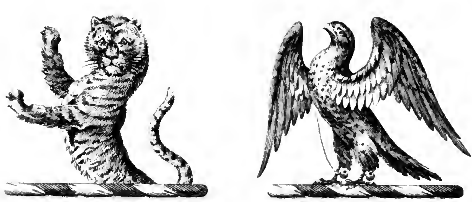


OUR
FARM CROPS.

BEING

A POPULAR SCIENTIFIC DESCRIPTION

OF THE

CULTIVATION, CHEMISTRY, DISEASES, REMEDIES, &c.,

OF THE VARIOUS CROPS

CULTIVATED IN GREAT BRITAIN AND IRELAND.

BY

JOHN WILSON, F.R.S.E.,

PROFESSOR OF AGRICULTURE IN THE UNIVERSITY OF EDINBURGH;
MEMBER OF COUNCIL OF THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND,
&c., &c., &c.

VOLUME II.

Lucem Libris Disseminamus.

BLACKIE AND SON:
WARWICK SQUARE, LONDON E.C.;
AND EDINBURGH AND GLASGOW.

"Moreover, the profit of the earth is for all: the king himself is served by the field."—Eccles. v. 9.

CONTENTS.

THE PARSNIP CROP.

THE POTATO CROP.

THE JERUSALEM ARTICHOKE CROP.

THE CLOVER CROP.

THE LUCERNE CROP.

THE LUPINE CROP.

THE SAINFOIN CROP.

THE VETCH CROP.

THE GORSE CROP.

THE RYEGRASS CROP.

THE CHICORY CROP.

THE LENTIL CROP.

THE MELILOT CROP.

BIRDSFOOT-TREFOIL CROP.

THE COMFREY CROP.

THE FLAX CROP.

THE HEMP CROP.

THE HOP CROP.

THE TEAZLE CROP.

THE WOAD AND WELD CROPS.

THE MADDER CROP.

THE CORIANDER AND CARAWAY CROPS.

OUR FARM CROPS.

THE PARSNIP CROP.

The only other member of this order—Umbelliferæ—which we cultivate for its roots, is the Parsnip, a plant indigenous to this country, and found as a weed growing abundantly in the waste places of the chalk and other light-soil districts. It is a biennial plant, producing its seeds the second year, like the carrot. In appearance it differs greatly from the carrot, the leaves being oblong-pinnate, with broad, distended stalks. When seeding the stalk rises to the height of 3 or 4 feet, carrying flowers of a yellow colour in compound umbels, and producing thin brown seeds, enveloped in a lighter coloured skin or pericarp. In the wild state the root is small, tough, and fibrous, and generally branched or forked. Cultivation has, however, effected a great change in its condition, and the root has become fleshy, succulent, tedner, sweet to the taste, and highly nutritious to man and beast. The botanical name of the plant is *Pastinaca sativa*,[1] or Common Parsnip, and of this we have four varieties which enter into field cultivation.

1. *Common Long-rooted* (No. 1) has a thick, fleshy, fusiform root, growing deep into the soil, entirely white in colour, and having a well-rounded crown, carrying a branching vigorous head, and producing large crops on soils of suitable depth and quality.

2. *Long Jersey*, or Hollow-crowned (No. 2), differs con-

[1] From *pastinum*, a dibble, owing to the shape of the root.

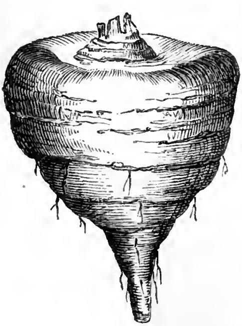
siderably in appearance from the foregoing, being less symmetrical in shape, and having a much greater dia-

No 1.

No. 2

meter at the crown or top, which is slightly concave, whence the name "hollow-crowned." The root is of a yellowish-white colour, tapering from the top, and not so long as the Long-rooted variety, more corrugated on the surface, and suitable for cultivation in soils of medium depth.

No. 3.



3. *Smooth-rooted* more resembles the first than the second variety. The root is neither so long as that of the first, nor so thick at the top as that of the second, but fully equal in bulk and weight to either; while it has the advantage of a smooth surface, which enables it to be lifted from its bed with less labour than is required for the others.

4. *Turnip-rooted* (No. 3) is a variety suited for cultiva-

tion in shallow soils. It is hollow-crowned, the root having its largest diameter at the top, and rapidly diminishing downwards, so as to assume rather the shape of the turnip. Its surface is much furrowed, but owing to its conical shape it is easily removed from its bed.

The parsnip has even a wider range of soils than the carrot; as, notwithstanding in its natural state it is a plant indigenous to light soils, especially in limestone districts, it will succeed well under cultivation in clay soils of more than medium tenacity. At the same time, like other of our cultivated plants, it has its choice of soils, and will thrive far better in some than in others. The extremes, whether of light or of heavy soils, are those which are least suitable to it, and on these the crop is rarely a satisfactory one. Alluvial soils, good strong loams, and the soils proceeding from the disintegrated metamorphic rocks of the Channel Islands, provided they be deep enough, are those most congenial to its growth; and on these, in favourable climates and seasons, the returns are very large. Like the carrot, it is fed chiefly by its tap-root; and this, in a vigorous plant, pushes itself down deep into the soil, in search of the mineral substances necessary for its general structural requirements. If these are met with plentifully it assimilates them rapidly, and commences that abnormal development of the root which distinguishes the cultivated from the natural plant. If these necessary ingredients be not present in the soil, or if the soil be too shallow, or too hard to allow the root a good downward range in search of food, the root will be checked in its development, and very likely become either curved or forked, from being opposed in its natural tendency of growth. Any obstacle in the soil, as stones, roots, or other substances, is also likely to produce this undesirable form of root, which not only lessens the produce, but also renders it more difficult to lift at harvest-time.

The preparation of the soil is much the same as that required by the carrot; more care and attention are needed, however, in preparing for parsnips, as the soil probably may be of a heavier class, and the seed has to be got in some three or four weeks earlier. These points render it most important to get forward with the work in the autumn, directly the preceding crop is off the ground, as every day at that season is of importance to the success of the intended crop. The means already described should be adopted for cleaning the stubbles both of annual and perennial weeds, and when this is satisfactorily accomplished, the manure should be laid on liberally and in a well-rotted state, and then covered in by a deep winter furrow. Subsoiling the land intended for parsnips will always be attended with beneficial results, and as the breadth cultivated generally is but small, it will not press too heavily on the team-power, so valuable at this period of the year. If this strongly recommended process can be carried out, it should be performed in the manner described at page 469, vol. i. In this way, subsoiling for both the carrot and parsnip crops, a moderate proportion of each in the root-break would in a few years get over a large portion of the land occupied, materially increase the depth of soil, and consequently the food-supplying area of the farm.

The *proper* place in the rotation for parsnips is between two straw crops; and this it generally has assigned to it, as owing to the long period it occupies the ground between its seed and harvest time, it quite fills up the interval between the crops which precede and follow it. If the land has been well prepared before the winter, and has laid pretty dry during that period, it is a pity to disturb its weathered surface by ploughing, even if the weather would permit, as running the grubber or cultivator pretty deep across the line of ploughing will break up the old furrow slice, and mix the soil quite sufficiently for the purposes of cultivation, without disturbing the fine tilth on the surface, so desirable for the seed-bed. It rarely happens on the stronger class of soils suitable for parsnips, that the plough could be used with any advantage at the early period necessary for preparing the land for sowing: the finely divided surface soil is buried, and wet slices, more or less cohesive, are exchanged for it, which it is well-nigh impossible to reduce to the desired tilth at that season of the year. On the lighter class of soils, especially if the season has been moderately dry, the plough may be used, and the surface reduced to the desired tilth by rolling and harrowing in the usual way. This adds somewhat to the cost of the crop, and at the same time, by delaying the work, increases the risk of getting in the seed at the period most suited to the crop and to the general arrangements of the farm.

The time recommended for sowing parsnips is towards the end of February or beginning of March, and they are ready for "lifting" about the end of October. This early seed-time is a point of some advantage on a farm where the breadth of root crop to be sown is considerable, and is one of the inducements for their more general cultivation. By admitting the different root-producing plants already described to a share of the acreage intended for the root crop each year, the average produce of the several portions would without doubt, in the course of years, greatly exceed that which would have been obtained from the same area occupied entirely by either one of them; as the different periods of the year at which they are sown, the different effects of seasons, wet or dry, upon their growth, and the different injuries they sustain from the attacks of insects and diseases, would tend to check any great loss that might be sustained by the failure of any one crop, and thus give a better average for the whole. Another point of importance to the farmer in thus dividing his root crop is, that by availing himself of these several root plants he is able to employ his field labour, and also his farmyard manure, in a more economical manner than can be done when the root produce of the farm is confined to a single crop.

The portion of the farm to be sown with parsnips requires to be got ready in February; as soon as this is satisfactorily accomplished the time for carrot sowing is at hand, for which the month of March is the best season. In April, the same labour is required for getting in the mangold-wurzel, and then in May comes the busy time of preparation for the turnip crop, which generally presses more than any other upon the labour resources of the farm. If, instead of growing the turnip alone, one-half of the root-breadth be occupied by other root crops—say one-fourth by mangold-wurzel, and the other one-fourth by carrots and parsnips—the field labour will be more easily carried on, the manure will be used more regularly, while, at the same time, the interval between the recurrence of the same crop on the same soil will be, of course, doubled. This will tend much to sustain the health and vigour of the turnip plant, which are now gradually being diminished by our forced system of cultivation, and our neglect of its physiological requirements.

In the selection of seed great care is required, as, unless it be *quite new*—the production indeed of the *last* season—it is very liable to fail.[1] In shape and appearance it differs greatly from the carrot seed: the smoothness of its surface, and the entire absence of the hairy attachments of the carrot seed, render any preparation of it unnecessary. It is, however, always desirable to test the quality of the seed previous to sowing, by sprouting a small quantity,

[1] Col. Le Couteur relates that on trying to sprout seed, the produce of the year but one previous, not a single seed would germinate.

which can readily be done by laying it in a piece of flannel, kept moist, and at a gentle temperature. If the seed be good, and its germination be regular, from 2 to 4 lbs. are amply sufficient for an acre; if the proportion of germinating seed be small—for the unsold seed of former years is too often mixed with it—a larger quantity will be necessary. The seed previous to sowing should be carefully mixed with about 2 bushels of sand, slightly moistened, which separates it, and assists much in its more equal distribution over the field; and for the reasons given at p. 472, vol. i., it is equally desirable that a small quantity of grain should be mixed with it at the time of sowing. In this state it can be deposited by the ordinary drill of the farm, either with or without manure, in the manner already described. The application of a top-dressing of some readily soluble artificial manure, say 2 to 3 cwts. of Peruvian guano to the acre, will generally be productive of good results; this, mixed with about the same quantity of sand or coal ashes, should be broadcasted and harrowed in before or at the time of drilling. The distances between the rows, and indeed the after cultivation of the parsnip, are exactly the same as that of the carrot crop—the principal object to be gained is, by means of hoeing and stirring the surface as frequently as necessary, to keep it clear from weeds, and ready for the reception of the succeeding grain crop.

About the middle of October the leaves begin to change colour and to show signs of decay, indicating that the further development of the roots has ceased, and that they may be removed from the soil. If lifted at this time, the leaves, which are larger and more succulent than those of the carrot, may be given with advantage to the stock; if their decay is too far advanced, they should be distributed over the surface and ploughed in as manure. The same labour and expense are required in lifting the crop as described in regard to carrots; the same description of fork (see *woodcut*), of which the details are given at p. 474, vol. i., should be used, and the storing of the crop effected in the same way. The parsnip, however, is such a hardy root, that it will resist the winter very well if left standing in the ground, and on very light and dry soils, where the breadth grown is but small, this practice might be permitted, and the roots forked up as required for food purposes.

The produce of the crop, generally speaking, is very inferior in weight per acre to that of carrots, though the general habits of the plants and their cultivation so greatly resemble each other. In the Channel Islands, where they are very largely cultivated, their reports of the returns are far more favourable than we are able to assign to them. There the soil and climate both appear to be favourable to their growth; and we hear not only of roots of a far larger size than we are accustomed to see, but also that the gross produce per acre[1] is much more satisfactory.[2] However, we are, from our acquaintance with the constituents of the root, quite ready to acknowledge its high feeding and fattening properties. In Jersey it is considered that 30 rods of crop will fatten a four-year-old beast in three months from store to butcher's meat. In various parts of the Continent, especially in Roman Catholic countries, parsnips are in general cultivation—salt fish and a good dish of parsnips being

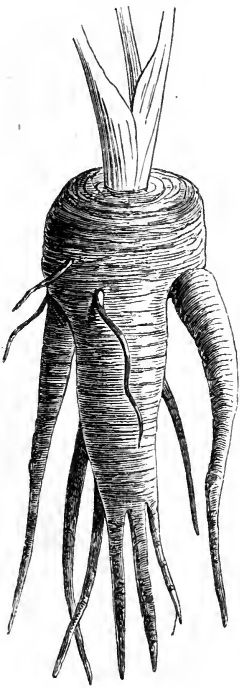
[1] In 1840, Col. Le Couteur reports that the produce in Jersey ranged from 11 tons to 27 tons per acre. In a more recent paper on the "Agriculture of the Channel Islands," we find that 20 tons is considered a good crop.—*Roy. Agri. Soc. Jour.*, vol. xx. p. 32.

[2] Some comparative details of the cultivation, cost, and produce of parsnip and other root crops, are given in the *Agri. Gaz.*, 1851, p. 650.

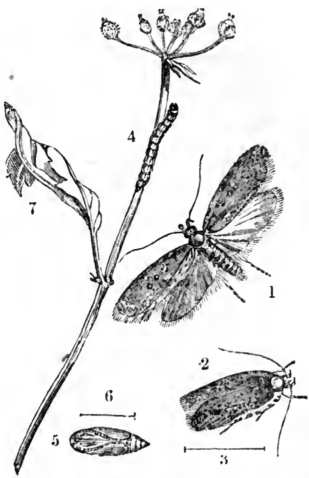
no bad substitute for the butcher's meat, from which the Church requires the inhabitants to abstain on certain days.

In growing parsnips for seed, the best-shaped and soundest roots should be selected at the time they are being lifted, care being taken not to cut off the tops too close to the crown. These should be preserved in a dry place until about the end of February, when they may be planted out at distances about 2 feet apart, in the ground allotted for the seeding plants, which, of course, should have been previously prepared for their reception by deep tillage and a liberal supply of good spit dung. When placed in the ground, vegetation is quickly resumed, a stout branching stem being thrown up, carrying heads of compound umbels, which flower in June or July, and ripen their seed about the middle of August. The seed is harvested in the way already described in the carrot crop. In threshing, it is separated from the stem much easier than the carrot seed, and generally produces a better return.

The parsnip is generally considered to be a hardier plant than the carrot, and to be less liable to be injured during its growth by *disease* or by the attacks of insects. In 1853, however, Mr. Berkeley noticed a form of disease affecting the parsnip, greatly resembling that which has been observed in the potato, and also in the carrot and the mangold. In the potato the disease is accompanied by *Botrytis infestans;* while in the parsnip it is indicated by the presence of an allied parasite, the *Botrytis macrospora.* The same disease, referred to at p. 479, vol. i., in reference to the carrot, has been noticed attacking the parsnip. The decay appears to commence in both cases while the root is in the ground, and to increase rapidly after it is removed, especially if moisture be present. If the roots are cleaned and kept in a dry place, the disease is checked, and the unaffected parts remain sound and fit for food. The disease appears first on the surface, and then penetrates to the inner tissues of the root, and is indicated by the presence of small, discoloured, brown spots on the surface, which are soft and yielding to the touch. These rapidly spread; and if the root remains in the ground, its tissues speedily undergo decomposition, and the whole structure is changed into a pulpy fetid mass. The parsnip is also subject to the same injury from that form of disease, or rather of degeneration, known by the name of "fingers-and-toes," and which has already been described at p. 316, vol. i., in reference to the turnip crop. The annexed woodcut is taken from Professor Buckman's paper "On Fingers-and-Toes in Root Crops," in which he states that the *natural form* of the root of the parsnip, and also of the carrot, *is forked,* and that the single unbranched tap-root can only be obtained by regular and careful cultivation. If this be not sustained—especially if the seed used be brought from a rich to a poor soil, or if it be grown year after year on the farm—the resulting produce will be more or less liable to be injured by this form of degeneracy in the plant.



Most of the *insects* which infest the carrot crop are equally injurious to the parsnip, though not to the same extent. Its early growth is frequently attacked or completely disposed of by the slugs and snails so destructive to our crops in the early spring months, the centipedes and millipedes following up any injury that has been inflicted by them, or by the grubs of the "crane-fly," or "carrot plant-louse." It is not, however, so subject to the attack of the flies (*Psila rosæ* and *P. nigricornis*) causing the "rust" in the carrot, but is liable to injuries from the attacks of a fly peculiar to it, the "parsnip-leaf miner"—*Tephritis onopordinis*—a beautiful tawny-coloured fly, which lays its eggs on the leaves of the plant, the pale green-coloured maggot feeding on the pulp, and forming large blisters and spots on the leaves, and of course destroying their functions. They eventually change to pupæ, from which the fly emerges about March or April, continuing to haunt our fields until about the end of July. Fortunately a parasitic ichneumon fly—the *Alysia apii*—is hatched about June, which materially checks the increase of an enemy so destructive to the health and welfare of our field and garden plants. The remedies recommended at p. 482, vol. i., are equally applicable here; and as regards the leaf-mining maggots, the best method is to destroy them by pinching the small blisters as soon as they appear on the leaves. The parsnip, when being grown for seed purposes, is greatly injured by the same class of small caterpillars described (p. 481, vol. i.) as infesting the flower-heads of the carrot. They all belong to the order *Lepidoptera*, and to the genus *Depressaria*. The members most commonly found on the parsnip umbels are the *D. depressella*, or parsnip-seed flat-body moth, and the



1. Common flat-body Moth (*Depressaria cicutella*). 2 and 3. Do. at rest (natural size). 4. Caterpillar of do. 5 and 6. Pupa (natural length). 7. Do. rolled up in leaf of plant (natural length).

D. pastinacella. The only mode of getting rid of these caterpillars is to carefully shake the umbels over a gauze net, and thus collect and destroy them. An *Aphis* resorts to the parsnip plants in the beginning of June, to which the specific name of *A. pastinacæ* has been given; but although it frequently appears in great swarms, Curtis says that he never noticed them to produce any of those injuries which they inflict on the carrot crops.

Although parsnips are comparatively but little grown in this country as a farm crop, their well-known feeding properties, and the high estimation in which they are held in other countries, where they are largely cultivated, have claimed the attention of our chemists, from whose investigations we are now pretty well acquainted with their general composition and agricultural value. The proportion of top to roots may be taken at from 20 to 25 per cent. at the time of harvest. The composition of the top or leaves has not yet been subjected to examination; the roots, however, contain from 80 to 85 per cent. of water, and about 1 per cent. of ash or inorganic matter. The composition of this inorganic matter has been determined by Dr. Richardson as follows:—

Potash,	36·12
Soda,	3·11
Lime,	11·43
Magnesia,	9·94
Phosphoric acid,	18·66
Sulphuric acid,	6·50
Phosphate of Iron,	3·71
Silica,	4·10
Chloride of Sodium,	5·54
Loss, &c.,	·89
	100·000

The organic composition of the root has been very carefully determined by Dr. Voelcker, who found it to contain a distinct fatty oil of a bright yellow colour, without smell, but possessing a sweet agreeable taste. The nitrogen compounds were also found to differ from the form they usually assume in roots; instead of existing as albuminous matters, they are chiefly in the shape of "caseine;" and the parsnip is further distinguished from the other root crops, as carrots, turnips, &c., by having a larger proportion of starch and a smaller proportion of sugar than they possess. The composition of the root, too, varies in its different parts; neither the heart of the root, nor its external layers, where the starch is principally deposited, contain so large a proportion of nitrogen compounds as the portion between the two. The relative proportions are thus given by Dr. Voelcker:—

	Heart.	External Layers.	Portion between the two.
Percentage of nitrogen compounds in the *dried* root,..................	6·668	6·493	9·375

The composition of the entire root in its natural state, as used for feeding purposes, may be taken as follows:—

Compounds containing nitrogen, ...	1·280
,, not containing nitrogen—as oil,..................	·546
,, ,, ,, starch, gum, &c.,	7·170
,, ,, ,, vegetable fibre, ...	8·022
Ash (mineral matters), ...	·932
Water,..	82·050
	100·000

Comparing these constituents with those found in the turnip, we see but little difference between their relative proportions of flesh-forming (nitrogen) compounds; but of the heat-giving and fat-forming compounds, as oil, starch, &c., the parsnip contains about double the quantity, which renders it so particularly suitable as a food for fattening purposes, or for milk-producing animals, which require an analogous process in the vital economy. The large proportion, too, of starch that the root contains, is a point of some importance to the grower, as it at once indicates to him that the parsnip may be kept, properly stored, without suffering injury, for a longer period than any other of his root crops which contain the same food materials in the form of sugar, as is seen in carrots, mangold, &c. If we compare the parsnip with the carrot, with which plant it is most closely allied, we see that it presents a superiority in many respects as a crop for feeding purposes. It contains on an average about 5 or 6 per cent. less water than the carrot, which materially improves its keeping qualities, the difference being made up by an additional proportion of solid extractive matter, by which its general feeding qualities are proportionately increased. The flesh-forming compounds, too, are nearly double those contained in the carrot; while the oil, starch, &c., in its composition would indicate that for fattening as well as for feeding purposes it is of greatly superior value.

THE POTATO CROP.

We now have to discuss the cultivation of another crop, differing greatly in all its natural characters from those which have preceded it, and belonging to an entirely different order—Solaneæ: an order which, although furnishing but few plants that subserve the wants or comforts of mankind, contains two which probably enter as largely as any into the consumption of the inhabitants of the temperate zones. These two are the Potato and Tobacco—the one cultivated extensively as a "Farm Crop" in this country, the other forming an equal object of importance to the cultivators in more genial climates than our own. With the exception of the tomato (*Solanum lycopersicum*)—which, though grown as a field crop on the Continent and in America, is in this country confined entirely to the garden—the potato is the only representative of this order which we cultivate in our fields as an article of food. The disease with which the potato has been visited, with more or less severity, during the last fifteen or sixteen years, has called public attention more particularly to this plant; and we can all testify to the very general feeling of loss sustained, when we have from time to time been restricted in the use of this necessary constituent of our daily food. In Ireland, where the potato enters more largely than with us into the food of the people, the loss was more severely felt. The statistics of population testify to the effects produced, and portray too truly the sad picture of a population trusting its food supply to well-nigh a single source, which failed them in their hour of need, and brought disease and decimation into their families and homes. The cultivation of the potato was checked for a time, both in this country and in Ireland, by the sad visitation of disease in 1843-5; substitutes, both in the field as a crop, and on the table as a food, were introduced; but as the cloud cleared off the land the potato again resumed its place, and at the present day the "upas tree" of Ireland, as Cobbett termed the plant, may be seen occupying its old position, and well-nigh to the same extent as in former years.

The introduction of the potato into this country is of comparatively recent date, and was attended by circumstances which have well preserved its early history. It is without doubt a native of South America, having been met with growing wild in Chili, Buenos Ayres, and along the coast of the Pacific. Humboldt appears to have had some scruples about its native habitat; he admitted that it is found in those countries, but raised the question as to whether it was an indigenous or merely a naturalized plant. Sir Joseph Banks[1] considered that it was brought over to Europe from the mountainous districts in the neighbourhood of Quito, by the Spaniards, in the early part of the sixteenth century. Potatoes appear to have soon found their way into Italy, as there is evidence that they were known in that country about 1550. In 1588, Clusius, at Vienna, received a present of some from the pope's legate in the Low Countries, from which source they gradually found their way all over Germany, where, however, during the next century their cultivation was confined to the garden. Their first appearance as a field crop, according to Thaer, was about 1771-72, when the progress of the country, first recovering from the seven years' war, was again arrested by the failure of the grain crops, and the potato, before

[1] *Horticultural Transactions*, vol. i. p. 8.

then cultivated only as a garden luxury, was gladly welcomed as a substitute for the bread-corn that had failed them. Their first introduction into this country is supposed to have been about the year 1584, in which year the queen (Elizabeth) granted a royal patent to a company of adventurers for discovering and taking possession of new countries not occupied by Christians. Under this sanction a fleet was fitted out for the purpose, through the means chiefly of Sir Walter Raleigh, under whose command it sailed in the ensuing year on its voyage of discovery. He was accompanied by Harriot, the afterwards well-known mathematician, who collected various specimens of the natural produce of the countries visited; amongst others that he transmitted to England, were samples of a root greatly esteemed by the natives of a new country in North America, to which the courtier-like gallantry of Sir Walter Raleigh had given the name of "Virginia," in honour of his maiden queen. This expedition returned, and brought home with it a larger quantity of the root, and the Indian name, *openawk*, by which it was called, was changed into the *Batatas virginiana*—under which name it is figured and described by Gerarde (1597)—to distinguish it from the sweet potato,[1] then already known. The sweet potato, Sir Joseph Banks tells us, was used in England long before the new potato of Virginia was known to us, having been introduced from Spain and the Canary Isles. It is this potato which is alluded to in Shakspeare and old contemporary authors. According to some authorities, however, the potato is said to have been known in Ireland some years previous to Sir W. Raleigh's expedition, having been introduced into that country in 1545, by a sea captain, John Hawkins, who had brought it

[1] The *Convolvulus* or *Dioscorea batatas*, a garden plant recently re-introduced.

with him from Santa Fé. There are also other traditions as to the period and mode of its introduction into Ireland, where it appears to have been known before Sir Walter Raleigh's return; one of the most probable of which is, that a trading vessel, on her return from a transatlantic voyage, was wrecked on the Galway coast, and amongst its cargo washed on shore were some curious roots, which, on being cooked and tasted, were so much liked, that some were preserved and planted as a trial, from the successful results of which the cultivation of the potato plant commenced.

