the conditions is evidenced by the thrifty growth on all kinds of soil, including strong alkali, very dry and very wet, producing more than any other grass (without care or planting), abundant feed during nine months of the year. The objections to this useful grass are mostly founded on the prejudice of the people, which renders them

blind to their own interests. Many men are wearing out their lives in poverty, trying to grow fruit on land poorly adapted to fruit-growing, but eminently adapted to Bermuda-grass.

"*Louisiana.*—For winter and early spring, Texas blue-grass and the clovers seem to fulfil all the requirements, followed in summer by Bermuda- and crab-grass, the two best grasses we have. It was impossible during the wet summer to restrict the last two to the plots allotted to them, but together, they covered the whole area of the (grass) garden, yielding several cuttings of hay for our work animals.

"*Mississippi.*—This grass is the most valuable species we have in the South, and is too well known to need any description. It succeeds best on rich bottom lands and on the black prairie soil, where it will yield two cuttings in a season, making two to four tons of hay per acre. This hay is of the very best quality, being especially valuable for horses and mules."

J. S. Newman, in Bulletin No. 76, of the South Carolina Station, says of the plant: "This most valuable acquisition to our list of pasture grasses seems to have come from India, where it is called 'Dhab.'

"Until its great value as a pasture grass and, on moist, fertile soils, as a hay producer, became known, it was regarded as a pest by the cotton

planters all over the southern United States. Many plantations, in the south Atlantic states, were abandoned on account of its prevalence upon them, which are now yielding more profitable returns from Bermuda pastures and Bermuda hay than were ever realized from the same fields while cultivated in cotton. There is a well authenticated record of 13,000 pounds of Bermuda hay, per acre, from three mowings during one season, on the Oconee river-bottoms in Georgia.

"Farmers who, a few years since, dreaded its appearance upon their farms as they did Canada thistle or the famous coco or nut grass, are now industriously planting Bermuda pastures and meadows."

Meadows of Bermuda-grass should be renewed once in three or four years, as the tendency is to become sod-bound. The meadows may be renewed by deep plowing, and seeding in the late fall with any of the crops usually grown for spring pasture or soiling; vetch and winter oats have been used for this purpose with great success. An abundance of seed should be used and the land well fertilized in order to insure a vigorous growth that will help to choke the grass. The sods and roots left will spread rapidly after the forage crops have been grazed or cut, provided the land is naturally fertile, or has been even manured or fertilized.

Methods of eradication

"The very qualities which render Bermuda so valuable as a pasture grass serve to make it an aggressive and pestiferous weed. On account of its tendency to spread and insinuate itself into land where it is not wanted, and to persist in fields which are to be used for other purposes, it has, in many cases, not been utilized to the extent that its good qualities would indicate. However, it can be eradicated from a field with comparative ease by proper cultivation. Since it will not thrive in the shade, it is only necessary to smother it out by some quick-growing crop. A method recommended by southern agriculturists, and which may be modified to suit conditions, is to plow the land after the last crop of hay is cut, if the field is a meadow, or about this season if it is a pasture. Sow the field to oats, wheat or other thick-growing crops. When this crop is harvested, plow the land immediately and plant to cowpeas. It is probably best to plant these in drills and cultivate them until the vines meet, after which they will shade the ground and prevent the growth of Bermuda. Usually this treatment is sufficient to completely destroy the Bermuda; but if not, the process can be repeated." (Circular No. 31, Division of Agrostology, Department of Agriculture.)

RUSSIAN BROME GRASS (*Bromus inermis*) (Figs. 62, 63)

This perennial grass was introduced into the United States in 1882, and is now widely grown in Canada and in North and South Dakota, and in the western parts of Minnesota, also in Kansas and Nebraska, and in parts of many other of the western states, both because it is itself a good grass crop and because it resists cold and drought.

The habits of growth of this plant are similar to those of quack-grass; it has creeping root-stocks, branching out in every direction, and these produce at each joint a bud, which is capable of producing another plant. It grows to an average height of about two feet, although under good conditions it will reach a much greater height. The leaves are broad, thick and abundant, when the soil is good. This grass makes a large yield, because of the thickness, even though the height is somewhat reduced. It is well adapted to light, dry soils. It starts in spring earlier than any of the other valuable grasses. It matures usually in the month of June. It is a very palatable grass, all animals being fond of it. Because of its habit of growth, it makes a valuable pasture throughout the entire season, and is also useful as hay. The yields from an average crop are one and one-half to three tons per acre.

Bromus inermis is adapted to a wide variety

Fig. 62 *Bromus inermis.*
Photographed by H. L. Bolley, North Dakota.

of lands, although it seems to do very much better on light sandy soils, deficient in moisture. This makes it a useful plant where others would not grow well; but it does not follow that it will not grow much better on soils of higher fertility. This brome grass is not well adapted to a rotation of crops, because of the difficulty of cleaning the land, although this is less difficult than in the case of Bermuda-grass. It should not be allowed to grow for a long period without breaking up, if used in rotations.

Fertilizing Bromus inermis

In renewing either pastures or meadows of *Bromus inermis* that are too thin, seed may be added in the fall and lightly covered with a harrow, although a thin stand will ordinarily thicken up sufficiently, if the plant-food is ample. As with other grasses, fertilizers or manures are beneficial, and top-dressings of manure, either in the late winter or early spring (four to six loads per acre), or top-dressings of nitrate of soda when the plants are well started, will usually pay well. When lands are rich and moist, there is sometimes difficulty in destroying the grass, when land is broken for other crops; but if plowed deep and followed by one or more cultivated crops, there need be little anxiety on this score.

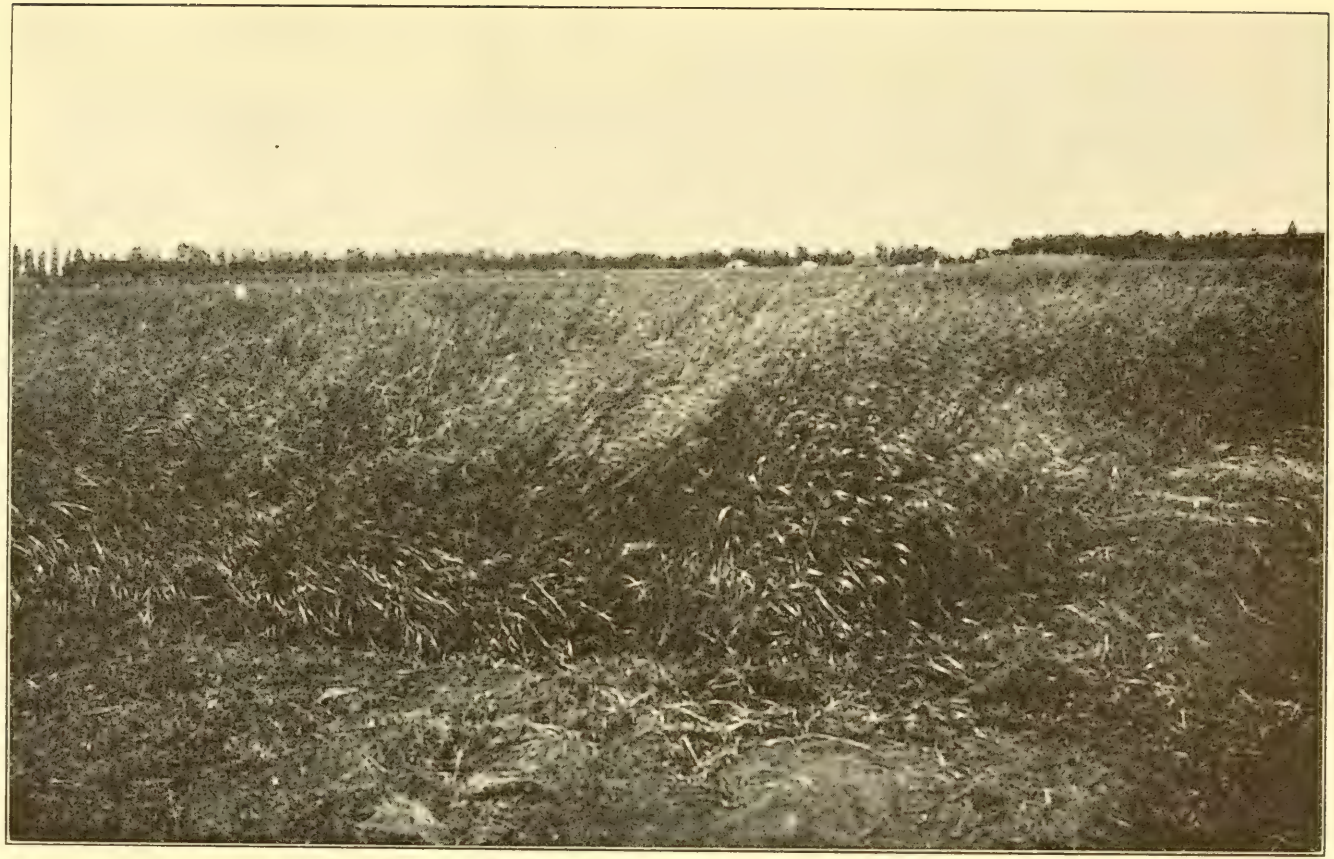

Fig. 63. Field of Russian brome grass, *Bromus inermis*.

The preparation of land, and seeding

Russian brome grass does not grow rapidly the first season. Therefore the land should be well prepared and free from weed seeds before planting. It is more desirable to sow after a cultivated crop, or on land that has been summer-fallowed part of the season. The good preparation necessary for the seeding of any grass will answer. It may be sown in fall or spring, although, under average conditions, the most favorable time is the early spring, especially if sown with a nurse crop. If seeded in August or September, on land that has been well prepared, it should make a good crop the following season. In the South, it is preferable to sow in the fall, owing to the fear of destruction by the hot, dry weather of the following summer.

When seeded without other grasses, twelve to fifteen pounds per acre is sufficient, when intended for hay; sixteen to twenty pounds should be used when intended for pasture. When it is a part of a combination of other grasses, the proportions may be two to five pounds, according to the object of the seeding, although little experience has accumulated in this country as to its permanent character in pasture and meadows. Its natural tendency is to crowd out other less vigorous grasses

Pasturing and harvesting

For pasture, the brome grass will stand close grazing, particularly on good lands, but if pastured very late and close in the fall, the yield of the next season's crop is likely to be reduced.

In cutting for hay, it should be harvested when fully in head, although for horses it may be cut when the blooms have disappeared. Probably the best time for cutting, as for other grasses, is when the plants are in full bloom. The cutting and curing does not differ from the methods recommended for timothy, or the other better known grasses.

CHAPTER XIX

COMPOSITION, FERTILIZER AND COEFFICIENT TABLES

THIS chapter contains tables showing the average composition of American forage crops and feed stuffs, together with the fertilizer constituents contained in them, and the average coefficients of digestibility.

The analyses represent the average as near as may be, although it should be understood that average compositions of products of varying quality are a guide only when accompanied with knowledge of the possible variations that may occur; they are chiefly useful in showing differences in the composition of groups, rather than giving exact information as to what may be expected under different conditions. This is particularly true in the case of crops used for green forage, as the range in content of dry matter is very wide, owing to the necessity of beginning to harvest when the plants are immature and continuing it so long as they remain palatable. The composition of fine feeds also varies widely, although it is possible now to so classify as to eliminate the variations that formerly existed.

The tables showing the average fertilizer ingredients of fodders and feeds are also subject to the same criticism, although not to the same degree.

These data are of special service, in the case of farm crops, in showing the relations between the different classes, and, in the case of fine feeds (which are not forage-crop products), in indicating the gains or losses that may be incurred in the exchange of home-grown herbage feeds for the more concentrated refuse or by-products.

The average coefficients of digestibility are also subject to variations, as must be apparent to those who give the matter consideration. They are to be used as guides only, and not as absolute facts.

The data contained in these various tables have been derived from a number of sources, but mainly from tabulations of analyses made by the various experiment stations of this country. The coefficients of digestibility are the averages of American digestion experiments contained in the report of the Hatch Experiment Station of Massachusetts, for 1906.

PLAN OF TABLES I AND II

1. *Green fodder*, pp. 347, 358.
   - *A*. Cereals and grasses.
   - *B*. Legumes.
   - *C*. Combination crops.
   - *D*. Miscellaneous.

PLAN OF TABLE III

TABLE I

Average Composition of Fodders and Feeds

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
1. Green Fodder.							
a. Cereals and Grasses.							
Corn (Maize)	71	77.4	1.3	1.6	5.2	14.0	0.5
White Thoroughbred Flint corn	1	80.3	0.9	1.7	3.8	12.7	0.6
Southern White corn	1	73.5	1.0	1.5	5.3	17.7	1.0
Sweet corn	3	79.1	1.3	1.9	4.4	12.8	0.5
Sweet corn, Stowell's Evergreen	1	77.9	1.2	1.8	4.5	14.0	0.6
Teosinte	1	90.1	1.4	1.4	2.7	4.1	0.3
Rural Branching doura	1	85.9	1.3	1.7	4.7	6.0	0.4
Yellow milo maize	1	83.2	1.5	1.7	5.5	7.5	0.6
Sorghum	10	76.3	1.1	1.2	5.8	15.2	0.4
Sorghum, Early Amber	2	85.2	1.2	1.4	4.0	7.7	0.5
Sorghum, Early Orange	2	83.2	1.5	1.7	5.5	7.5	0.6
Sugar-cane	2	84.2	1.1	1.2	4.0	9.0	0.5
Japan millet	14	79.9	1.5	1.8	5 9	10.4	0.5
Japan broom-corn millet	3	78.7	1.8	2.4	6.2	10.3	0.6
Barnyard millet	13	84.8	1.6	1.5	4.5	7.1	0.5
Pearl millet	2	81.5	1.5	1.2	6.2	9.3	0.3
Common millet	16	80.0	1.0	1.5	6.5	10.5	0.3
Canary Bird Seed millet	1	80.0	1.6	1.0	7.1	10.0	0.3
Early Harvest millet.	1	80.0	1.4	1.1	7.4	9.7	0.4
Golden millet	1	80.0	1.2	0.8	7.0	10.7	0.3
Hungarian grass	14	71.1	1.7	3.1	9.2	14.2	0.7
Millet	1	80.0	1.1	1.1	5.3	11.7	0.8
Hog millet	1	80.0	1.4	1.5	6.5	10.2	0.4
Broom-corn millet	2	78.6	1.4	1.6	7.5	10.4	0.5
Red kafir corn	1	81.6	1.3	1.8	4.8	9.9	0.6
White kafir corn	1	83.4	1.4	1.9	4.6	8.0	0.7
Rye	12	81.9	1.4	2.1	4.3	9.6	0.7
Barley	3	76.6	1.5	2.8	7.0	11.4	0.7
Wheat	1	77.3	1.8	2.4	5.9	11.9	0.7

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
GREEN FODDERS — Cereals and Grasses, continued.							
Oats	7	75.0	1.7	3.1	8.0	11.5	0.7
Pasture grass	7	63.1	3.2	5.6	7.4	19.2	1.5
Mixed grasses and clover	2	75.0	1.6	2.9	8.0	11.7	0.8
Johnson grass	1	75.0	1.4	1.2	8.9	13.2	0.3
Orchard-grass	8	73.0	2.0	2.6	8.2	13.3	0.9
Tall oat-grass	4	70.0	1.6	2.3	10.8	14.7	0.6
Italian rye-grass	24	73.2	2.5	3.1	6.8	13.3	1.3
b. Legumes.							
Red clover	43	70.8	2.1	4.4	8.1	13.5	1.1
Crimson clover	4	84.0	1.4	3.0	4.1	7.0	0.5
Mammoth Red clover	4	80.0	1.9	3.0	5.8	8.9	0.4
Alsike clover	4	74.8	2.0	3.9	7.4	11.0	0.9
Sweet clover	4	80.0	1.9	3.8	6.3	7.4	0.6
Alfalfa	35	77.5	1.9	3.6	6.3	10.1	0.6
Cowpea	32	84.4	1 9	3.9	3.6	6.8	0.4
Canada field pea	26	84.7	1.3	2.8	4.4	6.3	0.5
Soybean	20	75.1	2.6	4.0	6.7	10.6	1.0
Velvet bean	1	82.2	1.9	3.5	5.1	6.6	0.7
Sand vetch	14	85.3	2.1	3.6	4.0	4.6	0.4
Spring vetch	4	85.0	1.4	2.7	4.5	6.1	0.4
Kidney vetch	1	85.0	2.0	2.8	2.3	7.4	0.5
Rape	5	85.7	2.5	2.2	2.1	7.0	0.5
Horse bean	1	85.0	0.9	2.5	4.3	6.9	0.4
Flat pea	2	85.0	1.3	4.4	3.7	5.0	0.6
Sainfoin	1	75 0	2.1	4.4	6.0	11.6	0.9
Serradella	3	85.0	1.6	2.2	4.4	6.5	0 3
Sulla	2	75.0	2.3	4.3	5.2	12.5	0.7
c. Combination Crops.							
Oats and peas	7	79 7	1.6	2.4	6.1	9.6	0.6
Barley and peas	1	80.0	1.6	2.8	6.8	8 2	0.6
Corn and peas	1	80.0	1.8	2.1	5.3	10.4	0.4
Sweet corn and peas	1	80.0	1.5	1.8	4.8	11.4	0.5
Millet and peas	1	80.0	1.8	2.4	7.5	8.0	0.3
Sorghum and peas	1	80.0	1 6	1.6	6.5	9.9	0.4
Corn and soybean	3	80.0	1.5	2.6	5.0	10.4	0.5
Barley and vetch	2	80.0	1.2	2 8	6.5	9.0	0.5
Oats and vetch (1-1)	3	80.0	1.8	3.0	6.3	8.4	0.5