If Sir Walter Raleigh was not the first who introduced the potato into this country, he should have the credit of having been the means of making it more generally known after it was introduced, as he had them planted in his own garden at Youghal, and personally superintended their growth. An anecdote is related of his first crop, which was well-nigh bringing the career of the new esculent to an untimely close. Sir Walter, on inspecting them one day, considering their growth to be complete, directed that some might be gathered and sent in for cooking. The gardener accordingly gathered the fruit, and furnished the supply ordered. When they were served up and tasted, the company were sorely disappointed in the flavour of the dish of new Virginian fruit, which was most nauseous and unpalatable; and Sir Walter Raleigh, feeling certain that some noxious weed had been furnished to him instead of the new potato, directed his gardener to pull up the plants forthwith, and eject them from the garden. Whilst this operation was being done, some of the tubers remaining attached to the roots were observed by his master, who at once recognized the mistake that had been made, preserved them, and gave directions for their future cultivation in a proper manner.

Still, they made but slow progress either here or abroad, while their sister plant, the poisonous tobacco, pandering by its narcotic effects to the sensual appetite, was at once received and eagerly purchased by the people of every country into which it was introduced. In 1633, we find the Royal Society taking measures for encouraging the growth of the potato, as a means of providing supplies of food in times of scarcity of corn. In 1699, Evelyn makes mention of them, but thinks so slightingly of them as to say, "Plant your potatoes in your worst ground." In 1684, we find that the crop was pretty extensively cultivated in Lancashire, but it was not until 1728 that the first field crop was seen in Scotland, where, however, its culture increased so rapidly, that in a few years afterwards (1732) we find it entering extensively into the system of tillage crops. Difficulties, which it did not meet with elsewhere, appear to have opposed its reception in Scotland. The zealous but mistaken religious opinions of that period militated against the reception of this new plant, which was asserted to be a sinful plant, because no mention had been made of it in the Bible. Thus its introduction was delayed, and the people were debarred from its use, until Thomas Prentice, a labouring man, living near Kilsyth, procured, in 1728, some "sets" from Lancashire, which he planted and sedulously tended in his garden, propagating the stock each year, and disposing of it upon very advantageous terms to his neighbours, whose belief in its value, confirmed by the results of each year's cultivation, overcame their scruples as to its origin. In a few years the results of his good sense and of his good skill enabled him to accumulate sufficient money to purchase a small annuity, on which he lived independently to a good old age, dying in Edinburgh so lately as 1792. It is true that the potato is not mentioned amongst the other vegetables in the Holy

Scriptures; but, whether we view it in reference to its special adaptation to almost every soil and every climate where cultivation exists, or as an important and most useful source of food, grateful to the palate and nutritious to the animal system, we cannot refuse to acknowledge it as one of the most valuable vegetable gifts bestowed upon the human race.

The genus *Solanum* contains three species, well known in either garden or field cultivation; a fourth is an indigenous perennial weed, the bitter-sweet (*S. dulcamara*), growing wild everywhere in our hedgerows, and bearing clusters of bright scarlet berries, tempting yet poisonous to children.

The name given to the potato by botanists is the *Solanum tuberosum*, of which the (so-called) varieties in cultivation in different parts of the country are almost without number.[1] These varieties, however, though they differ in many cases but slightly from each other, have generally some peculiarity of adaptation to different soils or climates, or their quality or their productiveness gives them a claim to the character of a variety. Mr. Lawson divides the field varieties into three classes.

No. 1. Early field potatoes, the leaves and stems of which (under ordinary circumstances) are decayed by the time when they are usually taken up, and the tubers of which are then fit for use.

No. 2. Large field potatoes, the foliage of which, in ordinary seasons, does not decay until injured by frost, and the tubers of which generally require to be kept for some time before being fit for using to the greatest advantage.

No. 3. Late large, prolific sorts, more particularly adapted for cattle feeding.

[1] Lawson enumerates and describes, in the *Vegetable Products of Scotland*, nearly 200 varieties.

The varieties more generally approved of are—

CLASS I.—*Agricultural Late Kidney.*—In length nearly thrice its average diameter, slightly flattened and thickened towards the point; eyes few and very shallow, or almost level with the general surface; colour whitish; quality superior. Two tubers were received by us (Messrs. Lawson) from the late Mr. Loudon, the largest of which measured 10 inches in length by 11 inches circumference at the middle, and weighed 2 lbs. 6½ oz.

Bedfordshire Kidney.—Stem rather erect, about 30 to 33 inches high; tuber long, thick, and straight; colour reddish; medium, good flavour, and very healthy.

Blue Don.—Stem stout and spreading, about 30 inches in height; tuber round and hollowed at stalk; colour dark bluish purple, with small whitish blotches; mealy and very good flavour. Much liked, and largely cultivated in some districts in Ireland.

Common or Scotch Don.—Stem strong and spreading, about 30 inches high; tuber round and hollowed at the stalk; colour white, and reddish purple about the eyes; mealy, good flavoured, and tolerably healthy. As a feed potato this variety is more extensively cultivated in Mid-Lothian and adjacent districts than any other. When cooked its tubers are much whiter-fleshed than those of the Perthshire Reds and some others of the more esteemed field sorts; they are also mealy and of an agreeable flavour, but when grown to a large size, often hollow, or hard and waxy in the centre.

Cork Red.—Stem spreading, about 2 feet high; tuber flattened slightly, oblong and pointed; colour roughish and reddish brown; mealy, good flavoured, and healthy. The favourite variety in some parts of Ireland.

Douglas' Irish Kidney.—Stem spreading, about 2 feet high; tuber long, and thickest towards the point; colour darkish purple; mealy, good flavoured, and healthy.

Farmer.—Stem rather upright, about 3 feet high; tuber hollowed at both ends, with large deep eyes; colour red, but white about the hollowed points; skin rough; mealy, very good flavour, and very healthy.

East-Lothian Red.—A round potato of great merit, bearing some resemblance to the Perth Red; eyes large but not deep; skin of a deep red; pretty good flavour.

Fill Basket.—Stem loose and straggling, about 2 feet high; tuber round; colour whitish; slightly rough; mealy, good flavour, and pretty healthy.

Kilspindie Blooms.—Stem stout and erect, about 2½ feet high; tuber oval and flattened; colour dark bluish purple; very mealy, superior flavour, and healthy. A much and deservedly esteemed variety, considered, however, less productive than the Perth Reds, except when sown on peaty or moorish soils, for which it seems to be admirably adapted.

Leather Coat.—Stem stout and slightly spreading, about 30 inches high; tuber slightly oblong and much flattened; colour yellowish white; skin remarkably rough; mealy, excellent flavour, and healthy. An esteemed variety, formerly grown extensively in the middle districts of Scotland, where it is still to be met with, but considered less productive than the Perthshire White.

Old Flat White.—Stem long and slightly spreading, about 2½ feet high; tuber slightly oblong, much flattened; colour very white; skin smooth; mealy, superior quality, and healthy. This variety was formerly greatly esteemed, and cultivated almost exclusively in some of the potato-growing districts of Perthshire and of Forfarshire; but although it is generally allowed to be a superior variety to the Perthshire Reds, they have almost entirely superseded it in field cultivation.

Perthshire Red.—Stem slightly spreading, about 2 feet high; tuber slightly oblong, medium size and somewhat flattened; colour red; skin smooth; mealy, good flavoured, and healthy. There are three varieties in cultivation—the true, or "Oblong Flat," the "Small-eyed Round," and the "Large Deep-eyed." These three are grown indiscriminately, and are known in the markets under the names of Common, Scotch, or Perthshire Reds, the latter of which has been applied since they became so much esteemed in the London markets. The Small-eyed is about equal to the first-named in quality, but rather deficient in produce; the "Large Deep-eyed" variety is the stoutest grower, the most productive in quantity, but not equal in quality to the other two.

Red-nose Kidney.—A shortish variety, generally about 18 inches high, with spreading stem; tuber long, often slightly curved; colour whitish, with a reddish point about the eyes; mealy, good flavour, and healthy.

Rohan.—Tubers of large size, roundish shape, hollowed at the eyes, and whitish coloured. Raised at Geneva from seed in 1829-30, where the yield was stated to be unprecedented. Is now known all over the Continent and in this country as a good variety, but inferior to many others for the table, while it is at least equalled by others again for cattle-feeding purposes.

CLASS II.—*London Blue.*—Stem bushy, about 2 feet high; tuber roundish and slightly flattened; colour dark bluish purple; skin roughish; mealy, good flavoured, and very healthy.

Pink-eyed Irish Round.—Stem stout and erect, from 2½ to 3 feet high; tubers roundish; colour dirty white with pink eyes; moderately mealy, good flavour, and very healthy.

Scotch Black.—Stem strong, upright, and compact, about 3 feet high; tuber round and much hollowed at stalk; colour dull lead; skin shining, very rough and reticulated; medium size, medium flavour, and healthy. The dark colour, whence it takes its name, is confined to the stems and skins of the tubers. It has been long in cultivation, and is chiefly valuable from being suitable for use between the periods of planting and taking up the new crop.

St. Helena.—Stem upright and bushy, and about 2½ feet high; tuber roundish but irregular; colour whitish, sometimes tinged with red; moderately mealy, good flavour, and healthy.

Stafford Hall.—Stem erect and spreading, from 2 to 2½ feet high; tuber rather flattened, round, or slightly oblong; colour dull red, approaching to purple; very mealy, excellent flavour, and very healthy. Introduced in 1827 by Mr. Ross, of Stafford Hall (Cumberland), who obtained the Highland Society's medal for it. Rather a late variety, grows well in strong loams; requires to be pitted for two or three months before it acquires its full flavour and value, and then will retain them, and be fit for consumption until the earlier sorts are ready in the ensuing season. In Mr. Lawson's paper, in the *Highland Society's Transactions*, "On the Comparative Merits of Varieties of the Potato," this potato was found to have a higher specific gravity, and to contain a larger proportion of starch, than either of the other varieties—seventy-three in number—which were examined.

CLASS III.—*Brown's Fancy.*—Stem spreading, about 2½ feet high; tuber slightly oblong and flattened; colour whitish; medium size, medium flavour, and healthy. They are excellent for storing, well adapted for cattle-feeding, but of inferior quality for the table.

Common Yam.—Stem stout, and rather bushy, about 2½ to 3 feet high; tuber large and oblong; colour dull pink; waxy, flavour indifferent, very healthy. This variety is readily distinguished, on being cut open, from all others (save the wild potato), by having a ring similar in colour to the skin, and lying within, in a parallel zone. It is largely grown in Scotland, especially in the middle districts, for cattle-feeding purposes.

Connaught Cups.—Stems stout and erect, about 2½ to 3 feet high; tubers large and slightly oblong; colour dull reddish pink; mealy, good flavour, and healthy.

Cups.—Stem stout and erect, about 2½ to 3 feet high; tubers large, oblong, and irregularly shaped; colour dull pink; mealy, good flavour, and healthy. This, the Stafford Hall, and the Lumpers, are generally considered as the three best varieties for cultivation for cattle-feeding purposes. Of these, the Lumpers probably are the most productive as to weight of crop. The other two, however, are far superior in quality; the Cup, like the Stafford Hall, being a moderately good potato for table purposes when not grown of too large a size. Its tubers, owing to their irregular shape, are more difficult to wash than the others, which are almost always met with of a symmetrical shape.

Irish Lumpers.—Stem pretty erect and stout, about 2½ feet high; tuber large, slightly oblong, and much flattened; colour whitish; waxy, flavour indifferent, very healthy. A prolific sort, and largely grown for cattle.

Mangold-Wurzel.—A name under which the Red Yam has lately been brought into pretty general notice, and which possesses all the physical and economic characters of that excellent variety.

Ox Noble.—Stem about 2½ feet high, spreading; tubers slightly oblong, and flattened; colour whitish; rather waxy, flavour indifferent, very healthy; indeed, one of the most healthy varieties in cultivation.

Pink-eyed Dairymaid.—Stem bushy, about 2½ feet high; tuber large, roundish, and deep-eyed; colour whitish, and pink, or purplish; waxy, indifferent flavour, but very healthy. Not suited for table use; but a very large cropper, and well adapted for cattle feeding.

Red Yam.—Stem erect, spreading, and about 2½ feet high; tuber large and oblong; colour bright reddish; waxy, indifferent flavour, but very healthy. An esteemed variety for cattle feeding, the cultivation of which is rapidly extending in the districts where it has been tried.

The leading characteristics of the foregoing varieties thus briefly given, were those noted by Mr. Lawson in his experimental trials of the different varieties of the potato. The experiments were all carried on in the same soil, a medium loam of medium fertility, and thus well suited for testing the relative values of the different sorts planted. At the same time, we must recollect that one of the great benefits derivable from varieties is the increased facilities given for cultivation in a variety of soils; therefore, although the class of soil in question was perhaps the best that could have been chosen for the experiment, it is more than probable that very many of the varieties would have changed their characters considerably had they been grown in soils perfectly congenial with their habits of growth.

Before proceeding with the agricultural treatment of the potato crop, it will be well to bear in mind that, although it is usually looked upon by us as a *root crop*, botanists have clearly shown us that the potato tuber is *not a root*, but merely an *enlargement of the underground stem*, due principally to cultivation, and caused by an abnormal increase of the cellular tissues, in which are deposited the starch globules, which exist in such large proportion in the tubers. If a seed of the potato be sown, it germinates and sends forth true roots like those of any other plant; these have not the power to enlarge into the form of a tuber—their duty is to ramify through the soil and search for food. The potato, like other plants, consists of three parts—the cellular and vascular tissues, and the outer covering or skin. In its natural state, the tendency to carry the growth of the stem below the surface exists but to a comparatively small extent; even in raising new seedlings from cultivated plants, their produce the first year rarely exceeds the size of small birds' eggs, requiring two or three more years of continued cultivation to bring them up to the desired size. The enlargement of the stem under ground is effected by the abnormal development of its cellular tissue, existing naturally to a small extent, but increased by cultivation; the vascular tissue, however, is not susceptible of increase in bulk but merely in length, running through the cellular tissues, whatever may be their development; while the skin is capable of any extension required to cover the increased size.

The potato has a very wide range of soils, and also of climates; it will grow, indeed, in almost any soil or climate in which cultivation of any sort can be carried on. We have just seen that its native country lies within the tropics, while we have already had occasion to remark (p. 97, vol. i.) that its cultivation is carried on in countries even beyond the boundaries of cereal growth. The medium soils, however, are those which it prefers—the lighter class generally producing the best quality of potatoes, the heavier class the largest crops.[1] On the soils of the different sandstone formations large crops of excellent quality are frequently seen, while the London market is largely supplied with potatoes grown on the strong alluvial soils of Yorkshire, and of Perth and Forfarshires. The purely clay soils met with in the districts occupied by the London clay—by the weald and the gault clays in Kent, Surrey, and Sussex, and by the oolite clays (Ox-

[1] In an experimental trial of the influence of soil in the yield of the potato, it was found that the produce of four sets of the same variety,

Planted in a	strong rich loam,	weighed	34 lbs.
,,	light rich loam,	,,	29 ,,
,,	good gravel,	,,	19 ,,
,,	sandy soil,	,,	15 ,,

ford and lias) in Oxfordshire, Wiltshire, Gloucestershire, and Worcestershire—are those least suited to its growth, and consequently potatoes are rarely seen as a field crop in those places. The numerous varieties of the potato, however, give it a great advantage over most of our cultivated plants, as it offers a selection of sorts suitable, more or less, for every class of soils, some of which, indeed—the Yam, Irish Cup, Stafford Hall, for instance—prefer the stronger to the medium, and will give very productive returns in the soils even of our clay formations.

Within the last few years, our clay lands have undergone a great mechanical change; thorough draining, subsoil ploughing, and deep tillage have quite changed their agricultural characters, and have reduced the difficulties of their cultivation to about what the ordinary loams presented some twenty or thirty years ago. For the general cultivation, however, of the potato, the lighter class of loams form the best soils—the produce being of superior quality, and generally equal in quantity to that from any other description of soils. Calcareous soils are not generally very productive potato soils; they are usually shallow, and, from the nature of the composition, dry, while their geographical position in this country has placed them also in a dry climate. The potato in this respect somewhat resembles the oat (p. 144, vol. i.); it requires a considerable amount of moisture to support its natural functions in a healthy condition. In order to secure this moisture, therefore, which must be either obtained from the soil or from the atmosphere, it is desirable that, if the climate of the district in which it is cultivated be dry, the soil selected for the crop should be of such a retentive character as to supply sufficient moisture during its growth; if, on the contrary, the climate be comparatively moist, as we see on our western coast, then the soil apportioned to the crop should be of a drier nature, as the leaf surface would absorb from the atmosphere the necessary supplies. This probably is the condition under which it thrives in its native home. On the Pacific coast of America rain is of rare occurrence, consequently the surface soil is comparatively dry, and can furnish but scanty supplies to the thirsty vegetation of an intertropical country. But although the rainfall of other climates is unknown there, the air is charged with moisture, which, when the temperature falls towards sunset, is set free, and deposited on the leaves in the shape of dew, the absorbent powers of the leaves enabling them to drink in the vital fluid sufficient to supply their own natural processes, and to replace that which they had given out under the influence of the solar rays. On peat and bog lands, good crops are frequently obtained. The previous application of lime to such soils is always followed by beneficial results; the inert, or sometimes noxious matters combine chemically with the lime, and are neutralized or converted into valuable compounds, while, at the same time, it produces a mechanical effect on the mass, by giving it a greater solidity, and increasing its powers of absorption and retention of moisture. On soils of this description, where the straw crops are often limited to oats, potatoes generally enter into the system of farming, and form a very profitable crop to alternate with turnips in the rotation. In all cases, no matter what the character of the soil may be, it is important that it be free from stagnant water, and that the tillage processes be such as to secure a good depth and a fine division of the soil, so that the air may have good access to it, and exert its full oxidizing influence on the various ingredients.

If we look at the arrangement of the potato plant in its growing state, we see at once how far the physical conditions of the soil are likely to affect it. We have the erect stem and leaves appearing above the surface, and immediately beneath we have the stolons and underground shoots developed into irregular shapes and sizes, forming what we call the "tubers," or more commonly the potatoes, these again being terminated by the true roots of the plant, upon which alone it has to rely for its supplies of food materials from the soil. These roots are very numerous, being attached to each of the stolons or underground stems, and are all provided with a very large number of "spongioles" or absorbent points, by which alone the moisture and food materials necessary for its healthy development can be assimilated and carried up into the circulation of the plant. Passing upwards into the stem and leaves, these food materials come under new influences, and are elaborated into vegetable tissues and other different forms of matter, the surplus moisture being got rid of by evaporation from the leaves. We might reasonably deduce from these observations that the potato, owing to its large root-development and comparatively small evaporative surface, is a plant essentially suited to a dry soil, and that any departure from the conditions natural to it must be followed by consequences more or less injurious to its general health. These, as we have just observed, would be greatly affected by the climate of the district; if it be moist, the evaporative power of the leaves would be lessened; if it be dry, they would be increased, so as probably materially to counteract the effects of surplus moisture in the soil.

If we compare the structural arrangement and consequent functions of this plant with those of our ordinary root plants—take the turnip for instance—we find a vast and important difference to exist. The turnip sends down into the soil a single tap-root, from which depart numerous rootlets, each terminated by a small feeding point; but these are very much smaller in number, and less in absorbing power than those of the potato, while the drooping and spreading habit of its leaves, gives them a power of evaporation greatly exceeding that of the potato. The turnip consequently needs a plentiful supply of moisture in the soil to enable it to keep its more limited powers of absorption always in action, and any surplus moisture it may carry up into its tissues is speedily dissipated by its broad, expanded leaves. We find throughout nature that the various parts of a plant are beautifully proportioned to its natural wants and the duties they have to perform. The roots of the potato, therefore, being naturally intended to occupy and carry on their functions in a comparatively dry soil, are provided with a large amount of absorbing surfaces, in order that they may thus be able to abstract from the soil the moisture necessary for the plant; while the leaves, from the same cause, having but little surplus moisture to dispose of by evaporation, are placed on an erect-growing stem, and are comparatively small, both in size and in number. If a potato and a turnip were grown together, under the same conditions of soil and climate, it is extremely improbable that they would both thrive equally, their natural requirements being so different. The absence of moisture would allow the numerous absorbents of the potato to exercise their powers, and readily support its vegetation; while the small absorbent power of the turnip would speedily exhibit itself in the stunted development of the entire plant. Again, if the conditions were changed, the turnip would show, by its vigorous growth, that both its root and leaf powers were being fully and healthily exercised; while the potato would find that more moisture was absorbed and pumped up by its vigorous roots than its leaves could dispose of, and that its general functions would be impeded, and its healthy development consequently be more or less disturbed. The tissues would become gorged with more matter than they could digest, the sap would become weakened and vitiated, the whole circulation of the plant would be deranged and irregular, and if relief was not afforded speedily by natural causes, disease would ensue and the plant die.

Although by long cultivation we have considerably changed the powers of growth of the potato, we have not changed its natural structure, which clearly renders it more suitable for certain conditions of cultivation than for others; and the further we depart from those conditions the more likely are we to debilitate the plant, and to prepare it for the reception of disease. There is but little doubt that each of our cultivated plants differs in its soil and climate requirements from the others, and that the nearer we can secure those most congenial to its growth and development, the more satisfactory will be our returns in the shape of produce. Although these cannot always, in ordinary farming, be strictly followed, they ought never to be lost sight of or neglected. In the case of the potato they are more marked than in many of the others; and their importance cannot be too strongly impressed upon our minds, since, by long neglect of principles in our cultivation, the general condition of the potato has been gradually debilitated, and a tendency to disease induced, which has been very prominently exhibited to our cost and discomfort during the last fifteen years.

Potatoes are always looked upon as a fallowing crop; their proper place in the rotation, therefore, is clearly between two straw crops, and that is the place they invariably occupy in all well-farmed districts. Where they are grown solely for market purposes—as on the banks of the Humber, and in the immediate proximity of large centres of consumption, as London and Liverpool—the cultivation assumes a special character, and a departure from a regular rotation is justified by the larger money returns obtained, and increased sources of manure such localities command. In the ordinary business of farming, however, it is far safer in the long-run not to travel far out of the usual rotation for the sake of an extra money return now and then. As a speculation it may pay, but at the same time it is equally liable to failure, and in either case may cause more derangement in the farm system than the chances of extra gain are worth.

On the lighter class of soils farmed upon the four-course or Norfolk system, potatoes might advantageously be substituted for turnips in the rotations, either wholly or in part, according as the soil and climate were suitable. They would form an equally good fallow crop for the cereals, and would so far increase the interval of recurrence of the turnip crop on the same ground. In districts where the five, six, and seven course systems are followed — the Lothians, for instance—potatoes are generally taken immediately before wheat, for which they form an excellent preparative—the deep tillage and manure they have received, and the opportunities they afford of keeping the land clean during their growth, all telling most favourably on the succeeding grain crop, the straw of which is generally stronger and brighter than when preceded by any other crop. Its natural place in the rotation, as compared with that of other fallow crops, places it more directly before the winter-sown wheat than either of the other spring-sown cereal crops. The potatoes are all off the field, and the ground ready for ploughing by the middle or end of October, while the other straw crops, not requiring to be sown until the spring, give ample opportunity for the preceding root crop to be consumed on the field.

The preparation of the soil for the potato crop should commence as soon as the straw crop is cleared off the ground. The operations of cleaning (page 293, vol. i.) should be carefully attended to, as one day's work now will save many days' work and much injury to the crop in the spring and summer following. When the field is quite cleaned of all the weeds, perennial and annual, the ploughs may be sent, and the land left with a good, deep, winter furrow. Manure is rarely applied to the potato land in the autumn, but reserved for the planting time in the spring. No good reason, however, appears to support this practice, neither is there one reason why the manure, when applied before the winter ploughing, should not exert the same good influence on the succeeding potato crop, as we are inclined to allow that it does when preparing the land for beans or for mangold. If the stock of farmyard manure will admit of it then, we should recommend that it be applied at the time of winter ploughing, rather than in the spring at planting time—remembering always, that as potatoes are almost invariably planted on ridges, the manure used should be in such a state of decomposition as to get thoroughly incorporated with the soil, and offer no resistance to the ploughs in forming the ridges for planting in the spring. If the manure were applied in a fresh or green state, its decomposition would go on so slowly in the soil, during the winter months, that it would turn up with the plough and spoil the work of ridging; whereas, if well rotted before it is ploughed in, a turn across the furrows with the grubber or cultivator in the spring would insure its distribution through the soil, which, at the same time, would be opened and dried by the operation, and generally in a fit state for ridging up at once for the crop.