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
GREEN FODDERS—Combination Crops, continued.							
Oats and vetch (4-1)..	1	80.0	1.8	2.7	6.0	8.8	0.7
Wheat and vetch.....	4	80.0	1.6	3.4	6.4	8.1	0.5
Tall oat-grass and alsike	2	80.0	1.5	2.7	5.8	9.5	0.5
Orchard-grass and alsike	1	80.0	1.5	2.4	6.5	9.0	0.7
d. Miscellaneous.							
Apple pomace.....	6	83.0	0.6	1.0	2.9	11.6	0.9
Sugar-beet pulp.....	1	90.0	0.1	1.4	2.5	5.9	0.1
Cabbage waste.....	1	82.0	4.9	3.6	2 6	6.6	0.3
Carrot tops.....	1	80.0	2.8	4.2	2.7	9.9	0.4
Prickly comfrey.....	1	87.0	2.8	2.3	1.5	6.1	0.3
Purslane	1	91.0	1 5	2.3	1.6	3.4	0.2
Spurry.....	1	72.0	2.6	2.9	7.0	15.4	0.1
2. SILAGE.							
Corn	70	79.8	1.2	1.6	5.6	11.1	0.7
Sorghum.....	6	75.8	1.0	0.8	6.3	15.8	0.3
Red clover.....	1	72.6	2.7	3 8	8.6	11.4	0.9
Brewers' grains	4	70.3	1.2	6.3	4 5	15 6	2.1
Rye.....	1	80.8	1.6	2.4	5.8	9.1	0.3
Cowpea	1	83.3	2.0	2.8	3.9	6.7	1.3
Soybean	1	74.9	4.1	4.5	6.1	8 9	1.5
Soybean and corn	6	76.0	2.3	2.7	7.3	10.9	0.8
Soybean and millet...	9	79.0	2.8	2.8	7.2	7.2	1.0
Millet	3	74.0	2.4	1.7	7.5	13.6	0.8
Apple pomace.....	1	85.0	0.6	1.2	3.3	8.8	1.1
3. HAY AND DRIED COARSE FODDER.							
a. Cereals.							
Corn fodder.....	118	27.5	4.6	5.0	22.9	38.8	1 2
Corn stover.....	60	40.5	3.4	3.8	19.7	31.5	1.1
Oat fodder	6	15.0	6.9	11.7	25.5	38.3	2.6
b. Grasses. Hay.							
Mixed grasses and clover.....	12	15.0	5.4	7.5	28.0	41.6	2.5
Orchard-grass	10	10.4	5.5	7.0	31.1	43.8	2.2

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
HAY AND DRIED COARSE FODDER—Grasses, Hay, con.							
Timothy	25	13.3	4.1	6.3	29.3	45.1	1.9
Rowen	29	14.0	6.4	11.4	23.9	41.3	3.0
Hungarian grass	11	10.7	6.2	7.8	26.3	47.3	1.7
Short sedge	1	8.5	10.6	7.3	21.3	49.9	2.4
Creek sedge	2	41.8	6.6	2.0	16.2	32.3	1.1
Herd-grass	1	7.5	4.8	6.3	26.6	53.3	1.5
Salt marsh hay	13	15.0	6.6	6.1	23.4	46.8	2.1
Black grass	7	12.6	7.1	6.8	25.0	46.2	2.3
Marsh rosemary	1	7.8	5.8	5.3	25.1	54.0	2.0
Bog hay	4	11.0	7.0	7.4	25.9	46.7	2.0
Canada blue-grass	1	14.0	4.8	5.9	31.3	42.1	0.9
Kentucky blue-grass	3	14.0	6.4	7.7	30.5	39.7	1.7
English hay	102	14.0	5.3	7.9	27.7	42.8	2.3
Meadow fescue	7	14.0	7.1	5.8	32.2	39.3	1.6
Barnyard millet	9	14.0	7.9	10.6	28.7	37.1	1.7
Tall oat-grass	4	14.0	4.6	6.4	30.9	42.1	1.9
Italian rye-grass	4	14.0	6.4	7.1	28.6	42.2	1.6
Perennial rye-grass	4	14.0	7.9	10.1	25.4	40.5	2.1
Red-top	8	14.0	4.3	6.1	30.1	43.9	1.6
White-top	1	14.0	6.0	11.2	24.4	41.5	2.9
c. Legumes. Hay.							
Red clover	25	11.6	7.1	12.7	26.2	40.0	2.4
Mammoth red clover	4	15.0	8.2	13.1	24.4	37.6	1.7
Alsike	9	11.2	8.0	12.7	26.3	40.0	1.8
White clover	1	7.1	9.0	14.1	27.3	40.4	2.1
Crimson clover	3	9.0	8.1	15.5	29.8	35.7	1.9
Alfalfa	7	8.7	7.8	16.5	27.1	37.2	2.7
Cowpea	4	11.2	9.1	15.5	22.0	40 0	2 2
Oats and peas	6	10.5	7.1	10.3	28.3	41.2	2.6
Oat-grass and alsike	2	15.0	6.5	11.6	24.5	40.1	2.3
Orchard-grass and alsike	1	15.0	6.6	10.1	27.6	38.3	2.4
Oats and vetch (1-1)	3	15.0	7.4	12.8	26.7	35.8	2.3
Wheat and vetch	4	15.0	6.8	14.5	27.2	34.4	2.1
d. Miscellaneous. Hay.							
Hairy lotus	2	15.0	7.0	12.6	16.8	46.1	2.5
White daisy	1	15.0	6.0	6.6	30.7	39.7	2.0

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
HAY AND DRIED COARSE FODDERS, continued							
e. Straw.							
Wheat	16	11.2	3.9	4.4	34.2	44.8	1.5
Rye	6	6.6	3.3	3.1	38.2	47.5	1.3
Oat	7	8.1	4.8	4.0	36.3	44.7	2.1
Oats and peas	2	7.4	7.2	4.6	35.2	43.4	2.2
Buckwheat	1	9.0	6.5	7.8	37.2	38.8	0.7
Barley	2	15.0	4.8	6.5	32.2	39.0	2.5
Horse bean	1	15.0	8.1	8.3	35.2	32.1	1.3
Soybean	3	15.0	6.1	4.7	36.1	36.3	1.8
Millet	4	15.0	5.2	4.1	34.2	39.7	1.8
4. ROOTS.							
Sugar-beets	4	82.0	1.2	1.6	1.1	14.0	0.1
Mangel-wurzel	2	90.9	1.1	1.4	0.9	5.5	0.2
Artichokes	1	78.0	1.1	2 9	0.9	16.9	0.2
Beets, red	7	88.0	1.1	1.5	0.7	8.6	0.1
Yellow fodder beets	4	89.0	1.0	1.3	1.0	7.5	0.2
Cabbages	2	90.5	1.4	2.4	1.5	3.8	0.4
Carrots	5	89.0	0.9	1.0	1.1	7.8	0.2
Mangolds	5	88.0	1.2	1.4	0.8	8.5	0.1
Parsnips	1	80.0	1.5	1.3	1.5	15.0	0.7
Potatoes	22	80.0	0.9	2.1	0.5	16.4	0.1
Sweet potatoes	6	71.1	1.0	1.5	1.3	24.7	0.4
Rutabagas	3	89.0	1.1	1.2	1.3	7.2	0.2
Japanese radish	1	93.0	0.7	0.5	0.7	5.0	0.1
Turnips	6	90.5	0.8	1.1	1.2	6.2	0.2
5. GRAIN AND OTHER SEEDS.							
Corn	15	15.4	1.3	9.1	1.5	68.6	4.1
Sweet corn	3	11.0	1.9	12.5	2.4	64.9	7.3
Sorghum seed	6	12.3	1.8	8.6	1.8	71.9	3.6
Millet	5	11.5	2.9	11.6	7.6	61.8	4.6
Oats	20	11.4	3.1	11.3	9.9	59.5	4.8
Rye	6	12.0	1.8	10.2	1.7	72.6	1.7
Wheat	21	12.7	1.9	10.8	1.9	71.0	1.7
Buckwheat	1	10.8	2.3	10.1	8.7	65.6	2.5
Soybean	1	9.6	4.8	35.4	5.0	26.2	19.0
Cowpea	2	10.9	3.3	19.5	3.4	61.4	1.5