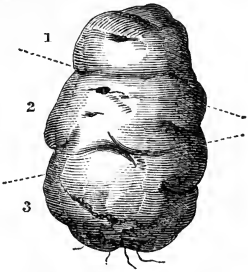
In the north, and in the well-farmed potato districts generally, it is customary to manure heavily for the potato crop—20 to 30 tons of farmyard dung and from 3 to 5 cwts. of Peruvian guano being frequently applied. If the dung be given, as recommended, in the winter, the guano or other artificial manure would be all that would be given in the spring, and this may be applied broadcast on the surface previous to ridging. In all cases the guano should be diluted by mixing with at least an equal portion of some other substance; for this purpose nothing is so suitable as gypsum (sulphate of lime), which in itself is a valuable manurial substance for the potato. It is a cheap substance, and may be liberally applied—say half a ton per acre. If this be not at hand, sand, coal ashes, or even dry mould would do, in order to dilute it and thus effect its more equal distribution on the field.

The end of March or beginning of April is, under ordinary circumstances, the best period for potato planting, previous to which the land ought to be properly prepared for the reception of the crop. If the autumnal cultivation has been well carried out, but little will be needed now; if that has been neglected, we must at once set to work, ploughing, cultivating, rolling, and harrowing, as may be required, until every weed is got out of it, and a fine deep tilth secured. When these necessary conditions have been attained, the operation of ridging may be proceeded with, at which time the farmyard manure intended for the crop should be applied, when it has not been laid on at the winter ploughing. The method of drawing the ridges, carting on and distributing the manure, and the principles involved both in the application of manurial substances and in the labour required for their distribution, have been fully described and discussed in a former part, when treating on the turnip crop (pp. 290 and 296, vol. i.), and these we would again recommend to the consideration of farmers, as they represent two important questions in farming which appear to be very imperfectly understood, or at all events very generally neglected, at the present day. When the farmyard manure is applied at the time of ridging, the additional guano or other substances should be broadcasted at the same time, and covered in by the moulding plough at the time of splitting the ridges and covering in the dung.

When this finishing part of the work of preparation has been satisfactorily accomplished, the seed is the next point for the farmer's consideration. Now, although the potato may be generated either from its seed or from its tubers, the latter are always resorted to for the purpose, as experience has shown us that when the seed has been used the tubers produced are so small as to be well-nigh valueless as articles of food, while, at the same time, they are very liable to "sport," and to exhibit great variations from the original stock. If the seeds be made use of for raising a stock, the largest and best-formed "apples," as they are termed, should be selected when fully matured; this is easily seen by their darker colour and by the decay of the stem. These should then be carefully kept until they become perfectly dry, when the seed is readily separated from the pulp by rubbing in the hand, and a few hours' exposure in the air is sufficient to render them quite dry. In the month of March they may be planted in a sheltered situation, and should be carefully attended to until the time of harvest, when a number of small tubers, from the size of a bean to that of a walnut, may generally be collected. These, the following year, may be planted at the usual time, and at the time of harvesting will be found to have increased the size of the tuber-produce from the walnut to that of an ordinary egg; while the produce of the next and the following years will show that the tubers have attained their full development. It is a curious fact that, whatever the original seed sown may be, the produce is sure to be very irregular, some of the tubers being white, some yellow, and some red, and of all varieties of shapes. This irregularity, however, is so far useful, as it affords the grower an opportunity of meeting with several new varieties, from which he may, by a careful observation of their habits of growing and ripening, select some which he may think likely to form desirable varieties to propagate for future crops. There are methods of even crossing the different varieties, by hybridizing them, and thus forming new and improved sorts; but this process is attended with considerable trouble, and requires some skill, and indeed comes more under the attention of the gardener than of the farmer, unless he happens to live within reach of any large centres of consumption, where the early potato crop, well managed, always produces very remunerative returns. Sometimes it will be found that plants which produce their tubers very early do not blossom at all, and thus produce no seed. When this is noticed, and the seed is desired, the soil round the plant should be carefully removed, and the tubers that are formed picked off. By thus preventing the plant from increasing its underground stem, it is stimulated to throw out leaves and flowers, producing seed in great abundance. In this way Mr. Knight, the President of the Horticultural Society, succeeded in procuring seeds from potatoes which had never before blossomed, and from these seeds he raised several excellent varieties—some being early, some late, and some of a more vigorous and of a hardier nature than those known before. Sargeret found that out of 300 plants of different varieties raised from seed, he had not a single plant exactly like the original one from which he obtained the seed, and that out of the whole number he only found three worth keeping.

If new sorts, or an entirely new stock be desired, they may probably be obtained by this method, selecting those only which appear likely to suit the purpose intended, and carefully continuing their cultivation for three or four years, until the tubers produced have reached the usual size. If, however, as under the ordinary circumstances of farming, a crop be required at once, the only plan to adopt is to make use of the matured tuber as seed, which in due course will reproduce others like itself, and thus secure the desired end. This is the usual method of growing the potato. Here, however, a great difference of opinion and of practice exists in the mode of carrying this into execution. Our ordinary farm crops are raised from seed, each grain of which possesses a single germ, the representative of the future plant. The tuber of the potato, however, instead of a single germ, often possesses several, generally more than one, each of which, though forming portion of the same body, is capable of producing an entire plant, and thus greatly increasing the reproductive powers of the original tuber. This is seen every year in all our potato fields, the plants growing in clusters of two, three, or sometimes more together, and very rarely indeed standing singly in the rows, as we are accustomed to arrange for the plants of our other fallow crops. The existence of these several germs, indicated by what are known as "eyes" in the potato, has of course been long noticed by practical men, and has led to the practice of dividing the seed potato into some two, three, or more pieces, which effects the double purpose of diminishing the quantity of tubers required for planting a given area of ground, and of thinning the number of plants to be grown on its surface.

Some little care is required in the division of the tuber into these pieces, or "sets," as they are termed, so that the germs should not be injured in the cutting, and that each "set" should contain one or two, in order to secure a good plant. For this purpose, good, sound, and fully-matured tubers should be selected; shape rather than size should, for ordinary purposes, always be preferred. Their preparation should be proceeded with at the same time the field work of preparation is in progress, so that they may be ready for depositing in the ground as soon as it is ready for their reception. An open shed or barn, where they can be spread out thinly on the floor, is the best place for the work; the operation is rather a tedious one where large quantities are required, as each tuber has to be divided singly by the hand; the "sets," however, may remain for a week or two without suffering injury, which gives an opportunity for profitably occupying any wet day that may occur with the work. In the division of the tuber the cut surfaces are apt to "bleed," and if thrown carelessly into a heap, and left for



1. Rose End. 2. Centre. 3. Heel End.

a few days, the exuded moisture causes the mass to heat, to the great injury of the germinating powers of the "sets." This may be readily avoided by dipping the incised surfaces into lime, chalk, or gypsum, which, uniting with the moisture from the divided cells, forms a coat on the surface, and thus prevents further loss by bleeding or evaporation. The latter (gypsum) is the best substance to use, as it is more effective for the immediate purpose for which it is intended, while at the same time it supplies, as far as it goes, an important manurial substance to the growing plant.

Where whole tubers are used in planting, the small ones are usually picked out of the heap and laid aside for this purpose. These are generally known by the name of "chats," and as they are not very saleable in the markets, they are thus rendered available for seed purposes. In this case, the tuber, small though it be, may possess as many germs or "eyes" as the large, fully-matured tuber used for dividing into "sets," and consequently will produce as many young plants. But here the great difference arises between their relative powers of reproduction. The young plant lives upon its parent until its own powers of supply are sufficiently established to enable it to send down its roots into the soil in search of inorganic substances, and to rear its stem and leaves above the ground in quest of organic materials of support. In the small, immature tuber, planted whole and throwing up several thin and sickly stems, it is obvious that the supplies of food-materials must be greatly inferior to those of the well-developed and well-matured tuber, which, being divided into "sets," planted separately, secures also to its young plants a greater range, both below and above the soil, for carrying on its after processes of growth. Indeed, so important is it for the health and vigorous development of the crop that the plants should not be too closely placed on the ground, that, even where whole tubers are used, it would generally add greatly to their produce were directions given at the time of hand-hoeing the drills to cut out the surplus plants, and only allow a single stem, or at the utmost two, to remain attached to each plant. The principles involved in the reproduction of plants have been already discussed at p. 21, vol. i., and although the potato is not exactly reproduced from the seed, still its mode of propagation is sufficiently analogous to be influenced by the same causes as therein described.

The quantities used per acre for planting vary much in different districts, both when used whole or in "sets." Probably about 8 to 12 cwts. may be taken as the average for the former, and from 6 to 9 cwts. for the latter mode of planting. We have no well-authenticated field experiments recorded in reference to the comparative production of the two methods. In some experiments on a small scale, and with another object (see p. 540, vol. i.), the produce of the divided tubers greatly exceeded that of the small tubers planted whole.

Many growers are of opinion that the unripe tuber produces stronger plants than the fully-matured, owing probably to the proportion of starch being less, and that of the inorganic substances relatively greater, than at a later period of its growth.

It has been noticed also that those potatoes which grow nearest to the surface, especially such as have been partially exposed, and have obtained a greenish brown appearance on the skin, always produce the healthiest and best plants. Acting upon this observation, it is a practice, especially with gardeners, to expose the tubers intended for planting to the action of the sun and the air for some time, in order to produce the same effect on the potato, as when it was attached to its parent stem, was seen to be of advantage to its reproductive powers. This practice can hardly be carried out on a large scale for field purposes; a week or two's exposure, however, on the ground, at the time of lifting the crop, in the manner described at p. 436, vol. i., would no doubt be of great advantage, by reducing the chances of injury they sustain in the heap, and thus keep them in a better condition for sowing in the spring.

A difference also has been observed in the germinating powers of "sets" cut from different parts of the tuber; that those taken from the "rose end," or upper part (see *woodcut*), produce more vigorous plants, and ripen earlier than those taken either from the centre or from the opposite extremity, or "heel," as it is commonly termed. These points, which have some practical importance, are quite consistent with the chemical constitution of the potato,[1] and help to strengthen the claims which science has upon all engaged

[1] Dr. Fromberg's investigations tended to show that the part from which the shoots are most abundantly produced contains more moisture than the opposite end, and that the proportion of inorganic matter also is greatest in the rose end, and continues so during the successive periods of growth. The following data bearing upon and confirming these points, are extracted from the results of his numerous analyses:—

	Water.		Inorganic Matter.	
	Rose End.	Heel.	Rose End.	Heel.
Forfarshire Buffs,...........................	66·50	63·38	1·55	1·16
Lothian Buffs,................................	82·88	80·15	1·29	1·10
Orkney Reds,.................................	61·92	61·21	1·94	1·60
Americans,....................................	78·74	78·71	1·01	·83

in farming pursuits, by giving them a solution of many apparently mysterious circumstances connected with their daily avocations. Now, to an observant man, this identified difference may be made serviceable in this way: with one tuber he has the means of raising three distinct plants —from the "rose end," from the "centre," and from the "heel sets"—each of which will come to maturity at a different period, the produce of the "set" from the "rose end" coming forward first, that of the centre being the next, while the "set" cut from the "heel end" will require some two or three weeks longer before it is ready for harvesting. In cutting the "sets," for planting in districts where it is important that the crop should come to maturity at a given time, this lower portion should be separated from the others, and thrown aside for feeding purposes, only the upper and centre portions being retained for use as seed.

The operation of planting, depositing the tubers or sets in the ground, is usually performed by the hand, immediately following the distribution of manure in the furrows of the first ridging, the sets being placed on the manure, and the moulding ploughs following up, splitting the ridges, and covering in the manure and the sets at the same time. For ordinary purposes, about 3 inches is the best depth for the sets; for winter planting they ought to be covered by 6 inches of soil. The distance between the ridges should not be less than 27 inches, which, for the reasons given at page 224, is perhaps the most convenient width. The "sets" or tubers should be deposited at about 12 to 15 inch distances apart in the drill,[1] and if directions be given to lay them with the "eyes" or germ downwards, they are placed under better conditions for propagating

[1] It is always bad economy to cover the ground too closely with cultivated plants. A good potato in a good soil should have at least 4 square feet of surface to itself. Some sets were planted at 5 feet distances, three of which produced respectively 16 lbs., 11 lbs., and 10½ lbs.; and twenty-six others gave a yield of 227 lbs. of tubers.—*Agri. Gaz.*, 1857, p. 582.

strong and vigorous plants than if they had been placed carelessly in the soil. On examining a sprouting "set," it will be seen that the young stem and the roots proceed from the same point (the germ). If this be placed uppermost the young roots have to find their way over the mass before they can reach the soil in which their special functions are to be exercised, while the stem is pushing its way unimpeded upwards to the surface. Now, as it is far more important that the root-development should be first secured, and should precede that of the stem, it is better to place the germ in that position which will secure to the roots immediate access to the soil, and leave the young stem to find its way to the surface as it best can. It may be a day or two longer in making its appearance above the ground, but it will be a stouter and more vigorous plant, and generally give a better produce than if these little matters in planting had been neglected. Where the manure has been applied in the autumn, the land is merely laid up in ridges at the required distances apart, and the sets or tubers are dibbled in by the hand, and deposited at a depth of about 3 inches from the surface. Machines have also been constructed for this purpose. Their principle of action is very similar to that of the ordinary sowing machines, but the irregularity of shape and of size of the "sets" presents greater difficulties than the seed-depositing machines have to encounter.

As soon as the young plants are first perceived breaking through the surface, it is a good practice to run a light set of harrows, the seed-harrows for instance, along the drills; this assists their growth very much, especially if the surface has been battered down by rain and wind since the planting. As soon as they have advanced a little in growth, and are about 6 inches high, the horse-hoes should be sent in between the rows the first favourable opportunity, and the ground well stirred and cleaned. These should be followed, as soon as may be convenient, by hand-hoeing between the plants in the line of drill; another turn of the horse-hoe will generally be desirable as the plants advance in growth, after which the moulding-plough should be sent in between the rows, and the soil again thrown up round the plants, to replace that which has been cut away by the horse and hand hoes. The stems should be moulded up to the first leaves, and they then may be left without any further tillage until the time for harvesting them arrives.

When the time of flowering arrives, which is generally about the month of July, according to the variety in cultivation, a practice has been recommended by some growers, who consider it of advantage to the future produce of the crop to pluck off the flowers as they are formed, and thus prevent the formation of fruit, which allows the whole productive powers of the plant to be exhausted in the development of its more valuable tubers. This practice, which is quite consistent with the theory of vegetable development, was first made known by Mr. Knight, who found it to produce an average increase of about 1 ton per acre to the crop. It has often been tried, but apparently with various degrees of success, as the practice is never seen in practical operation, except in isolated cases, and then only to a limited extent. It is, however, an experiment so readily and so cheaply tried, that it ought to be tested on a scale sufficiently large to enable us to accept the results as sound and reliable evidence, whether of its success or of its failure. In such case, the flowers ought to be carefully nipped off as soon as the petals begin to expand, which a child can easily perform at the rate of about 2 acres per day. In trying the experiment, alternate rows in the same field should be selected for picking; these rows would probably require to be gone through twice, so that the later buds might not be passed over. The cost of the experiment could therefore not exceed 1*s.* 6*d.* per acre, which would be repaid by a very small increase in the crop. As the flowers fade away they are succeeded by round, fleshy seed-pods, usually termed potato apples, the growth of which may be taken as good indications of the growth of the tubers beneath the surface. Until these make their appearance, there are no tubers fit for use in the ground.

When these are fully developed, the tubers are sufficiently large and ripe for table consumption; for storing and keeping purposes, however, they require to be perfectly matured, and must remain some time longer in the ground. The indications of full maturity are afforded by the condition of the stem and leaves, which begin to change their colour, and then to wither, and if left, to decay. When these signs are given, the sooner the crop is removed from the ground the better. The operation of "lifting" them is carried out in several different ways in different districts. Probably the most common is that with the heavy and cumbrous potato-fork (for which the new light steel fork is an excellent substitute). This mode of lifting them, when properly carried out, is very efficient, especially on soils or in seasons where the plough could not be advantageously used; it, however, involves a great cost for labour, and the work is proportionately slow; and we well know that time in all our harvest operations is an important element for consideration. In the potato-growing districts, where an advanced system of farming is generally to be seen, the plough is made use of for this purpose, the well-directed labour of a pair of horses being a far more expeditious, and, at the same time, economical source of power, than that of the labourer with his clumsy fork. Where the cultivation is small, the ordinary plough is frequently made use of, the coulter and share are removed, the sock lifting the tubers from their bed, and the mouldboard turning them out upon the surface. If the common plough be used, it requires to be held considerably on one side of the row of plants, otherwise it must return down the drill to throw out the tubers on the other (land) side. The work, however, may be effected by the double mouldboard plough at one operation, which, passing down the centre, opens up the row equally, and throws out the tubers of both sides at the same time.

An improvement in the plough for potato lifting was devised some short time since by Mr. Lawson, of Elgin,[1] who substituted for the ordinary shaped mouldboard a set of six iron bars, joined together in the form of a gridiron or "brander," and of the same size as the mouldboard. This skeleton mouldboard, when the plough is in motion, allows the soil to pass partly through it, instead of being all turned aside as by the ordinary mouldboard, and thus leaves the tubers uncovered and exposed at the side. This arrangement may be applied equally well to the double mouldboard plough as to the single. A machine, "Hanson's Potato-digger," has recently been introduced to public notice, for the express purpose of lifting the tubers from the soil. The working parts of the machine, which is carried on a pair of large wheels, with a small steerage pair in front, consist of a flat broad share, cutting below the soil horizontally, close above which a set of revolving forks, actuated by the driving-wheels, and working at right angles to the share, catch hold of and throw out the tubers with which they come in contact. A strong net is attached to the side of the machine to catch the tubers, which, falling to the ground, are left lying in a row, following the line of movement of the machine. The work performed has been considered highly satisfactory by those who have witnessed its operation in the field.

When the plough is used for turning out the potatoes, it should be followed closely by the harrows, for the pur-

[1] Drawing and description given in *Farm Implements and Machines*, p. 202.

pose of bringing them all up to the surface, where they may be collected by the workers—boys or girls—and either laid together in small heaps, preparatory to carting, or weighed at once in sacks, and thus made ready for the market. Should any have remained covered up in the soil, a light turn with the grubber across the field will generally effectually clear it of the crop.

It is most important that suitable weather should be selected for this operation. A few days' delay is of no consequence in comparison with the chances of injury to the land and to the crop, by getting it up in bad condition. If the weather or the soil be wet, the land is sure to suffer some injury from being moved and trampled on during the work, and the tubers never keep so well. In dry weather, the stirring of the soil in lifting the crop is beneficial to it, and the tubers speedily get into a proper state for storing. In all cases it is desirable to expose them for a few days on the ground previous to storing, in order that they may get thoroughly dry, and pass through their heating process (p. 436, vol. i.) previous to being closed up in the heap or "clamp." This heating process is greatly influenced by the condition of growth of the potato at the period of lifting. If fully matured, the change it undergoes is far less than if not quite ripe, and its keeping property is less likely to be disturbed. Potatoes being of a smaller size than either turnips or mangolds, they pack closer, and ventilation is less easily secured; therefore, they should always be placed in smaller heaps when exposed on the field, and then covered over with their tops or "shaws," so as to protect them as much as possible from the weather. This covering may be removed in the day, and again put on in the evening, taking especial care that they are not exposed to the action of *frost*, which would at once injure them, so as to render them unfit for keeping.

The potato being a more valuable crop than the ordinary root crops of the farm, should receive even more attention in storing than is bestowed upon them. Indeed, it is advisable to go carefully over all the potatoes at the time of storing, and to take out all that exhibit any appearance of disease; these should be pitted by themselves, or kept apart in a dry place for current use. The small-sized tubers should at the same time be separated, as being generally immature; they are more liable to heat and injure the mass; while, owing to their smaller size, they pack up the interstices, and obstruct the ventilation so necessary for the healthy state of the heap. The composition of the potato, containing as it does a large percentage of starch, and a comparatively small percentage of water (see page 68), would indicate that it possesses in itself keeping properties superior to those of the root crops, and probably this would be found practically to be the case, were they both constituted alike. The carrot or mangold possesses only a single germ; whereas, in the potato tuber, some four, or five, or six are frequently found, and as each of these becomes at the proper season a centre of disturbance, the condition of the potato, notwithstanding its more stable composition, is more influenced by storing beyond a certain time, than either of the roots referred to. Another matter, too, that no doubt of late years has exercised a great bearing upon the keeping properties of the potato, is the disease by which it has been so seriously injured; and as it is generally supposed that most if not all of our tubers are more or less affected by it, it becomes a matter of vital importance to the potato that we should secure to it such conditions in the store-heap as would arrest rather than develope any germs of disease that might naturally exist in its tissues. The two most important points to secure this desirable end are dryness and ventilation, and these are attainable by the same method of arranging the heap as that described at p. 441, vol. i. Owing to the comparatively small size of potatoes, however, and the consequent difficulty of ventilation, the heap should not be so large as that recommended for root crops, and should be made without the side hurdles at all, and built up at an angle of not less than 45°. A six-foot hurdle, by a depth at the centre of $4\frac{1}{4}$ feet, then laid on each side, and meeting at the top, would cover a space of about $8\frac{1}{2}$ feet in width. If the heap were built up at an angle of 60°, the height would be proportionably more and the width less; the contents of the heap would also be diminished. A dry and well-drained spot should be selected for the heap—a bottom 1 or 2 inches deep of hedge-row trimmings, or any other dry stuff, given if possible. The thatch should be laid on the hurdles sufficiently thick to keep out the weather—frost as well as rain; and a small trench, a few inches deep, and about a foot wide, dug all round it, the soil taken out being laid up against the ends of the thatch, so as to close it well down on the ground. If the potatoes have been exposed for a few days on the ground, and are in good dry condition at the time of storing, they will generally keep sound and good while they remain in the heap thus arranged; whereas, under the ordinary methods of storing—taking them fresh from the field, and placing them in heaps, frequently made in a trench below the surface, and covered up with the removed soil—the ventilation is greatly checked, if not entirely arrested, moist atmosphere, so favourable to fermentation and putrefaction, is secured, and the mass, if in an incipient state of unsoundness when stored, is sure speedily to become worse, and loss and disappointment ensue.

Notwithstanding the great susceptibility of disease in the potato, and the great losses which occur every year in the store-heaps or "pits," no more attention seems to be paid to the methods of arranging them than existed before the disease visited our crops. The conditions under which potatoes are commonly stored are frequently quite sufficient to induce putrefactive fermentation, even in sound roots; and when we come to consider that the potato possesses several germs, and consequently several centres of action, and that its tissues, being predisposed to disease, present less resistance to a change in their structure than would be met with in sound tissues, we ought to secure to them every condition that either science or practice has shown to conduce to the health and well-being of their mass. If these were better understood and better carried out than they are now, the losses sustained after the crop is harvested and stored, would be very considerably diminished.

A peculiar mode of planting potatoes is still to be seen practised in some places, especially in Ireland, and also on the Continent, which has received the name of the "lazy-bed" system. It consists in forming beds of soil, a few feet in width, with intervening spaces or trenches. These beds being well dug up, and the manure spread over their surface, the potato sets are laid on the top of the dung, and the soil obtained from the trenches thrown over them, so as to cover up about 4 to 6 inches deep. This mode of planting can only be admitted in districts or countries where spade husbandry is carried out, and the ordinary mechanical operations of tillage are unknown; or in marshy or boggy soils, where the plough could not act; or in soils of a peaty character, brought under cultivation for the first time.

In some districts, especially in the neighbourhood of; or where facilities of transport exist to good markets of consumption, the cultivation of potatoes forms the prominent crop of the farming, the grain crops even being merely of subsidiary importance. "On the early friable loams in the neighbourhood of Ormskirk and along the banks of the

Mersey, Mr. Caird tells us,[1] two crops of potatoes are sometimes got the same year. For the earliest crop, the seed is prepared about the beginning of the year, by being sprouted under cover, and planted out into beds as soon as the weather admits. The land is very heavily manured, and great care is taken to preserve the young shoots unbroken. The second crop, the seed having undergone the same preparation, is planted as soon as the first is removed. But the more common custom is to transplant Swedes after the first crop of early potatoes, and very excellent crops are "occasionally obtained in this way." On the "warp" soils of the Humber, near Goole and Selby, the same system of double crops may be seen carried out on the richer qualities of land; while on others, where the command of manure is favourable, they are frequently grown in succession, year after year, in the same field, or alternately with oats or wheat, as may be most suitable for the soil. In some places—in Wallasey, Morton, and Bidstone (Cheshire) Mr. Caird tells us that he found the small farmers growing early potatoes for the Liverpool markets. The ash-leaved kidney, previously sprouted 3 inches or so, was dibbled in upon a well-dunged bed in January, and covered with about an inch of soil; the ground was then covered with straw about 18 inches in depth, which was taken off in fine days, and put on again at night. By these means early potatoes have been sent to market by April 12th. This method of cultivation, though carried on in the field, is more the operation of market gardening than of farming. The portion of land under such cultivation rarely exceeds an acre, and the prices obtained for the produce, from 1*s.* to 2*s.* 6*d.* per lb. in a good season, make the money returns per acre very satisfactory.

The potato, although long known to be subject to certain *diseases* during its growth, was usually looked upon

[1] *English Agriculture*, p. 271.

as one of the healthiest of our "Farm Crops," the injuries, though noticeable more or less in different districts every year, being too slight to influence practically its produce in the field. In 1845, however, this idea of its natural health and freedom from injury was dispelled by the appearance of a disease of a peculiar character, differing materially from those previously known, and which spread itself far and wide over the country, leaving scarcely a single field without sad evidences of its visitation. From the virulence and prevalence of this attack, it was regarded as a murrain, and received the name of "the potato disease," by which it is best known even at the present time.

The effect of this disease is too well known, and its *cause* too little known—notwithstanding the investigations of scientific, and the opinions of practical men—to justify any lengthened remarks here: all we shall attempt will be to sum up the results of these investigations and speculations, and see how far any deductions may be drawn from them that may be made practically available in the field. Before we attempt this it will be well to give a passing notice of the other forms of disease, such as "the curl," "the scab," and "the dry rot," to which the potato crop has been for a long time past more or less subject. The "curl" is a diseased condition of the stem, first exhibited in the leaves, which, though in appearance green and juicy in their centres, become curled and twisted at their edges. This is more frequently met with in some varieties than in others; and it is also more prevalent in the northern than in the southern parts of the country. Martius, in his treatise on the "Diseases of the Potato," thus describes it:—"The curl is an imperfect formation. Soon after their first appearance the shoots become curled, and make but little progress afterwards; sometimes, indeed, they disappear altogether. Some, however, remain nearly stationary—either not producing blossoms at all, or only very weak ones, which soon fall off and yield no seed. They produce no tubers, or only a few minute ones, which are hard and unfit for food. These, however, when set, do not always produce plants infected with disease." Our own high authority on vegetable pathology, the Rev. M. J. Berkeley, tells us that the contraction of the leaves is probably caused by the parenchyma (fleshy part) of the centre of the leaf being multiplied, while that towards the margin remains stationary: this would at once cause that peculiar appearance at their edges from which the name "curl" has been applied to the disease. The opinions expressed in reference to the cause of the disease are various, and differ widely from each other, some attributing it to the use of over-ripe "sets," others, again, to the use of "sets" not fully matured. Some consider poverty of the soil as the determining influence, while the general high condition of our potato land is by others considered as conducive to the disease. The disease appears clearly to be a case of hypertrophy (or excess of nutriment); and if so, it is not difficult to understand why sets fully matured, and abundant in natural nutriment, should, when planted in a richly manured soil, give rise to such an excess in development of fleshy tissues as to hinder the proper expansion of the plant. It would therefore appear advisable to follow the recommendation given at p. 525, vol. i., and use "sets" that are not fully mature, or that have been greened by exposure to the light before planting. In all cases it is advisable to avoid the use of "sets" the produce of plants in which the particular disease, even in its mildest form, had been observed.

The "dry rot" has been more noticed in the potato crops of the Continent than in this country. It has been specially studied by Martius, who describes it as being "characterized by a hardening of the tissues, which are completely gorged with mycelium, which was often very closely compacted, and at length burst forth in the form of little white cushion-shaped tufts, loaded with fructification. Not only were the tissues themselves attacked, but even the starch granules were often covered with vegetation. The entire tuber became sometimes so hard as to make it difficult to break it even with repeated blows of a hammer." This form of disease exhibited itself some years before the "potato disease" was known. The "dry rot" was constantly accompanied by *Fusisporium solani*, to the presence of which Martius attributes the disease.

The "scab" affects the stem and the leaves, producing patches of a brown colour, which become larger as the disease progresses, and thus exert a greater influence upon the health and vigorous development of the plant. This form of disease, which exhibits itself on the tubers, and lessens their value, however, is less injurious in its effects than the curl; and both, indeed, have of late years been well-nigh forgotten in the presence of the more serious injuries inflicted on our crops by the "potato disease." Probably no subject affecting inanimate nature has attracted such general attention to it by scientific as well as practical men all over Europe as this peculiar disease; and yet, notwithstanding all their researches, we know but very little more about it, or rather its cause, than we did at the time it first made its appearance in our fields. Its effects, however, have been more satisfactorily observed; and far less difference of opinion exists on that head than still exists as to the part of the plant on which the disease first manifests itself. Even now, if the question be asked, some will reply that the leaves are first affected, some that the stem exhibits the well-known patches of decay, while others, again, trace its source to the "set" or seed-tuber itself, whence it ascends to both the stem and the leaves. The general opinion of those qualified to give one, appears to be that the disease first exhibits itself in the stem and leaves, and thence descends to the tubers; in all cases it is accompanied by a peculiar parasitic fungus—the *Botrytis infestans*—which, under certain conditions of the atmosphere, frequently spreads it rapidly over the stem and leaves, and induces a rapid decay. On examining a tuber from the decayed stem, a discoloration of its tissues will be noticed; and if the disease is far advanced, they will have become so far disorganized as to have lost their normal form and assumed a pulpy condition, emitting an ammoniacal odour, more or less strong and fetid. The portion of the tuber thus affected is of course unfit for food; if the sound parts be not at once separated they become rapidly inoculated, and the whole is lost.

The disease has generally been noticed as making its appearance in the first or second week in August; and Mr. Berkeley tells us that "if we then carefully examine the crop, we may find some of the plants with small brown patches on their leaves and stem, surrounded by a paler ring, the whole of which is frosted with *Botrytes*. If the weather be dry the progress of the disease is very slow; but if a moist, warm day intervene, an accurate observation of the same speck, at different times even of the same day, will show that the mould spreads with great rapidity, destroying all before it, or converting the green cells into brown. The separate spots soon become confluent, the evil extends to the stems, and, if the weather be favourable to its progress, in a few days the whole becomes corrupt and putrid." At this period of the season the electric condition of the atmosphere is frequently in a disturbed state, and we have thunder-storms, accompanied by heat and heavy rains. These conditions are eminently favourable to the development and spread of the disease, and have given rise to a very general, though at the same time very erroneous opinion, that electricity is the actual cause of it. In regard to the remedies recommended, the old proverb, *Quot homines, tot sententiæ,* has been fully verified. There has been no lack of remedies offered, but no cure effected. If we incline to the belief that the disease first exists in the above-ground stem, and thence is transmitted more or less quickly to the tubers below, the most rational treatment appears to be to separate the two parts, as speedily as possible after any indications of the disease have been observed, by pulling the stems up, and either leaving the tubers in the soil, or removing them, as may be most convenient. In pulling them the labourer should be directed to stand over the plant, and place a foot on each side of it, so as to separate and effectually to pull up every portion of the stem, without disturbing the position of the tubers. In this case, of course, the growth of the tubers is entirely arrested, but, if not previously infected, they will remain sound and good in their immature state.

If the seeds of the disease be supposed to exist in the tuber, and to be carried up from it to the stem in the ascending sap, the only remedial measures that can be administered must be at the period of sowing or planting, as any after treatment can be of no avail. The use of sulphur, which has been found so efficient in arresting the progress of the grape fungus, has been recommended, both abroad and at home, as a remedy against the potato fungus, when applied to the "sets" at the time of planting. If carefully managed, the moisture of the incised surfaces of the sets will cause a coat of sulphur to adhere to them; a little more dusted over the other portions will be sufficient. In an experimental trial[1] (1857), the results obtained were more favourable to

[1] "As the experiment was strictly comparative, the results may afford evidence of some value beyond the mere question of sulphur application. From a heap of 'Regents,' a certain quantity of small-sized potatoes (chats), such as are usually sold for planting, and also of full-sized mature tubers, were selected, care being taken that they were all free apparently from disease. The small potatoes were planted whole, whereas the others were cut into sets, one portion of which was planted in that state, while to the other portion sulphur was applied, being carefully dusted over the whole surface. They

the general increased produce of the plant than they appear to have been in reference to the prevention of the disease. It has also been recommended[1] to dry the potatoes intended for seed purposes at a high temperature; and it has also been recommended to cut them into sets at the time of lifting, and to dry them thoroughly by exposure to cold currents of air. In either case, the abstraction of moisture from the tuber would probably aid in arresting the progress of the disease; and if the temperature were carried sufficiently high (as its author, indeed, recommended), the vitality of the germs of the disease might be destroyed, at the risk, however, of the potato germ being placed in the same condition. The chemists show us by their analyses that the changes induced by the disease are clearly refer-

were planted on the 9th of April in three divisions—the chats, the cut sets *plain*, and the cut sets *sulphured*; the rows were 24 inches apart, and the plants set at 9-inch distances in the drill. On the 28th of August they were lifted, the gross produce of each division weighed, and then the proportion of sound and diseased tubers carefully ascertained. Of the whole potatoes (No. 1) 11 lbs. were planted in a single row, which produced 54 lbs. in all, 27½ lbs. of good, and 26½ lbs. of diseased tubers. Of lot No. 2 (*cut sets plain*), 20 lbs. were planted in three rows, the produce of which was 177½ lbs. in all—103½ lbs. of good, and 74 lbs. of bad. Of lot No. 3 (*cut sets sulphured*), 20 lbs. were planted in three rows, which produced 260½ lbs. in all—138 lbs. of good, and 122½ lbs. of diseased tubers. These results, therefore, give us in round numbers a gross return of five to one on the seed where *whole* tubers were used, or as the proportion of good to bad potatoes was equal, a return of 2½ lbs. of sound tubers for each pound planted. Where *plain* cut sets were used we see a great increase, the gross return being as nine to one on the seed used; and as the proportion of good to bad is as four to three, we have a return of 5½ lbs. of sound potatoes for each pound planted. When to these cut sets *sulphur* was added we have a greater increase, the gross return being at thirteen to one on the seed used, while the proportion of good to bad being as seven to six, we have a return of nearly 7 lbs. of sound tubers for each pound used in planting. These results tend, I think, to show that it is better policy to use the fully developed and matured tuber, than to adopt the too common practice with farmers of planting the small undersized potatoes, for which they may not have so ready a sale. In the mere quantity of seed required, one-third was saved by using sets of matured tubers, while the addition of a small quantity of sulphur to the cut surfaces of the sets appears to have added still more to their beneficial returns."—*Agri. Gaz.* for 1857, p. 679.

[1] *Les Moyens de prévenir la Maladie des Pommes de Terre.* Par A. R. C. Bollman. St. Petersburg, 1853.

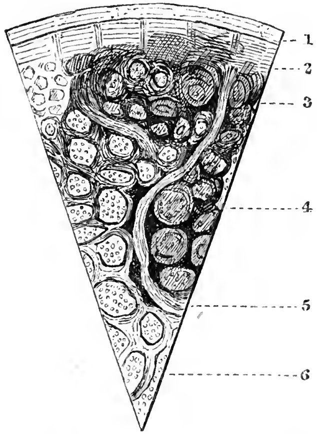
able to a putrefactive action, commencing with the organs, and not with the products of the plant affected. In an analysis of a diseased and of a sound tuber of the same crop, the following results were obtained:[1]—

	Sound Tuber.	Diseased Tuber.
Water,	75·21	78·61
Starch,	15·92	16·01
Sugar,	·67	...
Colouring matter, resin, &c.,	1·02	·62
Gum,	1·25	1·17
Nitrogen compounds (albumen, gluten, &c.),	2·34	·32
Ligneous fibre,	1·24	1·02
Ash (mineral matter),	2·35	2·15
	100·000	99·90

Although, from the proportions of starch remaining unchanged, the disease was probably not far advanced in the tuber examined, still we see that a great change had already taken place in its structural arrangement, by the disappearance of the proximate nitrogen compounds, which form a principal ingredient in its organs and juices. These compounds containing nitrogen, being of a more complex composition than starch is, enter far more readily into fermentation and decomposition when placed under favourable circumstances; and this tendency to change, if unchecked, communicates itself to all the other parts of the potato—the starch included—with which it is placed in contact. As long, however, as the starch remains unchanged the potato is more or less fit for use as an article of food, and but little injured for the purposes of the starch manufacturer. But directly a change commences in the starch granules themselves (*see woodcut*), its value is greatly deteriorated for both purposes, and unless utilized immediately, it speedily becomes reduced to a pulpy and offensive mass. If test-

[1] Prize Essay "On the Nature and Cause of the Potato Disease," by G. Phillips.—*Roy. Agri. Soc. Jour.*, vol. vii. p. 300.

paper be applied to the juice of a sound potato, it will give a slight acid reaction; at the commencement of disease this disappears, and the juice assumes a neutral character, which speedily changes as the disease progresses to an alkaline, accompanied by the well-known ammoniacal odour of decaying tissues. This change in the condition of the tuber resembles that described at p. 445, vol. i., in reference to the peculiar form of disease noticed in the mangold crop, and arises from the nitrogenized portions first undergoing decomposition, ammonia being always one of the first compounds formed. Without attempting any speculations as to the cause of the potato disease, its effects are too marked and too extensively known to allow us to disregard it; and we ought, all of us, to do our duty towards the community at large by taking such precautionary measures in its cultivation as common sense and past experience show us to be likely to check its ravages.[1] There can be little doubt that its existence is influenced greatly by the physical conditions surrounding it, whether in its early or its later development. We have been departing, for



Transverse Section of Diseased Tuber—largely magnified.
1. Bark. 2. Cuticle. 3. Reservoir of empty cells. 4. Diseased cells. 5. Channels leading to "germs," or "eyes." 6. Cells not diseased.

[1] In the *Cyclo. of Agri.*, Mr. Berkeley discusses the various phases and probable cause of the disease; and in the pages of the *Agri. Gaz.* may be seen, not only the results of the observations of many of our leading agriculturists at home. but digests of the more important speculations or theories that have emanated from the various scientific men—as, Schacht, Spierschnieder, Bollman, Schleiden, Mitscherlich, Payen, Decaisne, and others—who have investigated its effects on the potato crops of the Continent.

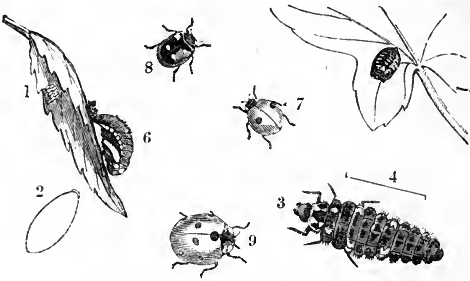
many years past, more and more from the natural conditions of its healthy growth; and it has paid the penalty of high cultivation by a debilitated constitution and a tendency to disease which in its normal state did not exist. Selected tubers, a deep dry soil, long intervals between the recurrence of the crop on the same ground, and the absence of rich stimulating manures, would no doubt do much towards restoring its general health and vigour, or, at all events, in arresting the further diminution of its powers; but then we should have to content ourselves with diminished returns; and, in the competition of our present production, there are few probably who will not think the remedy worse than the risk.

These same causes of deterioration are already affecting our regular root crops; our turnips have been visibly declining in general health and vigour for some few years past; and there is but little doubt our mangolds will in the course of time follow in the same way. These are both comparatively recent introductions to the potato. The great injury, however, has doubtless been inflicted during the last twenty or thirty years, when increased cultivation and production appear to have been accompanied by the anomalous conditions of increased neglect of the general laws and principles governing vegetable life, and of the natural habits and requirements of the plants we rely upon for our daily supplies of food. Attention to these is far more important for the prevention of diseases than any remedies that may be devised for their cure. We have ample evidence of this throughout the whole kingdom of organic nature; and we can adduce no more prominent instance of its truth and force than is seen in the potato and the disease now affecting it.

The number of *insects* known to us as infesting and more or less injuring the potato crop, is fully as large as that met with in either the wheat or the turnip crops. At the same time we must admit that their ravages are not, in general, in proportion to their numbers, neither is there any one that inflicts the same amount of injury on the potato as the "fly" does, for instance, on the turnip, and the aphis, or "black dolphin," on the bean crop. Curtis, in treating of these numerous enemies, divides them into those attacking the leaves and stems, and those attaching themselves to the tubers and roots. No sooner is the potato "set" planted in the ground than it collects round it all the wireworms in its vicinity, who at once take up their quarters on it, and live upon it as long as it lasts. If they injure the germ, the plant may never be able to push its head above the soil, or may only produce a weak, sickly shoot, owing to its stores of food being curtailed by their attacks. At a later period of the growth of the plant, when tubers are formed, these are frequently also punctured and injured by the different wireworms. When the young plant has made its appearance above the ground, various aphides, amongst which may be noticed the *Aphis rapæ* and the *A. vastator*, make their appearance upon the haulm, where they remain as long as the stem and leaves remain green and succulent. These insects puncture the leaves and live upon their juices, and when they take possession of them in such countless numbers as are seen in some seasons on the pea and bean crops (p. 234, vol. i.), considerable injuries ensue. On the potato, however, although they may nearly always be met with, they seem to inflict little or no practical injury. One noticeable feature in all the aphides is their enormous powers of increase; so that, where they are able to inflict an injury, it may under certain conditions, from their great numbers, be very serious. Curtis mentions,[1] as a proof of the great fecundity of these insects, that he put three from the potato crop into a quill, and in six hours they had produced forty-three young ones. For-

[1] *Farm Insects*, p. 429.

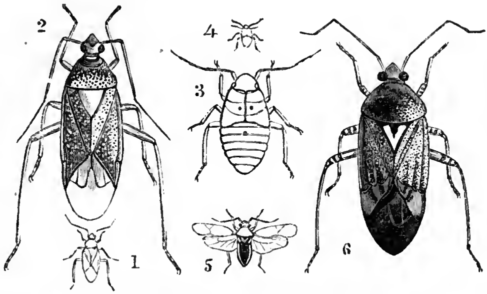
tunately there are several natural enemies, which keep the undue increase of the aphides in check. The common ladybirds (*Coccinella septem-punctata, C. dispar*) are the best known to us; these not only devour them, but lay their eggs on the same leaf, so that their little black larvæ,



1 and 2. Eggs of insect (natural size and magnified). 3 and 4. Larvæ. 5 and 6. Pupæ. 7. Double-spotted Ladybird (*C. bipunctata*). 8. *C. dispar*. 9. Large Ladybird (*C. septem-punctata*).

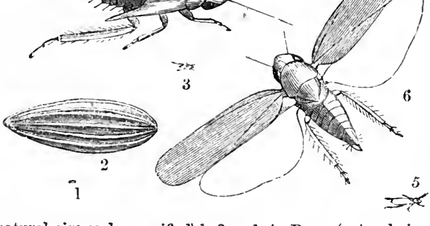
as soon as they are hatched, may find a supply of food at hand. Amongst other insects charged with injuring the potato, we find the *Thrips minutissima;* though frequently found on the stem, and known to support itself by suction, its numbers are never sufficient to affect the plant to any sensible degree. The "ground fleas," *Smynthurus solani,* and an allied genus called *Podura,* however, frequently injure the plant considerably by feeding on the pulp of the leaves. These are remarkably minute insects, not bigger than a small pin's head, and are nourished by eating the fleshy part of the leaves, thus materially interfering with their vital functions. In Nova Scotia these insects attack the cruciferous plants, whole crops of which have been swept away while in their seed-leaf by their attacks. These insects never appear on damp ground; a thin layer of sea-ware spread over the drills is sufficient to preserve them from a visit, or if salt is strewed on the surface it absorbs moisture, and thus keeps the soil damp enough to be distasteful to them. Various species of the

Cimicidæ, or "plant-bugs," with their larvæ and pupæ, have been noticed infesting the potato plants, and as these find a living upon the foliage by piercing the cuticle and feeding upon the juices, causing blotches on the leaves and a shrivelled appearance on the stem, there is no doubt their existence is accompanied by some injury to



1 and 2. Potato bug—*L. solani* (natural size and magnified). 3 and 4. Pupæ of do. (natural size and magnified). 5 and 6. *L. umbellatarum* (natural size and magnified).

the plant. Amongst these we find the *Lygus solani*, *L. contaminatus*, *L. bipunctatus*, and *L. umbellatarum*, all or some of which are to be met with on the potato throughout the country from May until the end of August or September. Equally, or even more abundant



1 and 2. Eggs (natural size and magnified).' 3 and 4. Pupæ (natural size and magnified 5 and 6. Frog-fly—*Eupteryx solani* (natural size and magnified).

than the plant-bugs, are the potato "frog-flies," *Eupteryx solani* and *E. picta*, who support themselves in the same way, at the expense of the juices of the plant. They are met with in abundance during the months of August and September, a dozen or more having been frequently found on a single leaf. In dull weather, Curtis says, they have a curious mode of evading notice, by sliding round to the underneath part of the leaf or the opposite side of the stem, but in bright, warm weather they leap and fly short distances.

Although the potato leaf is not so palatable as the cabbage or turnip leaves to caterpillars, there appear to be some two or three which find in it a source of food. One of these is the large caterpillar of the "death's-head moth," *Sphinx atropos*, which, in some places and in some seasons, is met with abundantly in the potato fields. The caterpillars live chiefly on potato leaves and flowers, but will also eat fuchsias, jasmines, and probably other plants. They are as big as the centre finger of a man's hand, coming out at night to satisfy their voracious appetites, and lying hidden at the bottom of the plant during the day. This caterpillar, which is the largest of all European species, has also received the name of "bee tiger-moth," from its propensity to enter bee-hives and make free with the honey. It is said by Reaumur[1] to be able to imitate the note of the queen bee, and thus gain admission to the hive, while its hirsute and thickly-covered horny case enables it to bid defiance to the sting of the bees. It is a very vigorous and powerful insect, and when kept in confinement will utter cries like the faint squeak of a mouse. The mode of depositing the eggs has not been ascertained. They are first seen in July, and these produce moths in September and October, while the later ones remain in the pupæ state during the winter, and do not appear as perfect insects until the following spring. These caterpillars are always accompanied by a

[1] *Histoire Nat. des Insectes*, vol. ii. p. 289.

parasitic ichneumon fly, the *Trogus atropos*, which, with untiring diligence, seeks them out, and puncturing their bodies, deposits its eggs within them. In due course these eggs undergo their appointed changes from larvæ to pupæ, and eventually, instead of the perfect moth, a parasitic fly emerges from the shell.

In some seasons great destruction has been committed by some of the surface grubs infesting our various crops; acres of potatoes have been destroyed by them. The stem is generally found either partially or wholly eaten through, just below the surface, and in many cases the tubers nearest the top have been also injured. The caterpillars, or grubs, of the "night-flying moths," *Agrotis segetum* and *A. exclamationis*, and also of the common "crane-flies" (see page 386, vol. i.), are always present on such occasions. The various insectivorous birds are our great protectors against this class of ravagers, whose work of destruction is always either on, or close to the surface of the ground. The "crane-flies" all delight in moisture, and draining no doubt has tended greatly to confine their range within certain particular districts. Wireworms (*Elateridæ*), millipedes (*Iulidæ*), and centipedes (*Scolopendræ*) are all met with in the soil, attacking the sound and the unsound tubers, from the time they are planted until the period for harvesting arrives. These, and their modes of injuring the crop, are all fully described by Curtis, Köllar, Westwood, and others.[1] Besides these there is a vast number of other insects infesting the tubers directly any disorganization takes place in their tissues, from direct injuries or from disease. Curtis sums up his account of them by telling us "that they amount to sixty or more, but probably that their name

[1] In the United States and in South America, the potato is subject to the attack of a peculiar weevil—the *Curculio trinotatus*—which lays its eggs on the leaves, the larvæ when hatched eating into the stem, and working downwards towards the root, causing the plant to wither and decay. In some seasons these insects have been very destructive to the crops.

would be 'legion' if we were thoroughly acquainted with all the species, in their different stages of development, preying upon this useful esculent; and although, in the foregoing statement, no attempt has been made to give undue importance to their agency, there can be no question that insects often injure the potato crops to a great amount."