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
GRAIN AND OTHER SEEDS, continued							
Black-eyed pea	1	12 2	3.3	21.6	4.1	57.2	1.6
Hungarian grass seed	1	9.5	5.0	9.9	7.7	63.2	4 7
Broom-corn seed	1	8.9	4.5	10.7	....	*73.3	2.6
Rice	1	12.0	0.2	7.4	0.1	80.0	0 3
Oats and peas	1	9.9	4.7	16.7	10.9	54.0	3.8
Horse beans	1	14.0	3.8	25.8	7.0	48.6	0.8
Red Adzinki beans	2	14.0	3.6	21.0	4.0	56.7	0.7
Saddle-beans	1	14.0	5.3	13.0	4.1	49.4	14.2
Barley	6	12.0	2.4	11.2	5.7	66.8	1.9
6. OIL CAKE MEALS.							
Cottonseed meal	144	7.6	6.6	44.6	4.9	25.8	10.5
Cottonseed meal (undecorticated)	9	8.8	4.9	25.3	18.5	35.1	7.4
Cottonseed feed	4	10.4	3.3	9.3	35.6	38.7	2.7
Linseed meal (old process)	191	9.8	5.5	33.9	7.3	35.7	7.8
Linseed meal (new process)	7	9 3	5.7	35.6	8.1	38.1	3 2
Flaxseed meal	9	8.3	4.2	23.9	5.1	23.8	34.7
Palm-nut meal	2	8.5	13.6	14.8	22.8	37.7	12.6
Corn-oil meal	3	9.0	2.4	24.8	6.7	43.6	13.5
Germ-oil meal	1	8.7	2.0	19.6	5.7	41.6	22.4
Blood meal (Armour's Edible)	3	11.0	3.1	84.3	....	1.2	0.4
Cocoanut meal	3	9.0	4.7	20.4	11.0	40.6	4.3
7 CORN PRODUCTS.							
Chicago gluten meal	19	9.8	0.9	35.9	1.9	47.0	4.5
Cream gluten meal	1	7.4	1.6	41.8	1 5	32.1	15.6
Hammond gluten meal	3	8.2	1.0	28.4	0 9	50.4	11.1
King gluten meal	2	8.3	1.4	37.2	1.4	33.2	18.5
Buffalo gluten meal	63	8.5	2.8	26.0	6.8	52.5	3.4
Davenport gluten meal	7	7.7	1.2	24.5	7.4	54.6	4.6
Globe gluten meal	18	8.2	1.5	25.9	7.9	53.5	3.0
Iowa Golden gluten meal	2	8.3	1.0	29.4	3.1	46.6	11.6

*Includes fiber.

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
CORN PRODUCTS, continued.							
Nebraska gluten meal	1	8.0	1.3	19.6	6.3	61.8	3.0
Pekin gluten meal....	1	....	....	26.1	....	....	3.1
Queen gluten meal...	15	8.5	1.7	24.2	6.6	56.2	2.8
Rockford Diamond gluten meal	6	....	....	27.0	....	....	3.6
Star gluten meal.....	2	7.6	0.9	23.2	6.5	59.4	2.4
Warner's gluten meal	2	9.1	1.1	17.8	6.5	62.8	2.7
Waukegan gluten meal	4	....	....	26.8	....	....	3.9
Hominy meal	86	9 0	2.8	11.0	3.6	65 0	8 6
Cerealine feed.....	24	9 6	2.6	10.5	5.4	64.1	7.8
Maizeline feed.....	8	6.8	3.6	9.9	6.7	65.2	7.8
Corn bran, fancy	18	9.2	2.6	12.6	12.2	60.0	3.4
Corn bran, or sugar feed..... ..	28	8.4	1.2	10.0	11.8	62.9	5.7
Starch feed, wet.....	4	68.8	0.4	5.0	2.9	19.9	3.0
Starch feed, dried....	2	9.1	0.9	14.6	6.7	64.0	8.3
Corn meal.....	110	12.7	1.5	9.0	1.7	71.0	4.1
Cob meal.....	18	12.6	1.4	7.6	5.6	69.6	3.2
Corn cob.....	4	31.5	1.0	1.5	24.0	41.7	0 3
Corn germ meal.....	2	7.2	1.6	11.4	7.8	61.2	10.8
Corn sprouts.....	1	8.3	5.6	26.0	5.8	52.0	2.3
Corn and oats (provender)	88	12.0	2.2	9.8	3.3	68.5	4.2
Corn, oats, barley	8	10.0	3.1	11 4	8 3	62.4	4.8
Corn screenings.....	1	11.0	2.1	7.4	2.9	72.6	4.0
8. OAT PRODUCTS.							
Ground oats.....	5	10.0	3.8	11.1	9.8	60.3	5.0
Oat middlings.....	2	7.8	3.8	16.3	8.2	56.2	7.7
Oat chop	4	6.8	5.9	8.3	22.1	53.8	3.1
Oat hulls.....	11	7.4	6.7	3.4	30.7	50.5	1.3
Hulled oats.....	1	....	....	16.2	....	....	7.6
Canada oat feed.....	3	7.3	5.9	4.4	28.4	51.9	2.1
Cream oat feed.....	1	7.4	8.8	7.1	21.7	51.8	3.2
Chester stock food ...	10	....	....	7.4	11.1	....	3.4
Iowa oat feed.....	1	8.7	4.8	10.6	18.8	54.2	2.9
Friends oat feed.....	12	5.9	5.9	8.6	21.0	55.2	3.4
Royal oat feed.....	13	7.2	7.3	7 0	24.9	50.8	2.8
Monarch oat chop	4	10.1	3.4	8.9	9.0	64.6	4.0

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
OAT PRODUCTS, continued							
Vine oat feed	17	7.2	5.7	7.0	25.6	51.7	2.8
"X" oat feed	1	6.9	6.1	7.5	22.5	53.9	3.1
9. WHEAT PRODUCTS.							
Wheat flour	6	12.4	0.4	12.0	....	74.0	1.2
Ground wheat	4	12 0	....	10.2	1.8	....	2.0
Wheat bran	190	11.2	6.0	16.0	8.1	54.1	4.6
Wheat middlings, white	91	11.3	2.7	15.8	3.5	62.5	4.2
Wheat middlings, brown	57	10.6	3.8	17.8	5.5	57.0	5.3
Feeding flour	49	10.1	....	19.4	2.6	....	5.3
Wheat feed	35	10.8	4.3	17.0	5.1	58.1	4.7
Wheat chaff	2	11.1	6.5	4.3	29.2	47.5	1.4
Wheat bran and oil	3	....	....	15.4	....	....	7.9
Gluten flour wheat	1	5 5	0.4	84.8	0.2	8 1	1.0
Gluten meal wheat	2	8.0	0.9	39.8	0.8	48.9	1.6
10. RYE, BUCKWHEAT, RICE, etc.							
Ground rye	1	12.0	....	9.1	....	....	2.1
Rye bran	11	11.7	3.3	13.9	3.5	64.7	2.9
Rye middlings	5	11.8	1.7	14.3	2.4	66.9	2.9
Rye feed	18	12.0	1.7	9 6	1.5	73.4	1.8
Buckwheat bran	13	12.5	4.2	20.0	4.3	53.6	5.4
Buckwheat middlings	30	13 6	5.6	30.5	3.1	39.2	8.0
Buckwheat feed	12	12.3	4.0	18.9	18.3	41.4	5.1
Buckwheat flour	5	14.1	0.7	4.8	....	79.6	0.8
Rice bran, or feed	3	9.0	9 2	11.5	13.0	48.0	9.3
Rice polish	1	9.5	6.3	14.3	3.3	55.4	11.2
Rice hulls	4	....	....	2.9	33.5	..	1.2
Rice meal	1	8.5	7.4	14.4	8.0	47.6	14.1
Barley feed	7	9.5	4.5	14.4	8.7	58.6	4.3
Pea meal	2	10.8	2.5	27.4	....	*57.1	2.2
Pea bran	2	11.0	2.7	10.0	39.7	35.6	1.0
Bean meal	1	10.9	5.7	23.2	3.8	54.9	1.5
Peanut bran	2	....	....	8.5	14.2	....	4.4
Peanut middlings	1	....	....	9.7	39.3	....	6.5
Peanut meal and hulls	1	10.9	2.1	7.0	62.9	14.7	2.4

*Includes fiber.

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
RYE, BUCKWHEAT, RICE, etc., continued.							
Peanut meal	1	8.0	4.0	49.0	3.5	24.7	10.8
Cocoa shells	1	2.7	10.7	15.5	9.9	44.7	16.5
Cocoa dust	1	7.0	6.3	14.4	5.5	42.7	24.1
Cocoanut meal	1	1.0	0.8	9.9	7.5	15.3	65.5
Clover meal	1	....	....	5.8	29.2	....	3.3
Sugar-beet feed, wet	1	89.9	....	1.1	....	..	0.1
Sugar-beet feed, dried	4	9.4	4.4	8.1	17.9	59.5	0.7
Molasses beet feed, dried	1	7.6	6.9	9.6	15.7	59.8	0.4
Marsden feed, No. 2	1	....	....	4.0	28.4	....	1.3
Cornaline (coffee hulls)	2	....	....	2.7	58.2	....	0.6
Cotton hulls	5	11.0	2.6	5.3	39.7	39.0	2.4
Cotton hull bran	1	11.0	1.9	2.3	35.0	48.7	1.1
Flax seed screenings	1	7.0	5.4	15.7	16.5	44.5	10.9
11. BREWERY AND DISTILLERY PRODUCTS.							
Malt sprouts	107	9.6	6.9	25.8	10.6	44.9	2.2
Brewers' grains, wet	13	74.1	1.0	6.4	3.7	12.7	2.1
Brewers' grains, dried	119	8.5	3.8	25.7	13.6	41.4	7.0
Brewers' swill	1	94.3	0.3	1.9	0.7	2.0	0.8
Distillery grains, dried	9	7.0	1.6	23.7	12.8	44.0	10.9
Molasses grains	6	11.4	7.7	19.3	10.6	48.2	2.8
Molasses feed	2	10.8	6.6	18.6	8.3	52.9	2.8
Molasses, Porto Rico	2	24.0	6.8	3.1	....	66.1	....
Atlas gluten meal	3	....	....	35.0	....	....	15.7
Ajax flakes	4	6.5	2.3	32.4	13.0	33.8	12.0
Corn protegran	1	7.6	1.7	31.3	12.2	36.4	10.8
Sucrene dairy feed	4	10.2	....	19.6	9.0	....	7.0
Sucrene oil meal	3	9.0	5.7	23.2	10.7	48.6	2.8
Grano-gluten feed	6	6.0	2.6	26.9	11.6	41.4	11.5
12. FEED MIXTURES.							
Blomo feed	5	13.3	11.6	16.3	10.9	46.9	1.0
Bibby's dairy cake	4	10.0	7.7	19.7	8.6	44.9	9.1
Boss corn and oats feed	8	9.2	4.1	8.8	12.3	61.1	4.5

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
FEED MIXTURES, continued.							
Buffalo dairy feed....	1	7.8	3 8	15.6	11.8	56.7	4.3
Buffalo horse feed....	1	8.2	3.8	13.3	9.0	60.2	5.5
Buffalo stock feed....	1	....	....	9.1	17 6	....	4.6
Cornelia dairy feed...	1	9.0	3.6	22.7	5.2	54.1	5.4
Crackerjack dairy feed.....	2	7.1	7.0	30.7	7.6	35.5	12.1
De Fi corn and oats feed.....	2	....	....	8.7	14.3	....	3.1
Diamond corn and oats feed.....	1	....	....	9.7	8.9	....	5.8
Durham corn and oats feed	1	....	....	7.5	13.1	....	2.8
Empire feed.....	1	11.1	2.6	7.8	7.3	67.2	4.0
Excelsior corn and oats feed.....	2	8.9	6.7	9.9	9.0	59.7	5.8
H. O. dairy feed.....	15	8.3	3.6	18.6	12.0	53.2	4.3
H. O. horse feed	18	9.5	2.7	13.2	9.2	61.0	4.4
Holstein sugar feed...	1	8.0	6.7	12.6	10.0	60.0	2.7
Imperial dairy feed...	1	7.6	4.7	8.3	20.0	56.3	3.1
Marsden feed, No. 1..	1	....	....	13.7	12.0	....	5.1
Macon sugar feed	2	6.0	6.6	14.0	10.2	61.6	1.6
Nutro-glen	1	8.9	4.7	20.2	7.4	53.9	4.9
Proteina.....	4	8.0	2.5	21.8	10.0	51.1	6.6
Parson's Six-Dollar feed.....	1	11.0	7.9	10.0	17.9	51.1	2.1
Puritan ground feed..	1	11.1	3.9	7.5	13.7	61.2	2.6
Quaker dairy feed....	26	7.3	5.5	14.4	15.3	53.7	3.8
Schumacher's stock feed.....	10	8.9	4.8	12.7	9.0	59.0	5.6
Speltz.....	1	8 0	3.9	11.5	11.1	62.9	2.2
Star chop.....	1	....	....	8.5	11.8	....	3.7
Victor corn and oats..	33	9.0	4.7	9.1	10.5	62.3	4.4
13. STOCK, CALF AND POULTRY FEEDS.							
American calf meal...	3	....	....	17.3	2.3	....	8.0
Blatchford's calf meal	8	9.0	5.5	25.2	4.6	50.6	5.1
Cut bone.....	1	26.0	21.5	20.7	....	0.2	31.6
American poultry feed	5	10.2	3.7	13.8	4 3	61.5	6.5
H. O. poultry feed ...	15	9.0	2.9	17.5	4.7	60 4	5.5
H. O. scratching feed	3	10.7	2.1	12.5	2.2	68.4	4.1

TABLE I. AVERAGE COMPOSITION OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred					
		Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat
STOCK, CALF AND POULTRY FEEDS, continued.							
Paine's stock food....	1	11.3	10.1	11.3	10.1	46 9	10.3
Nutrium milk powder.	1	....	....	33.8	....	....	0.7
Animal meal.....	7	4.8	....	38.0	....	....	10.4
Beef scrap	16	7.9	....	55.5	....	....	15.0
Raw ground bone.....	1	8.0	64.4	23.9	....	3.4	0.3
Cut clover.....	2	10.0	6.8	17.9	20.5	41.8	3.0
Meat and bone meal..	37	6.0	37.4	39.5	....	6.3	10.8
Meat scrap	11	9.0	17.6	50.8	....	4.5	18.1
Mutton scrap.....	1	7.0	33.1	39.9	....	5 3	14.7
Granulated milk.....	1	10.0	26.5	35.9	....	18.1	9.6
Bakery refuse.....	1	13.0	10.1	8.0	0.3	63.0	5.6
Cassava starch refuse	1	12.0	1.6	0.8	6.1	78.8	0.7
Mellin's food refuse..	1	7.0	3.9	11.4	7.1	67.2	3.4
Starch refuse	2	12.0	1.8	4.8	3.8	76.3	1.3

TABLE II

FERTILIZER INGREDIENTS OF FODDERS AND FEEDS

	Number of analyses	Pounds per hundred		
		Nitrogen	Phosphoric acid	Potash
1. GREEN FODDER	45	0.33	0.13	0.21
a. Cereals and Grasses.				
Corn	45	0.33	0.13	0.31
White Thoroughbred Flint corn	1	0.26	0.12	0.28
Southern White corn	1	0.24	0.10	0.24
Sweet corn	1	0.28	0.14	0.38
Teosinte	2	0.35	0.06	0.92
Rural Branching doura	1	0.28	0.15	0.46
Yellow milo maize	1	0.27	0.11	0.57
Red kafir corn	1	0.29	0.13	0.45
White kafir corn	1	0.30	0.12	0.50
Broom-corn	1	0.32	0.17	0.70
Japan broom-corn millet	1	0.64	0.16	0.73
Japan millet	5	0.32	0.13	0.43
Barnyard millet	8	0.27	0.11	0.58
Pearl millet	1	0.18	0.15	0.71
Millet	1	0.29	0.11	0.43
Sorghum	3	0.19	0.08	0.24
Sugar-cane	2	0.20	0.09	0.44
Orchard-grass	4	0.43	0.13	0.56
Pasture-grass	7	0.90	0.26	0.74
Hungarian grass	1	0.30	0.12	0.42
Rye	11	0.32	0.17	0.60
Barley	1	0.46	0.10	0.54
Wheat	1	0.38	0.16	0.60
Oats	3	0.72	0.19	0.56
b. Legumes.				
Red clover	20	0.54	0.12	0.67
Mammoth red clover	3	0.50	0.12	0.27*
Crimson clover	12	0.47	0.12	0.39
Alsike clover	6	0.53	0.15	0.50
Sweet clover	1	0.43	0.12	0.40
Alfalfa	33	0.58	0.12	0.50
Cowpea	20	0.47	0.13	0.46
Canada field pea	14	0.44	0.14	0.42
Soybean	39	0.63	0.14	0.56
Velvet-bean	1	0.55	0.14	0.57

* Below normal evidently.