The large consumption of the potato by the inhabitants of the different countries in the northern temperate zone as an article of food, and also for economic purposes, has caused its composition, organic as well as inorganic, to be well investigated by both our own and continental chemists. A wider difference in the results obtained is noticeable in reference to this than to any other of our "Farm Crops," due, probably, to the greater number of varieties of the potato in cultivation, and to the greater influences exerted upon them by the various soils and climates of the countries or districts in which they were grown. The proportions of stems to tubers are liable to great variation; on the average of a large number of trials, they may be taken at about two-fifths, or as 2 is to 5. The percentage of water contained in the tubers is influenced greatly by the state of maturity of the tuber at the time of examination, and also by the variety. Thus, in Dr. Fromberg's elaborate investigation of the composition of the potato,[1] the least ripe were found to contain 76 per cent. of water, while the ripest only contained 68 to 70 per cent. Again, the Irish Cup variety gave 74 per cent., while the "Buffs," grown under exactly similar conditions as to soil, treatment, &c., gave 77 per cent. The mean of fifty-one determinations in Professor Johnston's laboratory was 76 per cent.; the mean result of Körte's analyses of fifty-seven varieties was 75·1 per cent.; the average proportion of water, therefore, in ordinary samples of potatoes may be taken at about 75 per cent., or

[1] *High. Soc. Trans.*, 1847, p. 637.

three-fourths of their entire weight. In the stems a like variation in the proportion contained is seen; the average amount may be taken at 86 to 88 per cent. The percentage of ash or inorganic matter in the tubers varies from ·75 to 1·58; the mean of many determinations by Fromberg is ·87 per cent. In the tops or "shaws" the percentage averages about 2 per cent. The composition of this inorganic matter or ash is given as follows:—

	Tubers.[1]	Tubers.[2]	Shaws.[3]
Potash,	55·75	52·40	28·02
Soda,	1·86	3·88	16·26
Lime,	2·07	2·20	16·90
Magnesia,	5·28	3·85	7·09
Peroxide of Iron,	·52	·53	1·05
Phosphoric acid,	12·57	10·45	7·62
Sulphuric acid,	13·65	18·50	6·88
Silica,	4·23	2·35	3·85
Chlorine,	4·27	5·84	12·33
	100·00	100·00	100·00

Some more recent analyses of the inorganic matter of the potato tuber have been published, and are given in the table below. These differ from the foregoing principally in the absence of the silica and the chlorine, which

	1.	2.	3.	4.	5.
Potash,	53·476	54·166	55·610	55·734	53·029
Soda,	traces	traces	traces	traces	traces
Chloride of Sodium,	...	...	...	...	2·095
Carbonate of Magnesia,	3·530	0·273	1·257	2·565	·570
Phosphate of Magnesia,	9·247	12·298	7·550	3·545	7·643
Sulphate of Lime,	traces	traces	·125	traces	traces
Phosphate of Lime,	3·363	·683	3·835	5·374	2·856
Phosphate of Iron,	...	...	·062	...	...
Carbonic acid,	21·059	16·666	21·400	18·162	13·333
Sulphuric acid,	2·774	4·945	3·244	5·997	6·780
Phosphoric acid,	5·716	8·920	3·774	6·669	11·428
Silica,	...	...	·125	...	...
	100·000[4]	100·000	100·000	100·000	100·000
Percentage of Ash,	1·3029	1·0609	1·2709	1·0953	·8808

[1] Johnston, the mean of several. [2] Fromberg, do. [3] Thomas, do.

[4] Varieties analyzed:—1. White Apple; 2. Prince's Beauty; 3. Axbridge Kidney; 4. Magpie; 5. Forty-fold.

there occur in large proportions. They are by Mr. Thos. J. Herapath, and include five different varieties, all grown under exactly the same conditions of soil and climate.

If we take the foregoing analyses as the bases of our calculations, and assume that an average crop of potatoes consists of 8 tons of tubers and say 3 tons of tops, the former of which are removed from the field and the latter left on it, we should find that it had abstracted from the soil about 175 lbs. of mineral or inorganic matter, in about the following proportions:—

Potash,	90 lbs.
Soda,	8 ,,
Lime,	5 ,,
Magnesia,	8 ,,
Sulphuric acid,	34 ,,
Phosphoric acid,	20 ,,
Chlorine,	10 ,,
	175 ,,

The *organic* composition of the potato is that, however, in which we are more directly interested, as upon that depends the value of the tubers to us, either as articles of food or for manufacturing purposes.

The potato contains water, albumen or caseine, starch, gum, sugar, fatty matters, fibre, and certain inorganic or mineral matters which have just been described; and the proportions of all these several substances vary greatly with the different varieties and the different conditions as to soil and climate under which they are grown. We have, however, enough evidence, deduced from the great number of analyses that are before us, to assign something like an *average* composition for the potato, which may be given as follows:—

Water,	about	75·00
Nitrogen compounds (as albumen, &c.),	,,	2·00
Starch,	,,	15·00
Gum and sugar,	,,	1·75
Fatty matters,	,,	·25
Fibre,	,,	5·00
Ash,	,,	1·00
		100·00

Arranging these several compounds in the manner already adopted with the other crops, they would stand thus:—

Compounds containing nitrogen (flesh-formers),		2·00[1]
Compounds not containing nitrogen (heat-givers and fat-formers),	as starch,	15·00
,, ,,	gum, sugar, fat, &c.,	2·00
,, ,,	fibre,	5·00
Ash (mineral matters),		1·00
Water,		75·00
		100·00

The proportion of nitrogen compounds present would indicate rather a low feeding value to the potato, not superior, indeed, to that of the turnip or mangold, were it not for the large proportion of starch present, in addition to the other carbonaceous compounds, as gum, sugar, &c. These make up the proportion of its solid constituents to about 25 per cent., or about double that of the roots referred to.

For all purposes of consumption, however, whether as food or for economic use, the starch is the compound of most importance to us, and upon the proportion of this substance contained in the tuber we are accustomed to base our estimate of its value.

In this we find great variations exist, for instance—

New Potatoes.	contained	5·53	per cent.[2]
South Americans,	,,	8·14	,,
Ash-leaved Kidneys,	,,	9·52	,,
Red Dons,	,,	10·75	,,
White—East Lothian,	,,	12·24	,,
Red—Ayrshire,	,,	13·08	,,
Red—Lanark,	,,	14·08	,,
Cups—Argyleshire,	,,	15·14	,,
Red—Perthshire,	,,	16·53	,,
Orkney Potatoes,	,,	17·42	,,
Cups—(unknown),	,,	18·94	,,
Buffs—Forfarshire,	,,	20·71	,,
Canadians,	,,	20·92	,,
Cups—Mid-Lothian,	,,	23·82	,,

[1] Johnston gives 1·41 per cent. as the mean of several analyses, Horsford and Krocker give 2·43 per cent. as the mean proportion of nitrogen compounds.

[2] "Chemical Investigation of the Potato," by Dr. Fromberg.—*High. Soc. Trans.*, 1847, p. 669.

The proportion of starch appears to increase in the growing plant until it reaches its maturity, after which, on being removed from the ground, it appears to decrease in the same regular proportion. Dr. Fromberg, on examining tubers of the same variety, found that the starch had increased from 16·73 to 21 per cent. in the two months immediately preceding its maturity; and Payen found that the same variety of potato contained in

October,	17·2	per cent. of starch.
November,	16·8	,,
December,	15·6	,,
January,	15·5	,,
February,	15·2	,,
March,	15·0	,,
April,	14·5	,,

Thus we see the proportion of starch varies with the age of the plant, and also with the period that it is kept after the maturity of the tubers; besides these, the soil and climate also exert influence upon it. In an experiment with the same varieties grown in different localities, it was found that

Buffs grown in	Forfarshire gave	20·71	per cent.
,,	Mid-Lothian ,,	14·89	,,
Cups grown in	Argyleshire gave	15·14	,,
,,	Mid-Lothian ,,	18·94 and 23·82	per cent.

Since the prevalence of the potato disease in this country, and, indeed, on the Continent, the attention of scientific and of practical men has been attracted to the best means of utilizing those tubers which are injured by the disease, and have become unfit for use as articles of food. In this country, the separation of their starch is the simple and only way of utilizing them. On the Continent, they continue the manufacturing process by converting the starch firstly into sugar, and subsequently into spirits. The first is only a mechanical process of separation; the potatoes are rasped down into a fine pulp, and the starch granules washed through sieves, the coarser portions of the cellular tissues, fibre, &c., remaining behind on the sieves, whence they are removed, and used either fresh, or pressed into a form of cake, as a feeding substance, chiefly for pigs. The starch is then allowed to subside, and the liquor decanted off, fresh water is given to it, until all the impurities are washed away, when it is dried and rendered a marketable article. As the disease frequently makes its appearance long before the crop has arrived at its maturity, it has often happened that the crop has been lifted at an early period of its growth, in order to secure as much of it as possible from further injury from the disease. In this case the yield of starch has exhibited a variation in accordance with the data already given. Thus a sack of potatoes (240 lbs.) averages, under ordinary circumstances, in

August,	about	23 to 25 lbs.	of starch.
September,	,,	32 to 38	,,
October,	,,	35 to 40	,,
November,	,,	38 to 45	,,
February,	,,	45 to 38	,,
March,	,,	38 to 28	,,
April,	,,	28 to 20	,,

On the Continent potatoes are largely used for brewing and distilling purposes,[1] the fermentative process being set up in the starch, by the addition of yeast, in the same manner as when barley or any other grain is used. In this process the entire potato is used very beneficially—the only obstacle to the operations being the formation of a compound of a most offensive character, known to chemists as "fusel-oil," which has to be separated from the spirits before they can be used for any purposes of consumption or manufacture.

The stems or "shaws" of the potato are invariably left on the field, and ploughed in when preparing for the following crop. Their inorganic composition has already

[1] By a return lately published, we find that in Prussia, for the year 1858-59, the number of distilleries in operation was no less than 1551; and that the potatoes used amounted to 3,418,584 scheffels, equal to 5,170,607 bushels.

been given; their organic composition has been examined by Boussingault, and given by him as under:—

	Fresh state.	Air-dried.
Nitrogen compounds (flesh-formers),	2·51	12·55
Compounds destitute of nitrogen (heat-givers, &c.),	11·96	59·85
Ash (mineral matter),	3·13	15·60
Water,	82·40	12·00
	100·00	100·00

Dr. Fromberg's analyses give a far lower estimate of the nitrogen and of the mineral constituents of the "shaws;" and as these have reference to potatoes grown in this country, while Boussingault's refer to the produce of the Continent, where the plant is less luxuriant and herbaceous in its habit than with us, it will be safer to take Dr. Fromberg's results in our estimates of their manurial value.

The results of these several analyses show us the probable average amount of substances abstracted from the soil during the growth of the crop, and the relative proportions carried off the farm by the tubers, or returned to it again by the stems or shaws. They also enable us to form a correct estimate of the real value of the crop to us as a source of food-supply, whether for ourselves or for our stock, and show us that although the potato ranks far below any of our usual bread-corns in its individual nutritive value, still, owing to its superior produce per acre, the aggregate amount of food produced is considerably in excess of that obtained from either of those crops. Thus a crop of wheat of 32 bushels to the acre, would contain of nitrogen compounds (at 12 per cent.), about 240 lbs., and of starch (at 55 per cent.), about 1350 lbs.; while a crop of potatoes, of 8 tons per acre, would contain of nitrogen compounds (calculated at 2 per cent.) about 358 lbs., and of starch, at an average of 15 per cent., about 2685 lbs.

THE

JERUSALEM ARTICHOKE CROP.

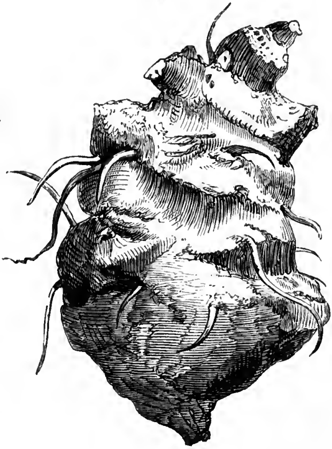
In this section of our "Farm Crops" we must include another tuberous-rooted plant, which, although well known in our gardens, is rarely or never seen as a distinct field crop in this country, while in the poor sandy districts of France and other parts of the Continent, it forms a very valuable and remunerative cultivation. This is the Jerusalem Artichoke—a plant belonging to an order (Compositæ) widely differing from those which we have already referred to, and of which this, and another sparingly cultivated crop, the "Chicory," are the only members which we admit into the list of our farm produce. The Jerusalem Artichoke labours under the misfortune of having a name which would lead one to expect an appearance and properties widely differing from what it really possesses. Though belonging to the same natural order as the common artichoke of the garden, it differs widely from it in every respect. The one is grown for the heads, which are eaten; in the other, the tubers are the only edible portions. Neither has the epithet "Jerusalem" any meaning, it being only a corruption of "girasole," the Italian name given to the sunflower (a closely allied species), from its supposed habit of turning round its flowering head, and following the daily course of the sun from east to west. The plant we have now to describe was introduced into this country early in the seventeenth century, and is generally said to be a native of the Brazils—a country from which we have derived many other of the plants belonging to this "order." Humboldt, however, states that he never met with it growing wild in any of the states of South America, and Correa denies its existence in the Brazils. The properties which the tubers have of resisting the cold, uninjured by our most severe winters, together with other botanical and geographical reasons, have led Brogniart to conclude that it must originally have proceeded from the more northern parts of Mexico. We find a description of it in Gerarde (ed. 1633), who speaks of it as a "wonderfull increasing plant," newly introduced from America and the West Indies. He says that in 1617 "I received two small roots thereof from Master Franqueuill, of London, no bigger than hen's egges. The one I planted, the other I gave to a friende; mine broughte mee a pecke of rootes, wherewith I stored Hampshire." In a drawing given, the plant is figured bearing flowers "about the size of large marigolds." The name given to it at first was *Aster peruvianus tuberosus.* In the early days of the potato, and, indeed, for some considerable period subsequently, this plant was held in higher estimation for the sake of its tubers and its ready method of reproduction, than it is at the present time. It was used largely as an esculent vegetable, having when cooked somewhat the flavour of the ordinary artichoke, from which circumstance it is supposed its present name originated. Although acclimatized by a cultivation of some two centuries to this country, it still gives evidence of its southern origin, by refusing to flower except in very favourable seasons, and then without ripening its seed.

The botanical name given to it is *Helianthus tuberosus*, or tuberous-rooted sunflower, which plant in appearance it greatly resembles. It is a perennial, growing, under favourable conditions of soil and climate, to the height of

8 or 10 feet, with a coarse, hairy, erect stem, surmounted (but very rarely in this country) by a small branching head with yellow flowers. Owing to the absence of seeds, it can only be propagated by its tubers, and these being, many of them, of small dimensions, and capable of remaining in the soil without injury during the most severe winters, are generally quite sufficient to keep the ground well stocked after the crop has been removed. The plant has the property of being able to grow productively in the poorest class of soils, and also under the shade of trees—two conditions of growth which are more or less fatal to most other plants.

Fig. 1.

Fig. 2.



There are two varieties known in our gardens, the Common Jerusalem artichoke (*fig.* 1), and the Yellow Jerusalem artichoke (*fig.* 2), the tubers of the latter being usually smaller and more irregular in shape than the other, and also said

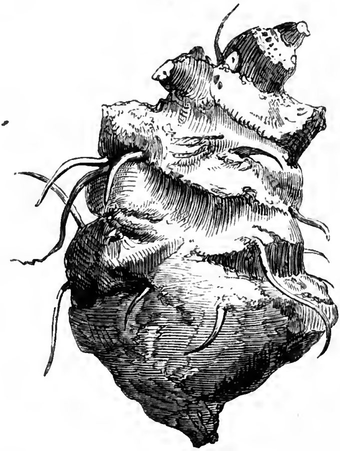
said to be a native of the Brazils—a country from which we have derived many other of the plants belonging to this "order." Humboldt, however, states that he never met with it growing wild in any of the states of South America, and Correa denies its existence in the Brazils. The properties which the tubers have of resisting the cold, uninjured by our most severe winters, together with other botanical and geographical reasons, have led Brogniart to conclude that it must originally have proceeded from the more northern parts of Mexico. We find a description of it in Gerarde (ed. 1633), who speaks of it as a "wonderfull increasing plant," newly introduced from America and the West Indies. He says that in 1617 "I received two small roots thereof from Master Franqueuill, of London, no bigger than hen's egges. The one I planted, the other I gave to a friende; mine broughte mee a pecke of rootes, wherewith I stored Hampshire." In a drawing given, the plant is figured bearing flowers "about the size of large marigolds." The name given to it at first was *Aster peruvianus tuberosus.* In the early days of the potato, and, indeed, for some considerable period subsequently, this plant was held in higher estimation for the sake of its tubers and its ready method of reproduction, than it is at the present time. It was used largely as an esculent vegetable, having when cooked somewhat the flavour of the ordinary artichoke, from which circumstance it is supposed its present name originated. Although acclimatized by a cultivation of some two centuries to this country, it still gives evidence of its southern origin, by refusing to flower except in very favourable seasons, and then without ripening its seed.

The botanical name given to it is *Helianthus tuberosus*, or tuberous-rooted sunflower, which plant in appearance it greatly resembles. It is a perennial, growing, under favourable conditions of soil and climate, to the height of

8 or 10 feet, with a coarse, hairy, erect stem, surmounted (but very rarely in this country) by a small branching head with yellow flowers. Owing to the absence of seeds, it can only be propagated by its tubers, and these being, many of them, of small dimensions, and capable of remaining in the soil without injury during the most severe winters, are generally quite sufficient to keep the ground well stocked after the crop has been removed. The plant has the property of being able to grow productively in the poorest class of soils, and also under the shade of trees—two conditions of growth which are more or less fatal to most other plants.

Fig. 1.

Fig. 2.



There are two varieties known in our gardens, the Common Jerusalem artichoke (*fig.* 1), and the Yellow Jerusalem artichoke (*fig.* 2), the tubers of the latter being usually smaller and more irregular in shape than the other, and also said labour they require until the time of harvesting arrives, when they are dug up with a fork in the usual manner. Owing to the erect and vigorous habit of growth of the plant, and the largely-developed stem and leaves which it carries, it is always good policy to give the plants full access to light and air, and this can only be secured by keeping them wide apart on the ground. Three feet distances each way would no doubt give a larger return per acre than when placed closer on the ground. The only attention they require during their growth is for the purpose of keeping the surface clean; one or two hoeings are generally sufficient, after which the plants cover the ground, and effectually keep down the growth of weeds. In subsequent years, when the ground is allowed to remain under the same crop, the young plants which spring up from the tubers left in the ground have to be set out by the hoe to the proper distances, after which a small double mouldboard plough is sent in between the rows, and the soil slightly moved and thrown up along the line of plants. At a later period the hoe is used to finish the work of cleaning, and nothing more is done until they are harvested.

In some districts, where forage is valuable, they are allowed to come up as thick as possible on the ground, and are cut down several times in the course of the season, and given in a green state to the cattle; in others, the plants are allowed to throw up a good tall stem before they are touched, and then the tops are cut off and used for the same purpose. In both cases, however, the practice must cause a decrease in the root produce, in proportion to the amount of injury inflicted on the growing plant. The question, therefore, lies between the respective values of the green or root produce to the individual cultivator. In some cases the forage produce may compensate for the loss of tubers; in others, again, the tubers may be the first consideration. The tubers may remain in the ground without any chance of injury until it is convenient to lift them; they may then be stored in the same manner as potatoes or any of our root crops. In this country no use is made of the stems or leaves; they are usually carted off in quantity to the courts or yards, where they make a good dry bottom for the litter, their fleshy stems absorbing a large quantity of the liquid secretions. On the Continent they are either cut down before they begin to wither and given to the cattle, or if not required for that purpose, they are treated in the same way as hemp or flax, and a coarse, tough fibre is obtained, which is available for rough cordage purposes.[1]

In the *Journal d' Agriculture Pratique* for April, 1858, M. Doniol, of Barliére (Haut Loire), gives the details of his cultivation of the Jerusalem artichoke on a poor—indeed, what he terms third-rate soil—for a continuous period of fifteen years. He makes no mention of the application of any manure during that period; his mode of disposing of the produce, however, would no doubt sustain at least the normal fertility of the soil. His practice has been to keep the plants as nearly as possible at 2½ feet distances apart, and to feed off the stems and leaves as they stood with sheep during the months of October and November. When the crop was cleared off, the tubers were taken up and supplied to the sheep either on the ground or in the stables—the difference in the value of the sheep which were bought in October and sold again in April, or when the produce was consumed, representing the money return of the crop. The details that are given refer to one piece of half an hectare (1¼ acre) in extent; from which it appears the produce was sufficient to keep eighty sheep, which being purchased in October at 20 francs per head, and sold out in April at 28 frs., gave a gross

[1] Schwerz estimates the produce of dried stalks at about 2 tons per acre.

return of 640 frs. From this M. Doniol deducts the outgoings for rent, taxes, labour, &c., which amounted to 280·75 frs., the balance, 359·25 frs., being the *net* profit on the half-hectare = £11, 10*s.* per acre. In all cases the tubers left in the ground were more than sufficient to secure a full plant for the succeeding year's crop. These surely are encouraging returns for soils such as M. Doniol describes his to be, and would show that we are negligent of our own interests in treating the plant with so little attention as we have hitherto done. There must be many persons having suitable pieces of ground in their occupation, frequently lying as waste places, or only occasionally tilled, which under cultivation with this crop would produce very remunerative returns.

The *diseases* to which the plant is subject cannot be of much importance, as no mention is made of them by the several authorities who have written about its cultivation. Its *chemistry*, however, has received some little attention; from which we find that the ash or mineral matter contained in the tuber amounts to 1·79 per cent., in the stem 1·94 per cent., and in the leaves 15· per cent.

The composition of the mineral matter of the root has been investigated by Boussingault, who gives it as follows:—

Potash,	54·67
Soda,	traces
Lime,	2·82
Magnesia,	2·21
Iron and Alumina,	6·39
Phosphoric acid,	13·27
Sulphuric acid,	2·70
Silica,	15·97
	98·03

Messrs. Way and Ogston included the Jerusalem artichoke in their analyses of the ashes of farm plants, and found that a ton of tubers removed from the soil the following quantities of mineral substances:—

Potash,	22·40	lbs.
Soda,	...	
Lime,	1·34	,,
Magnesia,	·52	,,
Peroxide of Iron,	·18	,,
Phosphoric acid,	6·81	,,
Sulphuric acid,	1·51	,,
Chloride of Potassium,	1·96	,,
Silica,	·61	,,
	35·33	,,

This would show that, weight for weight, the crop contains nearly four times as much phosphoric acid and three times as much potash as turnips, mangold, or carrots. The stems no doubt abstract a large proportion of potash also, which renders it the more remarkable that the crop can be cultivated remuneratively on the poorer class of soils, and that continuously, year after year, and without the addition of any large amount of manuring applications.

The organic composition of the tubers has been examined by Braconnot,[1] who found it to contain 14·80 per cent. of sugar (uncrystallizable), and by Payen, who found even a larger percentage of sugar. Boussingault has also investigated its composition (*Economie Rurale*, tome i. p. 413), which he found on the average to consist of—

Water,	76·3
Solid substances,	23·7
	100·0

These solid substances may be taken as follows:—

	Tubers.	Leaves.
Compounds containing nitrogen,	2·38	2·18
,, not containing nitrogen	19·99	82·48
Ash (mineral matter)	1·43	2·44
Water,	76·20	12·90
	100·00	100·00

The proportions of water and of solid matters contained

[1] *Annales de Chimie et de Physique*, tom. xxv. p. 358.

in the potato and the Jerusalem artichoke respectively, appear to be about the same. There is but little difference between these in the amounts of their nitrogen compounds, but an important difference exists in the constitution of their other substances; in the potato they exist chiefly in the form of starch, while in the Jerusalem artichoke they are represented by a peculiar form of sugar. This difference in their proximate composition no doubt has an influence upon their keeping properties, and accounts for the fact that the Jerusalem artichoke can stand the low temperature of the soil in winter better than the potato. When potatoes are frosted the cells are ruptured by the expansion of their contents, fermentation is at once set up, and the starch becomes gradually changed into sugar, occasioning that sweet taste peculiar to frosted or germinating potatoes. In the Jerusalem artichoke the sugar particles are arranged differently to the starch globules of the potatoes, and are not susceptible in the same way to the influence of low temperatures. Under a high temperature, again, the saccharine compounds enter far more readily into fermentation than those consisting of starch; and even under a moderate and dry temperature, the starchy tuber of the potato would probably be preserved without injury for a longer period than the saccharine tuber of the Jerusalem artichoke.

THE CLOVER CROP.

We now have to enter upon another division of our subject, the cultivation and treatment of those plants generally used in a green state for "feeding" or "forage" purposes. This division of our "Farm Crops," like that which has preceded it, is only met with in systematic operation in those countries where agriculture has assumed an advanced position, and where the policy, nay the necessity of a regular system of cultivation for the supply of food, animal as well as vegetable, for the people, has been acknowledged. We have hitherto been treating of the cultivation of plants bearing on substances more or less directly used as articles of food by ourselves. Such were the cereals and other seed-producing crops. The fallow crops, as turnips, carrots, cabbages, potatoes, &c., although consumed largely as food materials by ourselves, are less directly cultivated as food substances for ourselves than for our cattle, while the present division, "forage crops," never enters directly into human use, but is always grown for the purpose of providing food for our flocks and herds.