TABLE II. FERTILIZER INGREDIENTS OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred		
		Nitrogen	Phosphoric acid	Potash
GREEN FODDER—Legumes, continued.				
Sand vetch	6	0.55	0.14	0.52
Rape	3	0.35	0.12	0.62
Horse bean	1	0.41	0.05	0.21
White lupine	1	0.45	0.05	0.26
Yellow lupine	1	0.40	0.09	0.44
Flat pea	1	0.75	0.10	0.32
Small pea	1	0.40	0.09	0.31
Sainfoin	1	0.68	0.20	0.57
Serradella	2	0.36	0.12	0.37
Sulla	2	0.68	0.12	0.58
Spring vetch	1	0.36	0.10	0.45
Kidney vetch	1	0.44	0.08	0.28
Oats and peas	3	0.33	0.15	0.50
Oats and vetch	4	0.30	0.14	0.30
c. Miscellaneous.				
Apple pomace	2	0.21	0.02	0.12
Carrot tops	1	0.69	0.13	1.08
Prickley comfrey	1	0.37	0.12	0.76
Common buckwheat	1	0.44	0.09	0.54
Japanese buckwheat	1	0.26	0.14	0.53
Silver-hull buckwheat	1	0.29	0.14	0.39
2. SILAGE.				
Corn	30	0.33	0.12	0.36
Corn and soybean	1	0.65	0.15	0.36
Millet and soybean	5	0.42	0.11	0.44
Millet	3	0.26	0.14	0.62
Sorghum	6	0.13	0.15	0.19
Red clover	1	0.61		
Brewers' grains	4	1.01		
Rye	1	0.38		
Cowpea	1	0.44	0.15	0.46
Soybean	1	0.71	0.16	0.75
3. HAY AND DRIED COARSE FODDER.				
Corn	64	0.78	0.28	1.00
Oats	3	1.87	0.65	1.90
a. Grasses. Hay.				
Orchard-grass	7	1.07	0.33	1.62
Timothy	18	1.08	0.35	1.34

TABLE II. FERTILIZER INGREDIENTS OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred		
		Nitrogen	Phosphoric acid	Potash
HAY AND DRIED COARSE FODDER—Grasses, Hay, continued.				
Hungarian grass	9	1.22	0.43	1.54
Short sedge	1	0.16	0.14	1.13
Creek sedge	2	1.33	0.03	0.53
Herd grass	1	1.00	0.35	1.57
Salt marsh hay	3	0.73	0.09	0.82
Salt hay	1	1.05	0.23	0.64
Black grass	4	1.07	....	....
Marsh rosemary	1	0.84	0.06	0.27
Bog hay	2	1.23	0.18	0.73
Barnyard millet	3	1.29	0.43	2.88
Italian rye-grass	4	1.12	0.53	1.19
Kentucky blue-grass	2	1.20	0.39	1.54
Meadow fescue	6	0.93	0.37	1.98
Perennial rye-grass	2	1.16	0.53	1.47
Red-top	4	1.07	0.33	0.95
English hay (mixed)	13	1.34	0.32	1.61
Rowen	13	1.72	0.48	1.58
Branch grass	1	1.06	0.19	0.87
Fox grass	1	1.18	0.18	0.95
b. Legumes. Hay.				
Red clover	22	2.09	0.43	2.08
Mammoth red clover	3	2.14	0.52	1.16
Alsike	7	2.04	0.51	1.12
White clover	1	2.25	0.25	1.06
Crimson clover	3	2.48	0.62	2.11
Alfalfa	7	2.66	0.54	2.46
Cowpea	4	2.48	0.66	2.36
Oats and pea	2	1.65	0.61	1.81
Oats and vetch	4	2.00	0.60	1.27
c. Straw.				
Oats and pea	2	0.74	0.39	3.20
Wheat	15	0.43	0.13	0.74
Rye	6	0 50	0.29	0.79
Oats	7	0.65	0.22	1.22
Buckwheat	1	1.24	0.13	1.14
Barley	2	0.95	0.19	2.03
Soybean	1	0.69	0.25	1.04
Millet	1	0.68	0.18	1.73

TABLE II. FERTILIZER INGREDIENTS OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred		
		Nitrogen	Phosphoric acid	Potash
HAY AND DRIED COARSE FODDER, continued				
d. Miscellaneous.				
Broom-corn waste (stalks)	1	0.87	0.47	1.87
Palmetto root	1	0.54	0.16	1.37
Spanish moss	1	0.61	0.07	0.56
White daisy	1	0.26	0.41	1.18
4. ROOTS, ETC.				
Sugar-beets	4	0.26	0.12	0.48
Mangle-wurzel	1	0.19	0.06	0.46
Artichoke	1	0.46	0.17	0.48
Beets, red	8	0.24	0.09	0.44
Beets, yellow fodder	1	0.23	0.11	0.56
Mangolds	3	0.15	0.14	0.34
Carrots	3	0.16	0.09	0.46
Parsnips	1	0.22	0.19	0.62
Potatoes	5	0.29	0.08	0.51
Japanese radish	1	0.08	0.05	0.40
Turnips	4	0 17	0.12	0.38
Rutabagas	3	0.19	0.12	0.49
5. GRAIN AND OTHER SEEDS.				
Corn	15	1.48	0.61	0.36
Oats	20	1.81	0.77	0.57
Rye	6	1.62	0.81	0.52
Wheat	21	1.73	0.96	0.35
Buckwheat	1	1.62	0.78	0.59
Soybean	1	5.30	1.87	1.99
Red Adzuki bean	1	3.27	0.95	1.55
White Adzuki bean	1	3.45	1.00	1.53
Saddle-bean	1	2.08	1.49	2.09
Cowpea	2	3.12	1.01	1.20
Horse bean		4.10	1.20	1.29
Hungarian grass seed	1	1 59	0.47	0.38
Broom-corn seed	1	1.71	0.72	0.52
Common millet seed	2	2 00	0 95	0.45
Japanese Millet seed	1	1.58	0 63	0.35
Rice	1	1.08	0.18	0.09
Oats and peas	1	2.68	1.02	0.92

TABLE II. FERTILIZER INGREDIENTS OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred		
		Nitrogen	Phosphoric acid	Potash
6. OIL CAKE MEALS.				
Cottonseed meal	144	7.14	3.09	1.82
Cottonseed meal, Undecorticated	9	4.04	1.85	1.48
Cottonseed feed	4	1.49	0.45	1.10
Linseed meal, old process	191	5.43	1.88	1.31
Linseed meal, new process	7	5.70	2.16	1.49
Flaxseed meal	9	3.82	1.30	0.93
Palm-nut meal	2	2.69	1.10	0.50
Cocoanut cake	1	3.88	1.60	2.40
Corn-oil meal	3	3.97	1.40	0.18
Germ-oil meal	1	3.13	0.91	0.08
7. CORN PRODUCTS.				
Chicago gluten meal	19	5.74	0.34	0.06
Cream gluten meal	1	6.68	0.31	0.06
Hammond gluten meal	3	4.54	0.50	0.08
King gluten meal	2	5.95	0.66	0.06
Buffalo gluten meal	63	4.16	1.15	0.57
Davenport gluten meal	7	3.92	....	....
Globe gluten meal	18	4.14	0.62	0.12
Iowa gluten meal	2	4.70	0.43	0.08
Nebraska gluten meal	1	3.14	0.44	0.08
Pekin gluten feed	1	4.18	....	....
Queen gluten feed	15	3.87	0.37	0.04
Rockford Diamond gluten feed	6	4.32	....	....
Star gluten feed	2	3.72	0.33	....
Warner's gluten feed	2	2.80	0.32	0.05
Waukegan gluten feed	4	4.29	....	....
Hominy meal	86	1.75	1.40	0.75
Cerealine feed	24	1.68	1.27	0.67
Maizeline feed	8	1.58	1.41	0.78
Corn bran, fancy	18	2.02	1.01	0.62
Corn bran, or sugar feed	28	1.60	0.22	0.09
Starch feed, wet	4	0.80	0.05	0.02
Starch feed, dried	2	2.34	....	....
Corn meal	110	1.44	0.63	0.37
Cob meal	18	1.22	0.55	0.46
Corn cob	4	0.24	0.07	0.29
Corn germ meal	2	1.82	0.39	0.21
Corn sprouts	1	4.16	1.54	1.84
Corn and oats (provender)	88	1.57	0.71	0.44
Corn and cob meal	29	1.38	0.56	0.46

TABLE II FERTILIZER INGREDIENTS OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred		
		Nitrogen	Phosphoric acid	Potash
8. OAT PRODUCTS.				
Ground oats	5	1.78	0.76	0.50
Oat middlings	2	2.61	1.27	0.72
Oat chop	4	1.34	0.66	0.69
Oat hulls	11	0.54	0.24	0.52
Hulled oats	1	2.59	....	....
Canada oat feed	3	0.71	0.31	0.62
Cream oat feed	1	1.14	0.56	0.66
Chester stock food	10	1.18	....	....
Friend's oat feed	12	1.38	0.62	0.65
Iowa oat feed	1	1.70	0.48	0.53
Monarch oat chop	4	1.42	0.63	0.46
Royal oat feed	13	1.12	0.48	0.70
Vim oat feed	17	1.12	0.56	0.69
"X" oat feed	1	1.20	0.61	0.73
9. WHEAT PRODUCTS.				
Wheat flour	6	1.92	2.20	1.50
Wheat bran	190	2.56	2.92	1.57
Wheat middlings, white	91	2.53	1.34	0.70
Wheat middlings, brown	57	2.85	1.87	0.94
Feeding flour, dark	49	3.18	2.14	1.09
Wheat feed	35	2.72	2.04	0.54
Wheat chaff	2	0.69	0.95	0.56
Damaged wheat	1	2.26	0.83	0.51
10. RYE, BUCKWHEAT, RICE, ETC.				
Rye bran	11	2.25	1.54	0.95
Rye middlings	5	2.29	0.56	0.49
Rye feed	18	1.54	0.77	0.47
Buckwheat bran	13	3.20	1.77	0.93
Buckwheat middlings	30	4.88	2.60	1.33
Buckwheat feed	12	3.02	1.58	1.05
Buckwheat flour	5	0.77	0.52	0.16
Buckwheat hulls	1	0.49	0.07	0.52
Rice bran	3	0.71	0.29	0.24
Rice polish	1	2.29	3.29	1.19
Rice hulls	4	0.58	0.17	0.14
Barley feed	7	2.30	1.29	0.90
Ground barley	1	1.56	0.66	0.34
Pea meal	2	4.39	0.91	0.99