If we look back at the early period of our history, we find that although flocks and herds were emblematic both of riches and of power, and although frequent mention was made of the various grain-bearing and other plants necessary for the food or,raiment of the people of those days, no attention seems to have been paid to the cultivation of any of those plants upon which their animals had to rely for their supplies of food. As civilization advanced and population increased, we find the necessity for a systematic cultivation forcing itself on the people, who required not only a regular supply of vegetable but also of animal food, and who required also the assistance of their animals as sources of power in the various operations in which they were engaged. To feed these properly, and thus make them subserve the double purpose of furnishing a supply of power and also of food to the people, was well-nigh as important as to secure the direct food-supplies of the people themselves; and thus we see, in the pages of the Roman agricultural authors, the great attention that was paid to "forage crops" during the later periods of the Roman empire. In the days of barbarian Rome, when the inhabitants were few and their wants easily supplied, cultivation was confined to those plants which formed the food of man, and the cattle were left to obtain their supplies from the indigenous herbage of the fields. In the days of imperial Rome an increased population had necessarily increased wants, while the area of supply remained the same, and could only meet those wants by largely increasing its yield under a regulated system of cultivation. This conviction was clearly felt by the enlightened and practical Roman farmers; the loose mode of growing their crops, which, although bringing plenty one year, might prove an entire blank the next, was gradually exchanged for one based upon more defined and rational grounds, embracing, in many instances, principles which we are able to hold up as examples even at the present day. Not only were all the operations of husbandry studied and described, the nature and suitability of soils for different crops discussed, but amongst the crops recommended for cultivation were those which were most suitable for the support of the animals so necessary to the farm, both as sources of power and of clothing and food to the inhabitants of the country.

In the plants cultivated for this purpose we find many which we now class among our more valuable "forage crops," although this branch of husbandry cannot be said to have been introduced into this country until about the middle of the seventeenth century. The Medicks appear to have been the favourite forage plant in Roman farming, several species of which were cultivated, and among others our Lucerne—*Medicago sativa*—was in great estimation. Besides these, Pliny speaks of the *Trifolium;* and Dioscorides, who flourished in the time of Nero, describes and has left us drawings of the vetch, sainfoin, clover, &c.

Towards the latter days of the Roman empire, agriculture, which had advanced with its greatness, retroceded with its decline. The luxuries and corruptions then prevailing appear to have withered the intellectual face of the empire, and all the arts, useful as well as ornamental, lapsed back to their former neglected condition. The religious houses that sprung up so plentifully throughout Europe after the fall of the Roman empire, were the sole depositories of agricultural as well as of other knowledge; and through those centuries of turmoil that constitute our early and middle ages, when fields were ravaged, crops destroyed, and the ploughshare and pruning-hook laid aside for the sword, the land was given back to the wild treatment of nature, and the cares and labour of man confined to those crops which furnished the supplies of his own daily food. The flocks and herds were left to their own resources; the lessons of imperial Rome were forgotten, and were not revived until the internal feuds and struggles had ceased, and peace and quietude had again spread the mantle of security over the land.

The seventeenth century forms rather an important epoch in the history of agriculture, as it is marked by the introduction of two very valuable additions to our "Farm Crops," namely, red clover and turnips; and also by the more general practice of inclosing the cultivated land by hedges and fences, which up to this period was only to be met with in the immediate vicinity of large towns in the southern parts of the kingdom. These two points—the introduction of forage plants and inclosure of the land—occurring at about the same period, would indicate that up to this time very little had been done towards a systematic cultivation of food for cattle. It is true that many of the clovers were known as common weeds, and, no doubt, in the natural pastures had furnished food to the wandering herds. Gerarde, in his edition of 1597, describes and figures the Common Red and White clovers, the hop-trefoil, and several others. He makes no mention of either of them being in cultivation, but speaking of the "red clover," he says, "There is also a trefoile of this kinde which is sowne in fields of the Low Countries, in Italy, and divers other places beyonde the seas, that cometh up ranker and higher than that which groweth in medowes, and is an excellent food for cattel, both to fatten them and cause them to give great store of milke." This cultivated trefoil, or red clover, appears to have attracted the attention of Sir Richard Weston, at that time ambassador to the Low Countries, to whom we are indebted for its introduction to this country in the year 1645. Sir Richard gives an account of its cultivation in Flanders, where he says[1] he saw it being cut the previous year in the neighbourhood of Antwerp, on the 1st of June, being then 24 inches high, and very thick on the ground; that he saw the same field cut the second time, on the 29th June, when the crop was 20 inches high; and a third time in August, when the growth had again reached 18 inches in height. Its introduction into this country seems to have been attended with great success, as in 1653 we find Blythe speaking in high praise of it, recommending it to general

[1] *Discourses on the Husbandry of Brabant and Flanders*, 1645.

cultivation, and giving very copious directions about its growth and treatment.

At the beginning of the next century, Lisle, in his *Observations on Husbandry*, tells us that clover was to be seen in general cultivation in Hampshire, Wiltshire, Gloucestershire, and the surrounding districts. It rapidly spread itself throughout the midland and northern districts, and from this period it seems to have kept its place as a regular crop wherever tillage husbandry was practised and stock was kept, the strong clay soils of the dairying districts only refusing admission to the new and valuable plant.

CLOVER, as well as many others of our forage plants, belongs to the order LEGUMINOSÆ, of which it forms a distinct and important genus, TRIFOLIUM. The genus is a very numerous one, and includes several species which are cultivated in this country for forage and feeding purposes, while many of the others are met with in the natural pastures, both at home and abroad, and add to the value of their produce, whether consumed in a fresh state, or cut and made into hay.

This genus, which is met with largely dispersed all over the temperate zone, has always been a very difficult one to define, and species have been admitted into or rejected from it according to the views the particular botanist may take of its true characters. Don enumerates no less than 165 species, others again have reduced them to about one-fourth of that number Although the different species vary very much in their agricultural values, still none of them are in any way noxious to cattle, or even troublesome as weeds. The common species are readily recognized by their leaves and flowers; the leaves are composed of three leaflets, having generally a white streaky mark (subsagittate) in their centre; the stems are herbaceous, not twining; the flowers form a compact globular or rather oblong head, furnished with a straight seed-pod, not jointed, and containing but one or two, very rarely three or four seeds. The following species are those most commonly met with in cultivation in this country:—

Trifolium pratense—Common Red Clover.—Of this there are several varieties, which differ principally in the duration of the growth and the time they take to arrive at their full maturity. Mr. Lawson therefore suggests a separation of those varieties which, from their habit of growth, are most suitable for rotation husbandry, from those of more permanent growth, which he recommends as best adapted for sowing down in permanent pastures. Although the most short-lived varieties will be found to last for several years, still they lose their vigour of growth and comparative power of production, much earlier than some of the other more persistent varieties. Of those recommended for rotation sowing, the Common Red or Purple-headed clover is the most important. This variety differs from the Perennial Red clover by its roots being more fusiform and fleshy, and by its leaves and stems being generally smoother and less hairy. It is a very vigorous and productive grower in suitable soils, furnishing a large

TRIFOLIUM PRATENSE—Common Red Clover.

amount of nutritious and sweet herbage. It comes to full maturity the second year, and produces seed of a fine bold purple colour. As we have principally to rely upon other countries for our supply of seed, we meet with many different varieties in our crops, partaking more or less of the characters of the plants of the different countries that furnished the seed. For instance, we have in our markets seed known as Holstein, German, Cologne, Juliers or Dutch, Flemish, French, American, and Normandy Red Clovers; and of these the Dutch and French varieties are the most esteemed. The former of these is of a light colour, and of a strong and coarse habit of growth, and succeeds better than most of the others on strong soils of an inferior description, particularly such as are of a dampish character. Its seeds are easily distinguished by their being large, but not so plump and well filled, and of a yellower colour than those of most of the others, arising probably from the humidity of the climate in which they are grown. The French clover is remarkably smooth in all its parts; leaflets roundish, and altogether of a rich green succulent appearance. The seeds, which are chiefly from the southern departments of France, are small, plump, and have a considerable portion of purple in their colour. This variety is best suited for superior soils in good districts. The Normandy clover is from the northern part of France, and appears to be of a strong luxuriant habit of growth; it is of a dark green colour, produces comparatively few flowers, and is some days later than the common sorts.

Trifolium pratense perenne—Native Perennial Red Clover.—This variety is so distinct from the foregoing cultivated Red clovers, that by some it has been classed as a distinct species. Compared with the common clovers, its flowers, foliage, and stem are in general of a darker colour; the leaflets are narrower, and, together with the stems, are much more downy or hairy, and the roots more fibrous. It differs also in the shape of the calyx, and in other botanical points of minor importance. This is the variety found growing naturally in old pastures, moors, and waste places; and although existing under very different conditions, it preserves its general characters with great persistency.

The *Common Perennial* variety, or "Cow Grass," appears to occupy an intermediate position between the Native Perennial and the cultivated Red clovers. Its leaves and stems, though woolly in appearance, are more like those of the latter variety; it is more permanent in its duration, and comes to maturity generally a week or ten days later. Its feeding properties certainly are not superior to those of the Common Red clover; and as the seed is always higher priced, it offers but little inducement for cultivation. There are other varieties of the perennial sorts in the market, known by the name of the different countries which supply the seed, of which the French and the German are the most esteemed.

Trifolium medium—Zigzag Clover, or *Marl Grass.*—This species is generally confounded with the Cow Grass, from which, however, it is entirely different. In appearance, however, it greatly resembles the Common Red clover, but is readily distinguished from it by its more rigid zigzag stems, narrower and darker green spotless leaflets, and, above all, by its creeping roots, and being always found growing in considerable patches, instead of solitary plants, like the other varieties. It is also met with on very dry banks, the tops of old walls, &c. Owing probably to this variety having been confounded with the true Cow Grass, it has been recommended for sowing in permanent pastures, for which the Cow Grass is well adapted. It is most desirable, however, to avoid mixing this with any grass seeds, either in the rotation or for permanent pasture, as its herbage is less productive and less palatable to cattle than the other Red clovers; while, owing to its creeping habit and large fibrous roots, it displaces the more valuable plants, and occupies the surface in a far less profitable manner.

Trifolium repens—*White* or *Dutch Clover*—is a low, smooth species, with creeping stems, rooting at the joints. The leaflets are inversely heart-shaped, often exhibiting a darkish coloured mark near their base. The flower-stalks stand erect, without leaves, and carry a globular head, with white or pale pink coloured, sweet-scented flowers, which are abundantly produced during the summer and early autumn. The roots are fibrous, and ramify vigorously through the soil. It is a plant very commonly met in all the natural pastures, and even waste places on the Continent and in North America, as well as at home; and although it possesses a great range of soils in which it may be cultivated, it generally is met with in those of a poor and of a dry nature.

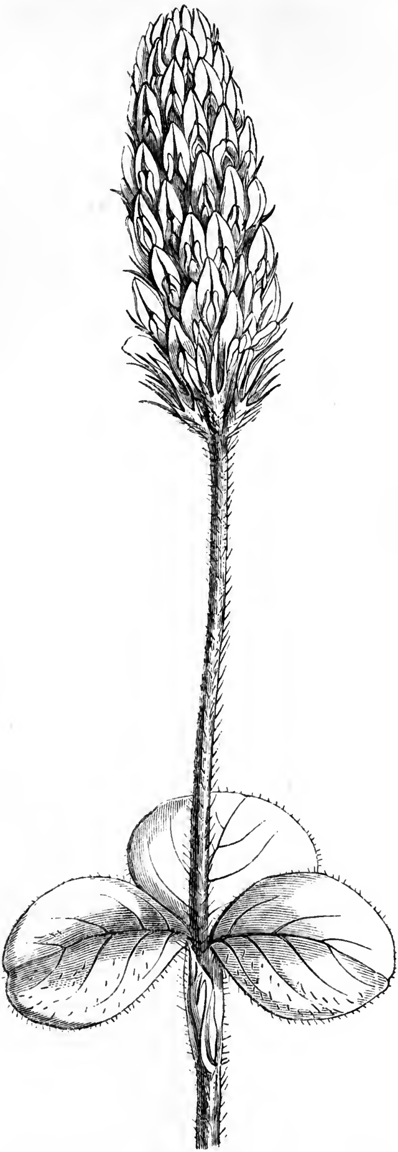
Trifolium hybridum—*Hybrid* or *Alsike Clover.*—This is so named from being intermediate in its appearance between the Red and White clovers. It resembles the former in its duration, size, and mode of growth, and the latter in most other respects. It was introduced into this country from Sweden, where it had been long in cultivation as the favourite clover for cold, moist clay districts. Owing to the price of the seed being much higher than that of the ordinary clovers, it has never been cultivated to any great extent. In the northern parts of Scotland, however, where it has been tried, it has succeeded, and been approved of. It grows fully as high as the Red clovers; the stems and leaves are quite smooth; the flower-heads, which appear in June and July, resemble those of the White clover in shape, but are rather larger, and of a good rose colour mixed with white. The stems are hollow, and inclined to spread out, if the plants are not close on the ground. The roots are fibrous, and are said to remain vigorous for from fifteen to twenty years. This opinion originates probably, however, from the facility with which the plant sheds its seeds, and arises self-sown when placed in a congenial soil.

Trifolium procumbens—Hop-Trefoil (*see woodcut*)—resembles very much another species, the *T. filiforme—Small Yellow Clover*—with which it is frequently confounded. They both are of a dwarf habit as compared with the foregoing, and are suitable for growing on soils of a dry and inferior character, rather than on the better class of soils, where the other clovers would give far more productive returns. They are readily distinguished by the yellow colour of the flowers; the stems and leaves are smooth, the roots fibrous, and the whole plant rarely exceeding 8 or 9 inches in height. When added in small proportions in the mixed seeds for artificial grasses, they serve to improve the bottom herbage. This increases the produce whether cut for hay, or fed off by sheep or cattle, to both of which they are generally very palatable.

TRIFOLIUM PROCUMBENS—Hop-Trefoil.

Although there are several other species which are more or less suitable for cultivation in this country, and, indeed, are seen as field crops on the Continent and elsewhere, the only one which claims our especial notice is the

Trifolium incarnatum—Scarlet or *Italian Clover.*—This species is widely different from any which have preceded it, being an annual, and having a habit of growth and an appearance which readily distinguish it from any



TRIFOLIUM INCARNATUM—Scarlet or Italian Clover.

of the ordinary clovers. Although long known in this country among gardeners as an ornamental border-flower, its introduction to our farms as a field crop is quite of recent date. The stem is upright and branched; the leaflets broad, nearly round, and with the stem covered with hairs (*see woodcut*); the flower-stalk rises to some height above the last leaves, and is surmounted by an oblong cylindrical spike, tapering towards the top, and consisting of bright scarlet or crimson coloured flowers, which give the crop a very beautiful appearance. It is very extensively cultivated in some of the southern districts in the country, especially on the light chalk soils of the sheep-farming counties of Hampshire, Berks, and Wilts. The practice is to sow it down on the stubbles, immediately the field is cleared—the surface of the field being merely cut up by the "broad-share," and the seed sown broadcast and harrowed in at the rate of 12 lbs. to 20 lbs. per acre. Owing to its rapid and vigorous growth, it gets firmly rooted in the soil before the winter sets in, and in the spring it furnishes an abundant supply of green food for the cattle; or if allowed to stand for a hay crop, it comes into flower early in June, when it may be cut, and the field got ready for turnips or any other of our fallowing crops. The produce per acre is generally very satisfactory, and the hay as well as the fresh herbage is generally relished by cattle.

A late French variety of this species has been introduced, and also another so-called species, to which the name of *T. Molineri* has been given, but which probably is only a permanent variety. This latter greatly resembles the *incarnatum* in its general habit of growth; its flowers, however, are of a light pink, or French white colour, and it arrives at maturity somewhat earlier. It is a favourite in some parts of France and Switzerland. Besides these species, which are met with in general cultivation in this country, there are several others which have been from time to time introduced here, and which occupy the same place in the farming of other countries as the foregoing do with us. Amongst these are the *T. alexandrinum*—Egyptian clover—an annual, growing to the height of 20 to 24 inches, and carrying pale yellow or whitish flowers, which is largely grown in the East, and constitutes the principal forage crop for cattle in those countries. In a good soil and favourable climate, like that of the valley of the Nile, it grows rapidly, and furnishes three or four cuttings, of from 18 to 24 inches long, in the course of the summer. It was introduced into this country by Mr. Lawson in 1832–33, but was not found to sustain in this climate the same vigorous growth that rendered it so productive in its native country, and therefore was less valuable to us than the *T. incarnatum*, for which it was expected to be a substitute. This probably would be a desirable species for some of our colonies, where the climatal conditions are more suitable. The *T. alpestre*, or Alpine Red clover—a native of the Alps, and various parts of Europe—is strictly a perennial species, carrying an oblong or oval head of bright purplish red flowers, and growing to the height of 18 or 24 inches on good soils. It is a hardy plant, and is strongly recommended by many of the continental authorities. The *T. elegans*, introduced by Messrs. Lawson in 1824, resembles very much the Alsike clover, of which it is probably only a variety. It is, however, of a smaller and more slender growth; flowers not above half the size, of a more uniform rose colour; leaflets usually bearing a horse-shoe mark. Though less succulent than the Alsike, it is usually considered more durable; and, losing less in drying, it makes a larger bulk of hay, while, at the same time, it will grow on an inferior class of soils. On those of a silicious or ferruginous character it will give a good return; whereas the *T. hybridum* delights in those of a rich, marly, or loamy nature.

The range of soils which the clovers possess is very large; indeed, every soil which is worth cultivation at all affords a home to some of the species of this extensive family. The only condition which is inseparable from their productive cultivation is the presence of lime in the soil. If this be absent, the clovers, like the other plants belonging to the same order—*Leguminosæ*—refuse to grow. Lime, however, is a natural ingredient in all soils, and is necessary more or less to all plants, therefore it rarely happens that any place could be found in which the clovers could not find a living. In their wild or natural state they are met with chiefly in dry, light soils, especially of the chalk or other limestone formations; and, indeed, enter into the class of indigenous plants indicative of soils of that character. In cultivation, however, we call upon our plants to depart from their normal conditions, and to increase their powers of development, and, consequently, productive returns; and then we place them in soils of a more fertile character than those they naturally inhabit, and we furnish them with additional supplies of food in the shape of various manures.

Clovers enter so generally into the rotations of the present system of farming, that we meet with them in cultivation on every description of soil, from the light sands of Norfolk and Suffolk, and of the green and the new red sandstone formations, to the compact soils of the districts occupied by the London, the weald, oolite, and lias clays.

The intermediate class of soils, however, is that which is most suitable to the growth of the clovers—a calcareous loam, such as is met with at the junction of the lower chalk, for instance, with the upper beds of the green sand, or of the lias with the new red sandstone. These soils are generally deep and well disintegrated, and contain most of the conditions, physical as well as chemical, essential to the vigorous growth of the crop. The habit of the clover plant is to form large and fleshy roots, which have a tendency always to penetrate deep into the soil, and to seek their supplies of food from the lower stratum. This tendency should always be encouraged in all our cultivated plants. It has a twofold power of benefit to the farmer—not only have his crops a greater range of feeding ground, but they abstract from the subsoil, and elaborate into their own structures on the surface, the food ingredients which, by the percolation of rain or other natural causes, have been carried down below the range of tillage operations; while, at the same time, their roots being buried deep in the soil, secure to them the power of obtaining moisture from below at a time when the more surface-rooted plants are suffering from the effects of the summer sun and drought.

Although the clover will grow in dry soils and dry climates, its development will be limited and its produce will be necessarily smaller than where a sufficient supply of moisture can be had. It possesses a large leaf surface, and considerable powers of increase under favourable conditions; and if these are secured to it, its productive returns are generally very satisfactory. Our knowledge of its requirements would therefore lead us to consider that in all cases we should endeavour to secure for it a deep, well-tilled soil, containing sufficient moisture in itself for the requirements of the growing crop, and yet free from any stagnant water, as directly the roots arrived at the water stratum, the further healthy growth of the crop would be at once arrested. The chances of injury from this latter condition of the soil can always be met successfully by thorough draining, an operation which forms one of the principal elements of success in all systems of farming. The chemical conditions of the soil necessary for the clover crops are generally secured by carefully following out the principles upon which our system of rotation farming is based. At the same time, we must recollect that the clovers require a larger proportion of lime than most of our other "Farm Crops," and that if this be not present naturally in the soil, it is desirable that it should be added to it in the form of some calcareous application. For this purpose gypsum (sulphate of lime) is very commonly used, and generally with very satisfactory results.

The proper place for clover in the rotation is between two straw crops, and this place it almost invariably occupies. This practice, which in itself is based upon sound principles, would admit of no question or comment were the clover cultivated in the rotation as a separate crop. Such, however, is very rarely indeed the case. In well-nigh every instance it is accompanied by other plants—rye-grass most commonly—differing from it widely in botanical characters, and belonging, indeed, to the same "order" to which both the preceding and succeeding straw crops belong—*thus ignoring in every way the principles upon which a rotation of crops is based, and neutralizing to a great extent the good we are taught to expect from a change of crops judiciously arranged.* The evils resulting from a continuous cultivation of the same crops on the same ground are known practically to every one. We find that under ordinary circumstances not only does the produce diminish every year, but that the health and vigour of the plants are also affected, and that the injuries they sustain from their insect enemies become more serious, as the insects infesting the crops are thus preserved from the crop of one year to that of the next. Thanks to chemistry, we now can understand clearly some of the causes why such effects should be produced. Investigations into the analytical composition of our various cultivated plants show that all plants belonging to the same natural order—take the *Gramineæ,* for instance—possess a great uniformity of composition, and consequently require for their growth the same food materials from the soil. Plants, again, belonging to a different order—the *Leguminosæ*, for instance—though possessing the same uniformity among themselves, differ more or less widely in their composition, and thus may be able to obtain a supply of food from a soil which has been exhausted by the growth of previous straw crops. There are other considerations, too, of an economic nature, which support the policy of a rotation of crops: the labour of the farm is more equally and beneficially distributed, and the productive returns rendered more regular and secure. Experience, therefore, has long ago pointed out to us the advantage of changing our crops on the same ground as frequently as we can; and we see that everywhere, far and wide throughout the country, the land is farmed upon some sort of a systematic rotation, which does, or is intended, to secure the crops against the evils consequent upon the continuous cultivation of the same plants on the same ground. Besides the chemical reasons in favour of a distinct system of rotation in our crops, there are others of a physiological nature, with which we are less perfectly acquainted, but which, no doubt, have an equal bearing upon their vigour and healthy development. Both of these are naturally met by arranging that the crops following each other in the rotation shall differ, not only in the "order" to which they belong, but also in their habits of growth, as widely as possible. The food requirements are then less likely to be interfered with, and the other conditions of growth which we know to be necessary to them are more fully secured.

In the Norfolk or four-course rotation, clover as a rule follows barley and precedes wheat. In the five-years, six-years, or longer rotations, it is met with following either barley, oats, or wheat. In these rotations it is kept down a second or even a third year, and is generally succeeded by wheat, except, of course, in cases where it was sown down with the wheat crop. For either of these grain crops clover no doubt is an excellent change, as it differs widely from them in its food requirements from the soil, and also in its habit of growth and general tillage treatment. Now, if these be the true principles upon which our system of rotations is based—a system which long experience has pointed out as necessary, and which science has confirmed and explained to us—we appear to be sadly negligent of our own interests in departing so widely as we usually do from the principles involved, by mixing with our clovers other plants belonging to exactly the same order as those to which the clover is intended to be a change. Throughout the country far and wide the universal practice is to mix ryegrass, either alone or combined with other grasses, with the clovers, and thus to a great extent to neutralize the benefit which clovers sown by themselves would confer upon the rotation. The ryegrass, which is the common companion of the clovers, is identical in its botanical characters with the ordinary straw crops which both precede and succeed the clover crop: its food requirements are the same, and it forms a home for the continuous production of the various fungoid diseases and insect enemies which so frequently and so seriously injure our grain crops. Here, then, our practice is totally opposed to our principles, and instead of growing an intermediate crop, differing in its agricultural characters and requirements from those which are next to it in the rotation, we diminish the benefits we might fairly expect to receive, by mixing with it plants belonging to the same family as those to which the clover crop ought to be an entire change.

Although this is the common practice that has been and is still followed, there can be but little doubt that it is an erroneous one, and in the long run detrimental to the produce of the farm. We hear on all sides complaints of the tendency of our fields to become what is termed "clover sick," and we see far too often, and over far too large a range of country, the scanty proportions of clover and the large proportions of grass that form what are called our "clover crops." In these districts, too, the succeeding wheat crop, by its stunted growth and diminished returns, generally tells its tale of bad treatment, the preceding crop of barley and the ryegrass of the clover crop having abstracted largely from the soil the same substances which the wheat requires for its growth. Although this practice of mixing grass seeds with the clover is so common throughout the whole country, some of our more enlightened farmers recognize and believe in the *principles upon which rotations should be based*, and take care to avoid such an anomaly in their practice as to cultivate three graminaceous crops in succession. On these farms the intermediate clover crop is either sown down unmixed, or if any other plant is added, care is taken to avoid those included in the same order as that to which our grain crops belong. The good effect of this good farming is seen, not only in the superior vigour and produce of the clover crop, but also in the succeeding crop of wheat, which, irrespective of the larger amount of manurial matter left in the ground by the clover crop, has also had the full benefit of its fallowing effects, and finds in the soil a large supply of readily assimilable mineral food, which was not suitable to the requirements of the clover, but which is absolutely necessary to itself.