TABLE II. FERTILIZER INGREDIENTS OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred		
		Nitrogen	Phosphoric acid	Potash
RYE, BUCKWHEAT, RICE, ETC., continued				
Pea feed	1	2.39	0.72	0.72
Bean meal	1	3.72	0.94	1.45
Peanut meal and hulls	1	1.13	0.15	0.62
Peanut feed	2	1.46	0.23	0.79
Peanut husks	1	0.80	0.13	0.48
Cocoa shells	1	2.48	1.14	2.39
Cocoa dust	1	2.30	1.34	0.63
Clover meal	1	0.93	....	....
Sugar-beet feed, dry	4	1.29	0.24	0.57
Molasses beet feed, dried	1	1.54	0.15	1.81
Cotton hulls	3	0.75	0.18	1.08
11. BREWERY AND DISTILLERY PRODUCTS.				
Malt sprouts	107	4.13	1.61	1.78
Brewers' grains, wet	13	1.02	0.26	0.03
Brewers' grains, dried	119	4.11	1.01	0.08
Distillery grains, dried	9	3.79	0.60	0.17
Molasses grains	6	3.09	0.85	2.11
Molasses feed	2	2.98	0.82	1.96
Molasses, Porto Rico	1	0.51	0.12	3.68
Ajax flakes	4	5.19	0.68	0.18
Corn protegran	1	5.01	0.58	0.11
Sucrene dairy feed	4	3.14	0.60	0.24
Grano gluten feed	6	4.30	0.65	0.19
12. FEED MIXTURES.				
Bibby's dairy cake	1	2.94	2.07	1.67
Blomo feed	5	2.61	0.45	2.54
Blood meal, Armour's	1	13.55	0.26	0.18
Boss corn and oats	8	1.40	0.88	0.63
Buffalo dairy feed	1	2.49	0.89	0.56
Buffalo horse feed	1	2.13	1.01	0.70
Cornelia dairy feed	1	3.63	1.45	0.85
Crackerjack dairy feed	2	4.92	2.24	1.70
Empire feed	1	1.25	0.83	0.54
Excelsior corn and oats feed	2	1.58	0.99	0.73
H. O. dairy feed	15	2.98	0 86	0.61
H. O. horse feed	18	2.11	0.99	0.60
Imperial dairy feed	1	1.32	0.47	0.51

TABLE II. FERTILIZER INGREDIENTS OF FODDERS AND FEEDS—Continued

	Number of analyses	Pounds per hundred		
		Nitrogen	Phosphoric acid	Potash
FEED MIXTURES, continued				
Marsden feed, No. 1	1	2.19	....	....
Nutro-glen	1	3.23	2.05	1.20
Proteina	1	3.04	1.02	0.58
Puritan ground feed	1	1.20	0.55	0.58
Quaker dairy feed	26	2.30	0.98	0.89
Schumacher's stock feed	10	2.03	1.15	0.75
Star chop	1	1.36	....	....
Victor corn and oats feed	33	1.46	0.77	0.60
13. STOCK, CALF AND POULTRY FEEDS.				
American calf meal	3	2.77	....	....
Blatchford's calf meal	8	4.03	1.45	1.13
American poultry feed	5	2.21	1.21	0.91
H. O. poultry feed	15	2.80	1.32	0.73
H. O. scratching feed	3	1.99	0.95	0.48
Paine's stock food	1	1.80	1.98	0.82
Nutrium milk powder	1	5.41	....	....
Animal meal	7	6.08	....	....
Beef scraps	16	8.88	....	....
Meat and bone meal	10	5.92	14.68	....
Meat scraps	4	7.63	8.11	....

TABLE III

Coefficients of Digestibility of Feed Stuffs

1. Experiments with Ruminants

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
1. Green Fodders							
a. Cereals and Grasses.							
Corn, dent, immature.	68	....	42	66	65	71	68
Corn, dent, mature...	68	72	34	53	57	73	74
Corn, dent, mature, Band W., coarse ...	52	....	....	24	46	59	78
Corn, Eureka, silage, just forming ears ..	67	....	42	67	60	72	66
Corn, Sanford, mature	69	71	34	52	75	71	66
Corn, sweet, milk stage	77	....	....	77	75	81	74
Corn, sweet, roasting	....	72	48	62	60	77	74
Millet, barnyard, blossom....	70	....	56	65	73	71	58
Millet, Japanese	....	64	55	50	62	67	68
Hungarian grass.....	66	68	....	63	70	67	62
Sorghum.....	67	....	....	46	59	74	74
Barley, bloom.....	....	67	....	72	61	71	60
Barley, seeds forming	....	68	42	69	56	74	49
Oat.....	....	62	60	73	55	62	69
Rye.....	74	....	....	79	80	71	74
Grass, meadow, young	69	....	....	65	74	72	55
Grass, meadow, young dried.....	71	....	....	71	77	73	60
Timothy	64	....	32	48	56	66	52
Timothy rowen.....	....	66	....	72	64	68	52
b. Legumes.							
Alfalfa.....	61	....	40	74	43	72	39
Soybeans, medium green, blossom....	....	63	25	77	47	71	50
Soybeans, medium green, seeding	65	67	28	78	45	77	55
Crimson clover, blossom.....	....	69	....	77	56	74	66
Red clover, blossom..	66	....	....	67	53	78	65
Clover rowen, blossom	....	61	....	62	52	65	61
Cowpeas, ready for soiling.....	68	74	23	76	60	81	59

TABLE III. COEFFICIENTS OF DIGESTIBILITY OF FEED STUFFS—Continued

1. Experiments with Ruminants

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
GREEN FODDERS, continued							
Canada field peas, before bloom	68	71	....	82	62	71	52
Canada field peas, bloom to seeding	64	....	37	81	45	76	55
Spring vetch	62	....	17	71	44	76	59
Winter vetch	71	....	42	83	63	77	71
Dwarf Essex rape	85	....	63	89	87	92	48
Barley and peas, bloom	....	65	54	75	52	68	59
Oats and peas, bloom	70	68	49	74	64	72	64
Oats and peas, seed	....	62	47	74	55	63	64
Oats and spring vetch, bloom	67	....	53	75	68	68	47
Winter wheat and hairy vetch	69	....	44	75	68	73	57
2. SILAGE.							
Corn, dent	64	70	37	49	65	69	77
Corn, flint, mature, small varieties	75	77	....	65	77	79	82
Corn, flint, earing, large	70	72	34	56	72	76	73
Corn, fine crushed, steers	64	....	....	38	75	65	76
Corn, fine crushed, sheep	54	....	....	21	64	55	68
Corn, mature, fed raw	....	....	....	45	59	71	86
Corn, mature, cooked	....	....	....	39	70	75	87
Corn, steamed	73	76	48	55	76	76	90
Corn, sweet, mature	68	70	....	54	71	72	83
Kafir corn, mature	55	57	....	28	57	62	50
Sorghum, mature	57	59	....	9	58	64	56
Soybean and barnyard millet	59	....	....	57	69	59	72
Soybean and corn (9–14)	69	72	42	63	62	78	83
Clover	44	45	36	35	48	45	45
Soybean	56	67	....	66	53	65	57
Cowpea	60	....	....	57	52	72	63

TABLE III. COEFFICIENTS OF DIGESTIBILITY OF FEED STUFFS—Continued

1. Experiments with Ruminants

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
SILAGE continued							
Oats and pea	65	67	52	75	61	67	75
Corn: 1A Sunflower heads ¼A. Horse-beans ½A	66	68	41	63	60	72	77
Corn: 1A Sunflower plant ¼A. Horse-beans ½A	65	69	26	58	65	74	74
3. HAY AND DRIED COARSE FODDERS.							
a. Cereal Fodders							
Corn, dent, immature	62	63	43	50	67	62	65
Corn, dent, mature	66	....	23	45	63	73	70
Corn, flint, ears forming	70	71	....	70	72	71	67
Corn, flint, mature	70	....	....	64	76	71	71
Corn, sweet, mature	67	70	....	64	74	68	74
Corn, stover	57	55	41	36	64	59	67
Barley hay	59	62	....	65	62	63	41
Oat-hay	54	54	39	53	51	55	60
Oat-straw	50	52	....	....	58	53	38
b. Grasses and Millets.							
Mixed grasses (8–10 per cent protein)	60	62	47	57	60	61	50
Mixed grasses, timothy predominating	55	58	30	47	65	59	45
Meadow, swale or swamp hay	39	....	....	34	33	46	44
Tall oat grass	55	....	41	51	55	58	56
Wild oat grass	64	65	....	58	68	65	50
Orchard-grass	56	56	....	60	61	55	55
Pasture grass	73	73	52	73	76	74	67
Prairie grass	56	....	25	18	61	61	57
Red-top	60	61	....	61	61	62	51
Rowen	....	65	....	69	66	64	47
Black grass	56	....	69	58	59	52	44
Branch grass	52	....	58	56	54	49	35
Flat sage	57	....	62	52	60	55	36

TABLE III. COEFFICIENTS OF DIGESTIBILITY OF FEED STUFFS—Continued

1. Experiments with Ruminants

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
HAY AND DRIED COARSE FODDERS — Grasses and Millets, continued							
Fox grass	54	....	58	60	53	53	36
Salt hay, mixture	54	....	69	42	58	52	28
Timothy	55	56	39	48	50	62	50
Timothy, cottonseed meal	50	....	16	20	41	62	59
Timothy and clover, poorly cured	55	....	....	38	53	60	58
Timothy and red-top	54	....	19	39	55	60	42
Witch grass	61	62	....	58	62	66	57
Golden millet	54	....	31	23	56	58	49
Hungarian grass	65	66	....	60	68	67	64
Millet	56	....	24	31	63	56	50
Kafir corn, fodder	61	....	8	38	60	66	61
Kafir corn, stover	57	....	24	34	67	60	75
Sorghum fodder, Minnesota Early Amber	58	54	44	43	49	61	65
Sorghum fodder leaves	63	....	....	61	70	65	47
Sorghum fodder bagasse	61	....	....	14	64	65	46
c. Legumes.							
Alfalfa	62	....	53	72	47	72	43
Soybean	62	....	....	71	61	69	29
Clover, alsike	59	60	42	66	50	66	38
Clover, crimson	62	56	....	69	45	62	44
Clover, red	57	54	30	58	54	64	55
Clover, white	66	67	....	73	61	70	51
Clover rowen	....	59	46	65	47	63	60
Cowpea	59	....	....	65	43	71	50
Peanut vine	60	....	....	63	52	70	66
Spring vetch	66	67	53	70	58	72	71
Winter vetch	69	....	42	82	61	73	70
Oats and vetch	58	58	56	65	55	59	55
Wheat and sand vetch	66	...	47	74	65	68	64
Oats and peas	61	60	58	73	58	61	59

TABLE III. COEFFICIENTS OF DIGESTIBILITY OF FEED STUFFS—Continued

1. Experiments with Ruminants

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
HAY AND DRIED COARSE FODDERS, continued							
d. Miscellaneous.							
Buttercups	56	57	....	56	41	67	70
Cottonseed feed	52	....	30	51	46	55	86
Cottonseed hulls	41	....	....	6	47	34	79
Saltbush	46	31	72	66	8	49	52
White weed	58	58	....	58	46	67	62
4. ROOTS AND TUBERS.							
Sugar beets	95	99	....	91	100	100	50
Mangolds	79	85	....	75	43	91	....
Potatoes	77	78	....	44	....	91	13
Rutabagas	87	91	....	80	74	95	84
English flat turnips	93	96	....	90	100	97	88
5. CONCENTRATED FEED STUFFS.							
a. Protein							
Soybean meal, variety unknown	78	....	....	90	33	71	89
Soybean meal, medium green, coarse	90	....	57	91	....	81	93
Bibby's dairy cake	70	....	33	66	46	81	92
Blood meal, Armour's	....	....	....	84	....	....	....
Brewers' dried grains	62	....	....	81	49	57	89
Buckwheat middlings	75	....	36	85	17	83	89
Cottonseed, raw	66	....	....	68	76	50	87
Cottonseed, roasted	56	....	....	47	66	51	72
Cottonseed meal	79	88	84	84	35	78	94
H. O. dairy feed	65	....	....	76	35	72	84
Distillers' dried grains, largely from rye	58	....	....	59	....	67	84
Distillers' dried grains, largely from corn	79	....	....	73	95	81	95
Germ oil meal	76	75	....	73	....	76	96
Gluten feed	86	93	....	85	76	89	83
Gluten meal	87	....	....	88	....	88	93

TABLE III. COEFFICIENTS OF DIGESTIBILITY OF FEED STUFFS—Continued

1. Experiments with Ruminants

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
CONCENTRATED FEED STUFF, continued							
Linseed meal, old process	79	....	....	89	57	78	89
Linseed meal, new process	82	79	....	84	74	80	89
Malt sprouts	67	68	....	80	34	69	100
Malt sprouts (Mass.)	82	....	19	76	99	85	87
Maize feed (Chicago)	84	....	...	84	72	85	90
Oat middlings, fine	90	....	36	81	49	96	94
Pea meal	87	88	....	83	26	94	55
Cowpea meal	87	....	33	82	64	93	74
Rye feed, bran and middlings	82	....	35	80	....	88	90
Wheat bran	66	....	....	77	39	71	63
Wheat feed, flour	67	70	....	79	....	76	....
Wheat middlings, flour	82	83	....	88	36	88	86
Wheat middlings, standard	....	73	25	77	30	78	88
Wheat, mixed feed, bran and middlings	73	76	37	78	62	77	87
Wheat, mixed feed, adulterated, and corn-cobs	62	64	31	63	28	71	92
b. Starchy Materials.							
Cerealine feed	90	....	....	80	82	95	81
Chop feed, corn, bran and germs	80	....	....	67	62	84	82
Corn bran	70	....	....	54	59	77	77
Corn-cobs	59	....	....	17	65	60	50
Corn meal	88	90	....	66	....	92	91
Corn and cob meal	79	....	....	52	45	88	84
Corn and oat feed, Victor	75	....	....	71	48	83	87
Kafir corn kernels	43	....	....	41	....	45	....
Kafir corn meal	66	....	....	53	....	77	46
White Kafir heads	24	....	54	12	27	31	31
Dairy feed, Quaker	62	52	....	70	55	59	74

TABLE III. COEFFICIENTS OF DIGESTIBILITY OF FEED STUFFS—Continued

1. Experiments with Ruminants

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
CONCENTRATED FEED STUFFS, continued							
Hominy meal	82	....	37	65	67	89	92
Horse feed, H. O.	74	78	....	70	56	83	80
Alma dried molasses beet pulp	85	....	62	64	84	91	....
Blomo feed	67	....	32	63	61	76	16
Macon sugar feed	71	....	20	59	44	82	82
Holstein sugar feed	71	....	33	66	44	81	88
Sucrene dairy feed	69	....	38	61	72	73	95
Oats, unground	70	71	25	77	31	77	89
Oat feed, Royal	47	48	37	69	33	51	88
Oat feed, excessive hulls	34	....	13	62	32	33	92
Parson's Six Dollar feed	56	....	12	59	47	64	81
Peanut feed, largely husks	32	....	....	71	12	49	90
Rice meal	74	....	....	62	....	92	91
Rice bran	62	....	18	64	21	78	72
Rye meal	87	....	....	84	....	92	64
Rice polish	83	....	31	66	22	93	74

TABLE III. COEFFICIENTS OF DIGESTIBILITY OF FEED STUFFS—Continued

2. Experiments with Swine

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
Barley meal	80	80	....	81	49	87	57
Linseed meal, old process	77	....	10	86	12	85	80
Maize kernels	83	83	....	69	38	89	46
Maize meal	90	92	....	88	39	94	80
Maize meal, with cobs	76	77	....	76	29	84	82
Hog millet seed	73	....	19	68	33	92	59
Pea meal	90	92	....	89	78	95	50
Potatoes	97	....	....	84	....	98	....
Wheat, whole	72	....	....	70	30	74	60
Wheat, cracked	82	....	....	80	60	83	70
Wheat, shorts (middlings)	77	....	....	73	37	87	....
Wheat bran	66	....	....	75	34	66	72

3. Experiments with Horses

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
Corn kernels	74	....	26	58	....	88	48
Corn meal	88	....	....	76	....	96	73
Corn stover, minus pith, Marsden's	50	....	22	68	55	47	60
Oat kernels	72	....	33	86	31	79	82
Oat, ground	76	....	29	82	14	86	80
Timothy hay	44	....	34	21	43	47	47

TABLE III. COEFFICIENTS OF DIGESTIBILITY OF FEED STUFFS—Continued

4. Experiments with Poultry

	Per cent						
	Dry matter	Organic matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Crude fat
Corn kernels	....	86	....	50	....	92	92
Corn kernels	....	87	....	84	15	89	85
Corn meal	....	85	....	48	....	91	93
Kafir corn kernels	....	88	....	53	20	96	74
Kafir corn meal	....	87	....	43	35	96	83
Meat	....	87	....	91	....	....	87
Oats	....	64	....	74	8	71	81
Cowpeas	....	71	....	40	18	87	89
Cowpea meal	....	72	....	44	10	88	89
Wheat	....	84	....	77	....	89	59

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