In the four-course rotation, where the clover follows barley, it is either fed off altogether on the field, or it is mown for hay, and the aftergrowth fed off with cake or corn, so as to compensate, in a manurial point of view, for the portion of the crop consumed off the field. If some enriching feeding substance be not used, an equivalent in manure should be applied to the succeeding wheat crop, either in the shape of farmyard dung in the autumn at the time of ploughing, or of some artificial manure at the time of sowing, or at a later period of the growth of the crop. Where clover is kept down two or three years, as in the longer rotations, it is generally mown for hay the first year and fed off afterwards. If intended for mowing the second year, it should not be fed down too close, and a good dressing of farm dung should be given to it at some convenient time during the winter. The subsequent growth should then be consumed on the ground, either with or without the addition of cake or corn, as the condition of the land may determine.

On the soils farmed upon the four-course system, a practice has been introduced of substituting another leguminous plant for a portion (say one-half) of the clover-break. This may be generally done with great advantage to the clover crop, as although the chemical principles of the rotation are not relieved by the substitution, still the soil undergoes a different mechanical treatment, and the chances of success of the crop are practically benefited. For this purpose, on the lighter class of soils, peas are probably the best substitute; on the stronger, beans, especially the winter-sown variety, have been successfully introduced. In the Eastern districts, sainfoin has been substituted with very satisfactory results; this practice, however, will come before us when we discuss the cultivation of that crop. By this arrangement of cropping, the interval between the recurrence of the clover on the same ground is just doubled from the fourth to the eighth year, and the chances of its failure proportionately decreased. In this case we must not forget that where peas or beans are substituted for the clover, they are carried off the field, which should receive a compensating supply of manure sufficient for the requirements of this and of the succeeding straw crop.

Clover, whether grown by itself or mixed with grass seeds, is invariably sown down with the straw crop, so that when the latter crop is harvested the young clover has full access to air and light, and is able to get well rooted in the soil before the winter sets in. The usual time for sowing is during the month of April; if got in earlier the plants are apt to make too much growth, and either get drawn up into tall spindly plants, or to get so strong at the bottom as to interfere with the harvest operations of the straw crop. If the sowing be delayed later than April, the straw crop is generally so far advanced as to render it very difficult to get the seeds properly in, while the growing crop is sure to be more or less injured by the operation. When sown down with barley or oats, it is desirable that the plant should be well up and have a good start before the seeds are sown; indeed, it would be well to delay the sowing until the crop had been hoed, by which you would not only prepare a suitable seed-bed for the clover, but also secure the young plants from being overpowered by the weeds, which generally are of a more vigorous habit, and tenaciously keep possession of the soil. In all cases where seeds are intended to be sown with the grain crops, it is most important that the drills should be wider apart than the usual practice. From 6 to 9 inches may perhaps be taken as the usual width of drills with our grain crops; if this were increased to from 9 to 12 inches, it would admit more freely of the use of the hoe; the produce per acre would not be lessened, while its quality would probably be greatly improved, and at the same time the young clover plant would get more access to light and air, and assume a more healthy and vigorous growth.

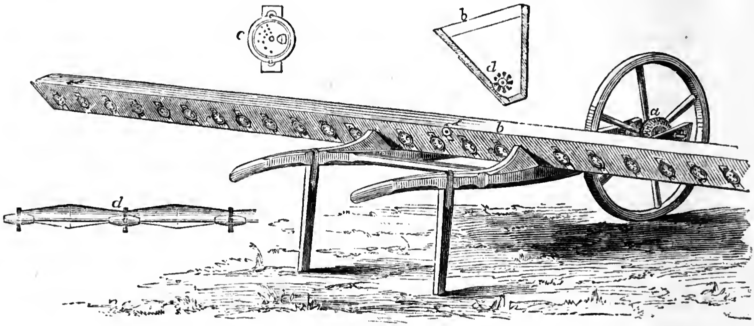
The quantity of seed sown depends very much upon the description of clovers and of grasses used. When the clovers are sown by themselves, about 12 to 15 lbs. per acre are generally sufficient—say about 8 to 10 lbs. of the common red clover (*T. pratense*), 2 to 3 lbs. of the white clover (*T. repens*), and 1 to 2 lbs. of the yellow clover, or hop-trefoil (*T. procumbens*). To this mixture a small proportion of the rib-grass, or narrow-leaved plantain—*Plantago lanceolata*—say about 2 lbs. per acre—is frequently added with advantage. This grows very well with the clovers, and adds considerably to the bulk of the forage produce. Where the mixture contains grass seeds, the proportions of the clovers are reduced to about one-half the foregoing quantities; ryegrass is usually added to the extent of from 1 to 2 bushels to the acre, and from 6 to 10 lbs. of some of the other pasture grass, selected for their suitability to the particular soil, of which perhaps the cock's-foot—*Dactylis glomerata*—is the most productive and most generally esteemed. If the seeds be only intended for one year's rotation, the Italian ryegrass should always be used; if for two or three years, it is advisable to use one-half of the Italian and one-half of the ordinary perennial variety—*Lolium perenne*.

The selection of the seeds—the clover seed and ryegrass seed especially—demands great care and attention. They are all liable to adulteration to an extent that frequently materially diminishes their productive returns.[1] The Red clover seed should be plump, and of a deep purple colour. This denotes that it has been fully matured and well harvested. To detect any impurities or adulterations, it

[1] The practice of "doctoring" clover seeds was carried to such an extent some few years ago, as to be made a subject of inquiry before a committee of the House of Commons. "White clover seed was first wetted, and then exposed to the fumes of burning sulphur; while the purple colour of the Red variety was improved by being shaken in a bag with indigo, or with a preparation of logwood tinctured with a little copperas, or sometimes with verdigris. Not only was old seed improved in appearance by these means, but often the germinating power of the best seed was entirely destroyed."

is a good plan to take a piece of white paper, moisten the surface, and then lay the seed thinly over it, and carefully examine the sample with a low-power magnifying-glass. Any colouring matter that has been used may then generally be discovered, and the seeds of other plants mixed with it be readily identified. Charlock seed, which is frequently met with, has a rounder and somewhat larger shape; the dock seed is much flatter; and the seeds of the common heal-all—*Prunella vulgaris*—which abounds in some districts in the clover fields, and flowers about the same time, although of the same colour as the clover, are much smaller in size, and may easily be distinguished from it. In some of the foreign samples a large proportion of pale-coloured seeds are met with. This probably arises from their having been harvested before perfectly matured. Clover seed contains a considerable percentage of oil in its composition, and will germinate after being kept for several years; it is, however, desirable in all cases, with clovers as with other seeds, to obtain them as fresh as possible. The ryegrass, whether Italian or perennial, is equally subject to adulteration; this, however, we shall have another opportunity of speaking about.

In sowing clover seed alone, the common seed-barrow should always be made use of, as it is quite impossible to distribute by broadcasting the small quantity of seed used equally over the surface; when mixed with ryegrass the different size and the different specific gravities of the seeds render the task equally impossible. This small seed-sowing machine (of which a perspective view is given in the accompanying woodcut) consists of a barrow frame, carrying a light wooden box of a given length, traversed throughout its length by a spindle, armed at certain distances—every 6 or 8 inches—with a circular brush (*d*), placed opposite to an aperture in the side of the box, which is covered by a copper plate, perforated with one large hole and several smaller ones (*c*), through which the brush, revolving with the motion of the barrow, forces the seeds contained in the box. By a simple arrangement these holes, or any of them, may be closed, so as to regulate the size and quantity of the seed sown, the large aperture being required for the larger sized



grass seeds, the smaller ones for the different varieties of clovers used. The breadth of the barrow is usually from 10 to 15 feet, so that a large number of acres of seeds may be got in in the day. A little care is required to distribute the seeds equally in the box, so that all the holes should be well supplied, and also that, in going up and down the field, no spaces should be left unsown. After the seeds are sown they should be brushed in with a bush-harrow, in preference to the light seed-harrows, which are always apt to cover them too deep; then a light roller sent over the field, if the state of the grain plant will admit of it, finishes the operation. The roller breaks down any small clods that may be on the surface, consolidates the soil, keeps in the moisture, and renders the germination of the seeds more equal, leaving the field in a better condition for mowing when the time for harvesting the crop arrives.

This operation usually takes place in August, and by this time the clover, if well got in and cared for, has acquired a considerable power of growth, which shows itself, immediately the field is cleared of the straw crop, by its vigorous development, the field being soon covered by its deep green foliage, and all traces of the stubble completely hidden. This generally is a period of great importance to the future welfare of the crop, and the more healthy and vigorous it appears to be now, the greater are the chances of injury to be inflicted on it. The first of these generally arises from the pigs of the farm, which it is customary to turn into the young clover, for the purpose of picking up any portions of corn that, owing to the too common practice of leaving the barley standing until dead-ripe, may have been left on the ground during the operations of harvest. These trample down the young and tender plants in search of corn, root them up with the snout in search of any roots of which they are fond, and in some cases, when they fancy the clover itself, being unprovided with cutting-teeth, they tear it up, frequently destroying the entire plant, and always materially injuring it. These animals are frequently followed by both cattle and sheep, the former of which do far more injury than the latter. Sheep, however, feed much closer than cattle, and when left on too long are apt to eat down to the crown of the root, which, if left exposed to the winter's frosts, is sure to succumb and die away before the spring comes round again. This, probably, is one of the causes of what is termed "clover sickness" in our fields. In many cases we hear of the plant showing well at first, but disappearing during the winter, and when the growing time comes, either weeds or grasses taking its place. In its early growth the clover is a very tender plant, and the less it is touched after the straw crop is cleared off the ground the better. The great object is to get it well rooted, and the stems and shoots hardened before the winter; if these be injured in any way—and every footstep even, either of man or beast, is liable to inflict an injury upon them—its chances of withstanding that trying season are proportionably diminished.

Early in the spring the growth of the clover is resumed, and where the conditions of soil and climate are favourable, about the month of June it has generally reached a height of 18 or 20 inches, and has begun to form its flower-heads. Where it is intended to be mown for hay, it is desirable to wait until this process has commenced, so as to derive the largest amount of produce; where, however, it is intended for consumption in a green state, for "soiling," as it is termed, cutting should be commenced at an earlier period, so as to get the whole cut cleared off before the flowering process is completed, when the leaves die away, and the forage value of the crop diminishes every day. About the latter half of June or beginning of July is the usual period for cutting for hay: the crop is mown with the common scythe, and left lying in the swathes. Here, however, the process differs from that of the ordinary hay-field. Instead of tossing it about either with forks or the "tedding" machine, for the purpose of exposing it as much as possible to the air, the less the clover is handled the better; all that should be done is to turn the swathes over carefully from one side to the other every day, or oftener, when the weather is suitable, leaving them as open as possible to the admission of the sun and wind. Under ordinary circumstances, in three or four days the juices will have been sufficiently evaporated to admit of forming it into cocks or heaps, and in another day or two it may be safely carted and stacked in the usual way.

Some little care and attention are required throughout the operation. If the cut crop be tossed about in making, the leaves get easily separated from the stems and lost on the field, the stems get bruised and broken, and allow the juices to exude and become oxidized and changed by exposure to the air, while the object of the farmer is to keep them in their natural state, for the purpose of giving flavour and quality to his fodder. In stacking, too, it is desirable that the crop should contain sufficient natural moisture in its tissues to induce a gentle heat and fermentation in the mass, by which the quality of the hay is greatly improved; whereas, if it be carried and stacked too soon, the excess of moisture is always accompanied by an equivalent of heat and fermentation; while, if left out on the field too long, the juices all become dried up, and no heating in the stack takes place at all. Although a certain amount of natural moisture is always desirable at the time of stacking, it is most important that it be free from any surface moisture from rain or dews. Not a forkful should be pitched up until every particle of moisture has disappeared; as, if allowed to be stacked in this condition, mildew and deterioration are sure to be the result.

In the neighbourhood of large cities it is very much the custom to sell the clover hay, and load back with stable manure. In other districts, where the clover is intended for home consumption, it is a very good practice to stack it with layers of straw, intermixed with layers of clover. By this practice the clover may be carried a day or two sooner, more of the juices are retained, and the hay generally remains in a more tender and assimilable state, while the interstratified straw has imbibed to a certain extent the flavour and odour of the clover, and is ready for being cut up into chaff with it for the cattle. When straw is thus used no other precautions are needed in regard to the ventilation of the stack; in ordinary cases, where the quantity stacked is large, a chimney in the centre is frequently resorted to, for the purpose of checking any excessive heating. Owing to the comparative softness of the hay, it always sinks very much in the stack; it is therefore best to leave it open for a few days, or to cover it with merely a temporary thatch, and then to complete the operation when the mass has passed through its stage of fermentation and heat, and sunk down to its permanent shape.

After the hay crop is cleared away, the plants continue their growth in a very vigorous manner; and if the weather be cloudy, with a little moisture, the whole surface is speedily covered with verdure again. It is always desirable to let the plants acquire a certain growth before sheep or cattle are placed on the field. If wheat is to follow in the rotation, the crop should be fed off by sheep, with cake or corn added as a manural equivalent for the hay crop carried off the ground; if the crop be intended to stand a second or third year, it should also receive a good dressing of manure to keep up its fertility. For this purpose nothing is better than farmyard manure, which may be applied as soon as the cattle or sheep are taken off the field. This is distributed over the surface, and serves to protect the plants, which, by being fed off, are deprived of their foliage, from the effects of the winter's frosts. If a crop of hay be taken in the second year, cake or corn, or direct manure must be given in equivalent proportions to compensate for it. It is, however, far more customary to feed the entire crop, and get the field ready early in autumn for the succeeding wheat crop.

When the crop is grown for seed, the practice is either to take a crop of hay first, and then let the second growth stand for seed, in which case it is rarely ready before September, or to merely feed off the first growth and then put up the field, allowing the crop to stand until the flowering is completed, and the seed-pods fully matured. This is by far the best and most productive practice. The sheep are penned on the field early in the spring, and may be kept as long as the keep lasts, or until the end of May, the field is then shut up, and about the beginning of August the crop is ready for cutting; after which, what little keep there is may be disposed of in the usual way. Our climate is certainly far more favourable to the herbaceous growth of clover than to its full maturity and seed produce, and consequently the seed-crop is rarely a satisfactory one. We are limited to about two months for the crop—July and August. If it comes to maturity earlier, it never ripens so perfectly; and if it remains in the field later, it is frequently injured in the after operations of harvesting. It is important that the seed be fully matured at the time of cutting, and that it be left out in the field until it becomes quite dry and hardened; the same, or indeed more care is required in moving it about than for hay, otherwise a large portion is sure to be lost. The operation of separating the seed from its husk or capsule is a very difficult one. Machines, however, have been introduced for the purpose, and are always used by those who cultivate the crop regularly for its seed.

The *diseases* to which our cultivated plants are liable, are still very imperfectly understood. The effects, however, are well known, and are often discussed. Neither have we any lack of opinions and speculations as to their cause; but, with the exception of the self-imposed labour and investigations of one or two individuals, no systematic attempt has been made to arrive at the real causes. The crop now before us affords a marked instance of this great deficiency in our agricultural knowledge. Although a moderately hardy plant, and not generally susceptible to disease, the clover plant is frequently greatly injured by a form of disease which, in our ignorance of its true character and mode of attack, we are accustomed to term "clover sickness." This, in some soils, is accompanied by such destructive effects on the crop, as to have led recently to much discussion at the Central Farmers' Club (Nov. 1859), and in the agricultural journals, as to the preventive precautions to be taken, or the best substitutes for the clover plant in our farming rotations.

Although these discussions produced no direct results as to the cause of the disease, they have been the means of calling the attention of scientific as well as practical men to the subject, and of pointing out the direction in which our observations should be directed. A few years back we were inclined to trace many of the various unaccountable effects in farming to chemical causes, and sought, by analysis of our soils, &c., to arrive at their defects, and thus readily provide compensating remedies for them. Vital effects, however, are clearly not to be judged by chemistry alone. Each plant we cultivate probably differs in its nature and powers from the others, and is influenced for good or for bad by entirely different causes. "If the analysis of plants alone could tell us precisely what has been withdrawn by a given crop from the soil, and what must be restored to it to insure success, agriculture would become in a great measure a matter of certainty, instead of being subject to a thousand accidents, as it is. That the farmer may and does derive great advantage from his own chemical knowledge or that of others, it would be folly to deny; but he must not suppose that all begins and ends there. There are mysteries far beyond the reach of the highest human knowledge; but the veil is sometimes capable of being withdrawn, yet only where people do not rest satisfied with a foregone conclusion, but are content to keep their minds open to fresh suggestions, without indolently making up their bundle of faggots, and wrapping themselves up in their own prejudices." The investigation into the composition of soils on which Red clover succeeds and fails, by Dr. Anderson,[1] clearly shows that we must seek elsewhere for the cause of the disease, and fully justifies

[1] *High. Soc. Trans.*, 1849, p. 202.

Mr. Berkeley's opinion, that "it seems quite preposterous to believe that clover will not succeed once in a four-years' course, from mere exhaustion of the soil."

Dr. Anderson's investigations were made in reference to a field at Craiglockart, on a particular part of which Red clover always succeeded, though it failed on the adjoining portions, and even when it did not fail altogether, the crop on this particular part invariably presented a remarkable superiority, in strength of plant and abundance, to that on the remainder of the field. This difference was traced distinctly to a sort of shale, which formed the main proportion of the soil where the clover succeeded, which had been thrown out of an old quarry in the corner of the field; the same luxuriance of growth had also been noticed in a shale of precisely similar character in Fife. Every precaution was taken to obtain a fair sample of the soil (page 84, vol. i.), its examination was conducted with great care, and with the following results:—

	Shale.	Cultivated Soil.
Organic matter,	6·526	6·65
Peroxide of Iron,	4·248	4·69
Alumina,	1·740	1·84
Lime,	2·268	·33
Magnesia,	traces.	·27
Sulphuric acid,	·400	·01
Phosphoric acid,	·042	·14
Carbonic acid,	·560	traces.
Potash,	·329	·24
Soda,	·121	·02
Insoluble Silicates,	84·170	85·93
	100·404	100·12

The only difference worthy of remark between the two analyses exists in the reduced proportions of sulphuric acid and lime in the soil which has been under clover cultivation, both of which substances appear to be essential to the healthy development of the plant. In some analyses of other soils on portions of which clover had succeeded, and on some portions failed, the results were even less satisfactory, the portions on which it failed giving higher indications of fertility than where it succeeded. Similar negative results were obtained by Dr. Anderson, in a more recent examination[1] of the soil of a field at Thurston (East Lothian), on the old red-stone formation, "in which the contrast between a good crop of clover on one part of the field, and its absolute and total failure on another part, was so striking as to merit careful examination." The analysis showed a very close similarity between both the soil and the subsoil of the two portions of the field on which such a difference in the produce was seen. The lime and the magnesia were present in satisfactory proportions, and the proportion of alkalies in excess of that usually met with in soils. The proportion of phosphoric acid, which we usually look upon as so necessary to the fertility of our land, was nearly five times as large in the soil on which the clover failed as in that which carried a large crop; while the proportions of sulphuric acid were exactly the reverse—the soil on which the crop succeeded containing about six times as much in its composition as that on which the crop failed.

Here, then, we have confirmatory evidence, as far as it goes, of the importance of sulphur in some shape to the healthy growth of the clover plant; and, consequently, that the application of bones, which has been recommended strongly as a remedy, is not likely to be followed by such beneficial results as when applied in the shape of "superphosphate," which always contains a large proportion of sulphuric acid in its composition. In each of the cases alluded to, however, the soils in which the plant throve contained sulphate of lime in far larger proportions than those in which it failed. With this exception, which would tend to show us the importance of sulphuric acid

[1] *High. Soc. Trans.*, 1857, p. 117.

and lime as constituents of our clover soils, no chemical deductions could be drawn as to the cause of failure or success; neither did an investigation into the organic composition of the soils examined give any additional information. Long practice has shown that the application of gypsum is generally followed by beneficial results. Sulphate of magnesia, too, has been strongly recommended for the purpose. Some experiments at Braidwood gave the following comparative results:—

The crop without manure produced	125 stones per acre.
,, with 3 cwts. of gypsum, produced	200 ,,
,, with 1½ cwt. of sulph. magnesia, produced	290 ,,

Thus half the quantity of sulphate of magnesia gave an increase more than double that of the sulphate of lime.

The mechanical treatment of the soil has been assigned by some as the cause of failure; and rolling, pressing, and consolidation, by keeping sheep penned on the field, have been recommended as the remedy. Mr. Berkeley, to whose opinions we are obliged so frequently to refer, is inclined to trace the cause of the disease to infection, from the decaying vegetable matter of previous crops in the soil in which it is grown. He says[1]—"Now, as clover is usually sown with barley after a crop of turnips, portions of which are always buried with the plough, it is not impossible that occasionally, though not always, the plant may be impaired in constitution in an early stage of growth from this cause, though the evil is not apparent in general, or at least is not observed until the following year. We have examined the roots of sick clover repeatedly, without ever finding any unhealthy appearance about them, or the slightest trace of any fungus spawn, which might affect them. It is the part above the ground which is the seat of the disease. The leaves lose their healthy green, and ultimately the base of the stem, or what is

[1] *Agri. Gaz.*, 1860, p. 10.

often called the crown of the root, decays, and the whole plant falls a sacrifice. Minute fungi may exist upon the leaves, but if so, they are in no way the cause of evil. It is indeed possible that in some instances there may have been some original constitutional defect, which was inherent in the seed; but such defects usually show themselves at an early stage of growth, and we are far more inclined to attribute the condition of the plant in the majority of instances to infection from decaying matter than to the cause just named. Mr. Berkeley continues the subject by saying, "that whatever may be thought of the notion just put forward as to the origin of 'clover sickness,' we would strongly recommend no one to attempt to sow clover seed where a large portion of the crop has failed, for the produce is almost sure to be diseased. In the case of oats we have proved, by consecutive experiments, that seed from diseased plants will produce a diseased offspring, and we do not doubt that even where the original cause of disease may not exist, it may be propagated by seed, an evil which no one can guard against till measures be taken by agriculturists to insure a supply of seed from healthy sources. More, we are convinced, depends upon this than is generally imagined."

In the last number of the *Highland Society's Journal,* in a well-written paper on Clover and Turnip Sickness, Mr. Russell, while agreeing generally with the foregoing opinions, appears to think that they do not quite meet the case, and that the clover plant suffers less from any infection generated by the decaying organic matter in the soil, than from its existence there checking the roots of the growing plants from exercising their full powers of assimilating the inorganic substances necessary for their healthy development. In the case of clover, for instance, he says, "There is an immense quantity of vegetable matter left in the soil when a clover stubble is ploughed under. The fresh succulent roots are ramified over a great extent of the superficies of the soil. If clover is sown on the same land too frequently, the young roots, coming in contact with the decaying remains of the former crop, may be attacked by mildew; or more probably the rootlets do not exercise their functions in a healthy manner, and failing to take up a proper quantity of earthy matter, render the plant weak and sickly. When in this state mildew or insects may attack the plant, and complete its destruction." The presence of fungi is generally considered as indicative of the existence rather than the cause of disease: they are only present when the health of the structure has been impaired by other influences. Mr. Russell further observes, "that the presence of certain kinds of decaying vegetable matter weakens the constitutions of those plants that require a change of soil, by interfering with the absorbing powers of their roots. These are rendered unable to dissolve and absorb the food which is diffused through the mass of the soil, and as a consequence, assimilation does not take place in a healthy manner; the fluids circulating in the vessels of the plants not being in a sound state, become a fit nidus either for the growth of fungi or the attacks of insects." As Mr. Berkeley observes, "The clover roots are rarely found having any unhealthy appearance about them. The disease is first seen in the leaves, and afterwards extends to the parts below the surface. The upper parts of the plant, being more exposed to all the variations of the atmosphere, are the first to give way when the constitution of the plant is weakened by other causes. In some cases infection may result from contact with decaying matter; but we consider that the evidence favours the view of the diseased conditions arising from the want of proper nutriment being taken up by the roots."

Here we have the opinions of two competent men, the one our highest authority on pathological botany, the other ranking high both as a scientific and practical agriculturist. From these, although they contain nothing definite, we may at least conclude that anything that tends to reduce the healthy condition of the plant renders it more susceptible to the influence of disease, and that one form of disease may be readily engendered by the decaying organic matter with which it comes in contact in the soil. It would be desirable in any experiments on the subject to see how far the practice of feeding down the young plant may affect its vigour and power of standing uninjured through the winter. If this, as we are inclined to believe, exerts a debilitating influence upon it, it will, when practised, account for much of the loss sustained either from the plants being killed out by the winter weather, or so reduced in vitality as to fall ready victims to any form of disease by which they might be visited.

The clover plant sometimes suffers from "mildew," especially on poor thin soils, where the annual varieties are principally grown. This form of disease, however, rarely injures them to any extent, and they speedily recover their condition after a fall of rain; indeed, the Red clover (*T. pratense*) is a very good rustic hygrometer, as its leaves are always more or less flaccid in dry hot weather in summer, but on the appearance of rain they stand up, and become firm and stiff.

The diseases of plants, especially those cultivated on our farms, have been so little studied in this country, and are so little understood, that there is no doubt we annually sustain enormous losses in our crops, without being at all aware of the fact, or if we are aware of it from the disease showing itself in too marked a manner to be unnoticed, without being able to apply any remedies, owing to our ignorance of its true causes. A question may here naturally present itself, as to what constitutes a disease, and the botanist would reply that, strictly speaking, every departure from the normal healthy condition of a plant would constitute a disease. In agriculture, however, we should take exceptions to this rigid adherence to principles, as one of the objects of cultivation is to depart from normal conditions, and to induce increased development of various parts of the plant, which must have some influence upon its natural condition and habits of growth. We should rather look upon disease as existing only when the plants cultivated, whatever they may be, do not possess the power of carrying on their processes so as to complete satisfactorily that state of development which constitutes the difference between a vigorous and an unhealthy crop. Mr. Berkeley, in an excellent article on the Diseases of Plants,[1] tells us that "there are two main causes of diseases; the one arising from the derangement of the conditions necessary to healthy growth, the other from injuries inflicted directly by other organized beings, whether belonging or not to the same great division with themselves. The first class will comprise what may be considered as internal disease, so far as it is independent of the presence of other organized beings, as well as all injuries arising from the greater or less intensity of those outward agents and elements which are conducive in their proper proportion to healthy development; the latter, injuries derived directly from the depredations of beasts, birds, or insects, or from the parasitic development, whether of phenogams or cryptogams, as also the diseased structures due to the presence of insects, whether in a more or less perfect state of development. It is quite obvious that the more usual distribution of the diseases of vegetables into internal and external is not tenable without giving some latitude to the terms; for far the greater portion of diseases called inter-

[1] *Cyclo. of Agri.*, p. 656.

nal are produced by outward agents, and no diseases can be more strictly internal than some of those produced by parasites, such as "smut," "bunt," and "vibrio."

A mere glance at the vegetable kingdom, as it is distributed over the face of the globe, is sufficient to show that plants are greatly affected by inorganic agents. Not merely is there a visibly marked difference between the vegetable productions of the tropical and temperate zones, but in proportion as there are differences of soil and altitude; we see this plainly enough at home. The driest and the wettest places have their peculiar denizens; the meadows and the woods have again theirs; and, according to the nature of the soil, these are clothed with different vegetables, which are wholly absent in some spots, and in others barely maintain an existence; while very slight alterations of drainage or tillage completely drive away some, and others take their place. Some species, again, which abound for miles in certain districts—as the foxglove and the red campion—in other tracts, where they flourish perfectly when introduced into the garden, are wholly wanting. If resident in a mountainous district, especially one that ascends up as high as perpetual snow, we see distinct zones of vegetation; and if the plants of the upper zones are brought into the garden, with every care and skill, and a perfect knowledge of their exigencies of a long rest, and of abundant light and warmth at the period of active growth, it is frequently found impracticable to preserve them.

It is clear, then, that certain conditions of soil, atmosphere, and other inorganic agents, are not merely necessary to the healthy development of particular vegetables, but that any great derangement of these conditions, or of any one of them, is sufficient to prevent their growth; for if this were not the case there could not exist, as there does at present, a distinctly marked distribution of vegetable forms. These changes are often inappreciable to our senses and powers of observation, and consequently disease may often be set up in plants which come within our care and notice, without our being able to assign the reason or to suggest the remedy.

Good cultivation consists in adapting the mode of treatment to each particular plant; and without some knowledge of general principles success is seldom attainable. By cultivation plants are led more and more from their natural habits of growth: in some the conditions are so widely different as to interfere greatly with their vital powers; in others, again, they exert a less debilitating influence. At all times, however, a departure from normal conditions engenders a susceptibility to disease, which may exist in every degree, from a simple constitutional derangement up to such an aggravated form as to be fatal to the plant. In the first stages altered conditions may be able to arrest the progress of the malady, and it is here that the observation and knowledge of the cultivator is called into play to apply the proper remedy. In a state of nature, when disease is once set up there is but little probability of amendment, as the plants are confined to the spot on which they grow, and there is no power of selection. The air is imbibed by the leaves, whatever be its quality, and the moisture and inorganic matter by the roots, in whatever state they may be, and however they may be deficient in the constituents necessary for the healthy nutrition of the plant; and if these are not suitable to the nature and requirements of the plants, we have at once the elements of internal disease.

Diseases from external causes vary very much in their origin, and in their mode of exhibiting themselves. In some places it is not an unusual thing to see the clover fields marked in various places by large circular patches, on which the plant is entirely obliterated, though growing vigorously all around them. These spots are occasioned by the existence of a curious parasitic plant, the "clover dodder"—*Cuscuta trifolii*—which attaches itself to the clover, feeds upon its juices, and thus depriving it of its own means of supporting itself, the plant speedily is killed. This pest is generated from seeds like our ordinary plants, and is no doubt sown down in the field with the clover and grass seeds, among the former of which it is frequently found mixed to a greater or less extent. It appears to remain in the soil without germinating for a longer period than the clover, as it is rarely seen exhibiting its characteristic effects until the straw crop has been harvested and the young clover been exposed to the air and light. Its habit, and growth, and mode of attack have been well observed, though, from the recent discussions already alluded to, the practical farmers who suffer most from its visitation seemed to be but very imperfectly acquainted with its nature. The plant, which is usually sown with the clover, especially where foreign seed has been used, commences its existence like any other plant: the seed germinates, sending its radicles downwards into the soil, and a shoot of a thread-like nature upwards above its surface. At this period of its life it is not a parasite, but derives its food from the soil by means of its roots, as other plants. It cannot, however, carry on this existence long; and if it does not meet with some congenial plant to which to attach itself, it speedily withers and dies. If it succeeds in doing this, it protrudes a sucker, which, coiling round the plant and forming fresh suckers as it grows, extends out in all directions and envelopes every plant within its reach. No sooner has it firmly fixed itself upon any part of a plant than it has a new and perfectly independent seat of life; and as it is incessantly coiling and separating and attaching itself again, a single plant is speedily in the condition of a polype; so that, if it be cut into a thousand pieces, each piece will immediately go on growing as if nothing had happened to injure it. Tearing the "dodder" to pieces, then, by harrowing or raking, so far from assisting to extirpate it, only multiplies the mischief instead of arresting it. The accompanying woodcut, showing the early growth of the dodder plant,

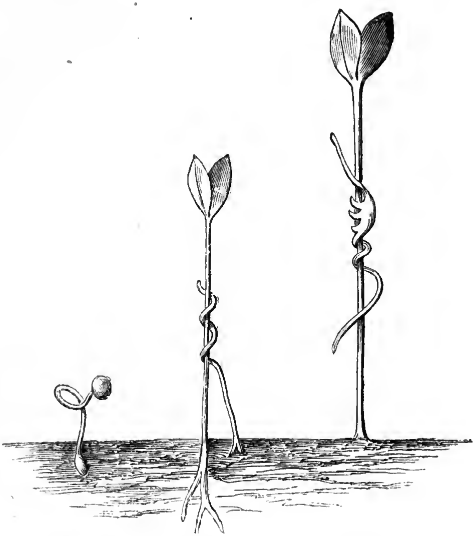


Fig. 1. Fig. 2. Fig. 3.

and its mode of attaching itself to the plant on which it feeds, is taken from Professor Buckman's paper on the subject in the *Agricultural Gazette.*[1] Here we see the plant (*fig.* 3) just elevated above the soil, bearing the testa or seed-covering on its apex: its next state (*fig.* 2) is more advanced in growth; it has now become sufficiently developed to clasp a plant and wind itself round the stem. In four or five days more, if again examined, it will be seen, as in *fig.* 3, to have coiled itself in three or four turns tightly round its victim, during

[1] *Agri. Gaz.*, 1859, p. 746.

which time this latter has been enlarging in size, which increases the compression of the coils round its stem, thus causing the bark or skin of the plant to become more delicate, while the parasite is preparing a series of aerial roots to penetrate it. Having done this its new position is established firmly, its own natural root dies away, and thenceforth its true parasitic growth goes on without a check until the juices of its victim are completely exhausted, by which time it has itself probably arrived at maturity,

flowered and perfected its seeds, as is seen in the woodcut, which are generally left to fall to the ground, and thus be ready to resume their growth and attacks upon the crop of the following season.

The appearance of the plant itself, and of the effects produced by it, are sufficiently remarkable to prevent their being passed over unnoticed by even the least observant farmer. It has the peculiarity of possessing no leaves, consisting of merely a mass of twining suckers, of a semi-transparent nature, and a yellowish white colour, very much resembling, to use Professor Henslow's words, "fine, closely-tangled, wet catgut." The flowers, which are very abundant, are white, tinged with pink, and give the plant a very beautiful as well as singular appearance—appearing in knotted bunches, each bunch containing on the average about sixty seeds, capable of producing as many plants. As it is an annual it could be readily disposed of if we could only arrest its flowering; but that, owing to its mode of growth, being hidden in its early stages by the foliage of the clover, is very difficult; while, from its great powers of increase, a few bunches of flowers would produce seed enough to stock the ground for another growth. The best mode of treatment is, undoubtedly, to dig up the surface soil to a distance of 2 or 3 feet all round the spot in which it is noticed, and then to burn the soil and vegetable matter altogether, so as to destroy any seeds that may already have been formed and shed. Any attempt to extirpate merely the injured plants will be ineffectual, as the suckers, which are quite sufficient to continue the growth, extend themselves in all directions round the spot, and some would be sure to be passed by unobserved.

On the Continent this form of injury has been the subject of experiment, and a remedy, which is said to be entirely successful in its application, has been recommended. This is the common green vitriol (sulphate of iron), which should be dissolved in water at the rate of 1 lb. to the gallon, and distributed by a watering-pot over the infected spot. The action is immediate on the "dodder," which it speedily destroys, while the clover and other plants are comparatively uninjured by it. Two applications on succeeding days are said to be quite sufficient, and the clover plants, if not already too much injured by the parasite, soon resume their vigour, and the bare and blackened spot disappears. This is a simple and inexpensive remedy, and well deserves a trial. At the same time, it is always more desirable to prevent than to cure; and this may be materially secured by a little attention to the seed, if, on examination, any doubts exist as to its purity and freedom from dodder. The seed of the latter differs in colour, size, and shape from the clovers, being of a grayish colour, but little more than half the size, and spheroidal, or rather like the divisions of the orange in shape. A "No. 17 sieve," Dr. Lindley tells us, will allow the dodder seed to pass through, and will detain both clover and lucerne seed.

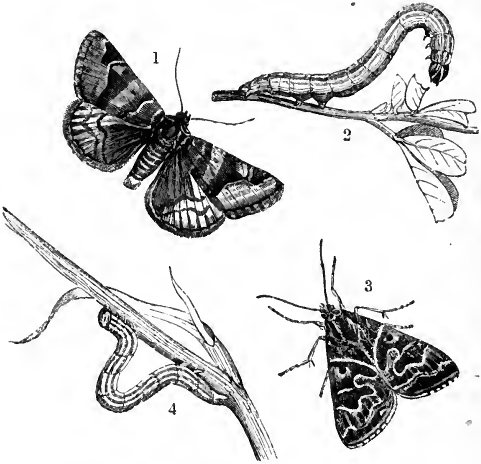
The clover plants are also liable to great injuries from another class of parasitical plants, which differ in their mode of attack from the dodder, which latter attaches itself to the *stem* above the surface, while these confine themselves to the *roots* of the plant. Foremost amongst these are the "broom rapes"—the *Orobanche major* and *O. minor*—a class of herbaceous leafless plants growing parasitically upon the roots of other species, the two members specified confining themselves chiefly to clover and allied genera of leguminous plants. The habit of the "broom rapes" is to attach themselves to the end of the roots; the latter then swell and form an enlargement, which serves as a base from which the parasites can draw their supplies of food from the circulation of the plant they have fixed themselves upon. It is most probable that the seeds of these plants are also sown down with the clover. They differ, however, greatly from them in appearance, being of a grayish colour, and less plump and smooth in the skin; and as they are much smaller in size, they can readily be distinguished and separated by using a sieve of the size given above.

In Belgium and Holland, where this class of parasite is very abundant, the only effectual way of getting clear of it is to steep the clover seed in a weak alkaline solution, to separate it from the *Orobanche*, which is supposed to be attached to the clover by a fluid of an oily nature, and this latter floats on the top, and is carried off as the water is poured away.[1] Two weeds very commonly met with in clover fields, the common heal-all—*Prunella vulgaris*—and the *Bartsia odontitis*, are also charged with exerting a similar injurious action on the roots of the clover plants.

The clover crop is infested by a numerous variety of *insects*, which destroy not only the herbage but the seed produce also; indeed, Curtis says that the clovers and artificial grasses are the nurseries of those myriads of flies, gnats, beetles, &c., which disperse, and, settling in the fields, carry with them blight and destruction. The amount of injury the crops suffer from them cannot be properly estimated. The farmer finds his crop thin and the leaves riddled; this is the work of a weevil, which will pay a visit eventually to his bean or his pea crop. His seeds fail, not yielding a tithe of the expected amount. Let him spread a white napkin on the ground, and shake and beat the clover-heads, and he will find the destroyer in myriads, probably in the shape of a little black weevil with a long pointed nose. There are also various caterpillars feeding on the foliage, which are less destructive, because they are less numerous, from their being kept under, in all probability by parasitic flies. The leaves of the plants, especially in their early growth, are liable to the depredations of slugs and snails, which have already been described at page 385, vol. i. The remedies there recommended—broadcasting soot, salt, or lime, or all mixed together—are equally serviceable here. Nitrate of soda is

[1] *L'Agriculture Pratique de la Flandre.* J. L. Van Aelbroeck. p. 283.

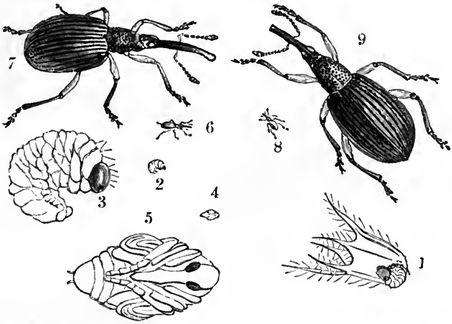
frequently used with great success, as it acts very beneficially on the growing crop. There are several caterpillars, too, that feed on the foliage of the clovers, lucerne, and allied plants. The large hairy caterpillars of the "clover eggar moth"—*Lasiocampa trifolii*—in some seasons and districts, when they are abundant, consume large quantities and do considerable damage to the crop. The caterpillars of the "burnet moth"—*Euclidia*



1. Burnet moth, *Euclidia glyphica*. 2. Caterpillar of do.
3. Shipton moth, *Euclidia mi*. 4. Caterpillar of do.

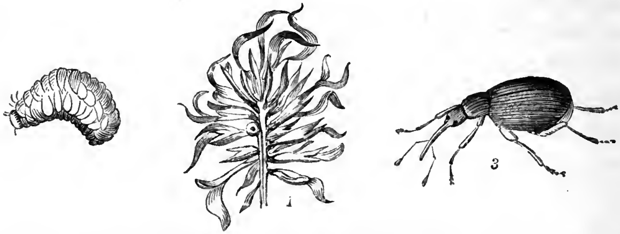
glyphica—and of the "shipton moth"—*E. mi*—two very pretty moths, which may very commonly be seen flying over the clover fields by day, and sporting in the sunshine—are equally injurious in their habits. These moths lay their eggs on the stem and leaves of the plant, on which the caterpillars commence the work of destruction directly they are hatched. Happily this work is checked, and their numbers reduced by sundry parasitic flies of the ichneumon family, among which the *Peltastes dentatus* has been particularly noticed as attaching itself to the moths just mentioned.

The "spotted and striped pea-weevils," described and figured at page 258, vol. i., are very destructive to the clover crops also, frequently destroying a large proportion of the plants, in their early stages, or nibbling and injuring them at a later period of the growth of the crop. But the greatest pests to the clover crop are a family of very minute weevils, the "purple clover weevil"—*Apion apricans*—



1. Floret attacked by larva of weevil. 2 and 3. Larva (natural size and magnified). 4 and 5. Pupa (natural size and magnified). 6 and 7. Clover weevil, *Apion apricans* (natural size and magnified). 8 and 9. Do. *Apion assimile* (natural size and magnified).

and a similar species—the *A. assimile*—which infest the plants of the Red clover, and the "yellow-legged weevil," *A. flavipes*—which is equally destructive to the White or Dutch clover. These insects not only injure the plants by nibbling and eating through the leaves, but seriously affect the seed produce, by breeding in the flower-heads, and rendering them partially or entirely abortive. They appear to be in greatest abundance when the clover crop is in flower, at about which period the female lays her eggs. The flower-heads attacked by them soon exhibit symptoms of maturity in advance of the others, and become withered in appearance. If they are opened (as shown in the following woodcut) and examined, three or four little fat white maggots, with small brown heads, will be found curled up at the base of the calyx of the flowers, and eating the seed from the outside of the calyx, through a hole which they had first made. They change to pupæ in the same situation, and when



1. Section of flower-head of *Trifolium pratense* injured by weevil. 2. Grub or larva of do. 3. Clover weevil, *Apion apricans.*

the beetles hatch, the females proceed, after impregnation, to a fresh head of flowers, to deposit their eggs. Curtis[1] gives some reports of the injury these small insects are capable of inflicting on the clover crop:—"I have a field of clover," says one of his correspondents, "which has been twice mown, and there is now a fine aftermath. The part of the field near the stack has been lately attacked by a small black weevil, which advances in a semicircle, totally destroying every leaf, leaving only the fibre. I should think there are on many of the leaves as many as 100 to 150. Since last night they have eaten nearly as much as would have kept a sheep, they destroy every leaf in their progress." In the *Transactions of the Linnean Society*,[2] a statement is given of the losses inflicted on a crop of clover seed by this weevil. The produce of a small field of 4½ acres gave a return in seed of £41, 17*s.* 6*d.* in one instance, while the same acreage of crop infested by weevils produced only a money return of £18, 15*s.*, showing a deficiency, or rather difference, between the two crops of £23, 2*s.* 6*d.* The insects are of extremely rapid growth, and multiply very

[1] *Farm Insects*, p. 477. [2] *Trans. of Lin. Soc.*, vol. vi. p. 142.

fast; and owing to their great numbers and powers of increase, they are capable of inflicting great injuries on the crops in which they have been observed."

Here, as indeed in well-nigh every case we have studied, however, nature has provided a remedy, in the shape of the *Ichneumon braconide*, one of that numerous and beneficent family which no doubt is intended specially to check the excessive multiplication of insects injurious to our crops. These natural means, however, do not always save us from the loss of our crops, which might be materially prevented by taking the precaution to cut early, and feed off while green, the clover crops which are known or supposed to be much infested by the weevils—to carefully avoid allowing the clover to remain for more than two years in the same ground—and to avoid allowing clover infested by the weevil to stand for seed purposes. Curtis recommends that the field intended for seed should be swept with a light bag-net, directly the flowers first begin to show themselves, in order to get rid of the weevils, which would, if allowed to remain and multiply, effectually destroy the chances of a crop of seed. The contents of the bag could readily be destroyed by immersion in hot water, or by the vapour of turpentine in a covered vessel.

It would appear also that clover crops are not exempt from the inroads of the curious little worms called *Vibrio*, for it is stated by Mr. Murcott, of Leamington,[1] that he had discovered in the interior of Red clover seed some worms which he believed to be a *Vibrio*.

The *chemistry* of our clover crop has received considerable attention of late years, and we are now made pretty well acquainted with both the organic as well as inorganic composition of the several species met with in cultivation in this country. The average composition of the plant, in its natural or green state, may be taken at

[1] *Agri. Gaz.*, March 20th, 1852.

about 80 per cent. of water, 18 to 19 per cent. of organic matters, and 1·5 to 2 per cent. of inorganic matters or ash. When dried in the air and made into hay these proportions are altered by the evaporation of about three-fourths of the water, the clover losing from two-thirds to three-fourths of its original weight. The composition of the inorganic matter or ash of the different species has been determined by several chemists, in this country chiefly by Dr. Voelcker and Dr. Anderson, the chemists to the Royal Agricultural and the Highland Society respectively, who have furnished us with the following results of their examinations:—

	1.	2.	3.	4.	5.	6.
Potash, ...	14·85	31·24	31·23	23·451	29·090	24·928
Soda..................	1·40	...	...	...	...	3·039
Lime,.................	35·39	26·32	25·98	34·286	26·753	34·908
Magnesia,............	11·22	10·34	10·05	12·605	8·974	12·176
Peroxide of Iron,...	·97	1·54	1·81	1·204	1·413	1·470
Phosphoric acid,....	6·35	5·01	8·22	8·496	4·034	7·352
Sulphuric acid,......	4·18	3·63	3·93	3·650	3·502	3·718
Chloride of Sodium,	2·36	8·45	10·08	2·777	4·621	11·096
,, Potassium,	2·96	11·08	5·83	12·098	18.944	...
Silica,................	3·34	2·39	2·86	1·433	26·73	1·313
	99·95	100·00	100·00	100·000	100·000	100·000

These analyses, which relate to the composition of the Red clover (*T. pratense*) only, show that the plant, from its powers of partial substitution of one mineral substance for another, is able to carry on its growth in a great variety of soils.

No. 1 was grown in England from English seed.
,, 2 was grown in Edinburgh from English seed.
,, 3 was grown in Edinburgh from seed from Germany.
,, 4 was grown in Edinburgh from French seed.
,, 5 was grown in Edinburgh from American seed.
,, 6 was grown in Edinburgh from Dutch seed.

The composition of the ash of the other species of clover met with in cultivation closely resembles the foregoing :—

	1.	2.	3.	4.	5.
Potash,	14·33	23·360	15·541	25·80	23·26
Soda,	3·72	...	...	...	...
Lime,	26·41	26·872	30·251	16·00	18·61
Magnesia,	8·15	19·855	10·857	7·78	8·34
Oxide of Iron.	1·96	1·600	1·293	1·30	·86
Phosphoric acid,	11·53	6·450	6·197	4·48	7·15
Sulphuric acid,	7·21	4·259	3·334	4·00	4·42
Chloride of Sodium,	4·94	...	2·341	7·57	5·98
Chloride of Potassium,	...	15·943	15·514	10·86	11·98
Silica,	3.68	1·581	1·402	1·64	1·01
Charcoal and Carbonic acid,	...	...	...	13·71	15·51
	99·96	100·000	100·000	98·48	100·00

No. 1 is of White clover (*Trifolium repens*), by Mr. Way.
,, 2 and 3 of Cow-grass (*Trifolium medium?*), by Dr. Anderson.[1]
,, 4 and 5 of Yellow clover (*Trifolium procumbens*), by Dr. Anderson.

The organic composition of the various species, by which their relative feeding values may be estimated, has also been carefully determined by Dr. Voelcker and Dr. Anderson.

The first series of determinations relates to the samples of Red clover—*T. pratense*—only, whose inorganic composition is given in the foregoing analyses.

	1.	2.	3.	4.	5.
Nitrogen compounds,	3·606	2·31	2·81	2·25	2·87
Other organic compounds,	13·864	11·09	14·02	12·29	15·57
Ash (mineral matter),	1·890	1·30	1·49	1·95	1·58
Water,	80·640	85·30	81·68	83·51	79·98
	100.000	100·00	100·00	100·00	100·00

The second series comprises several other species whose

[1] It is not quite clear which species of clover is here meant. The analyses are stated by Dr. Anderson to have reference to the *T. medium* or Cow-grass; whereas this species is properly the Zigzag clover or Marl-grass—the Cow-grass being the *T. pratense perenne.*

inorganic composition has also been given in the analyses already quoted.

	1.	2.	3.	4.	5.	6.	7.
Nitrogen compounds,	2·25	3·19	3·25	4·52	4·82	3·28	3·44
Other organic do.,....	17·53	13·13	12·31	10·26	16·45	13·53	17·16
Ash (mineral matter),	2·73	1·92	1·88	1·57	2·06	1·89	2·02
Water, ...	77·49	81·76	82·56	83·65	76·67	81·30	77·38
	100·00	100.00	100·00	100·00	100·00	100·00	100·00

No. 1. Cow-grass (*Trifolium medium?*), Duke of Norfolk's variety.[1]
,, 2. ,, ,, Ordinary.
,, 3. Crimson clover (*Trifolium incarnatum*).
,, 4. White or Dutch clover (*Trifolium repens*).
,, 5. Alsike clover (*Trifolium hybridum*).
,, 6. Bokhara clover (*Melilotus leucantha*).
,, 7. Yellow clover (*Trifolium procumbens*).

These analyses are very valuable, as they afford a sound and safe means of calculating the feeding values of the several species, and tend to show how greatly we err in the estimates we have formed in reference to some of them. The White and the Yellow clover are generally looked upon as very inferior for forage purposes to the Red clovers, whereas their percentage of organic compounds, especially of those containing nitrogen, is fully equal to the best samples of the Red species. Again, the Alsike clover appears to be a valuable species, and to possess high feeding properties; and as this is a bolder plant, of a more vigorous growth than the White and Yellow species, its produce per acre, combined with large percentage of organic compounds, should obtain for it a more general introduction into our "seed mixtures" than we at present are accustomed to recommend.

[1] See footnote in preceding page.

THE LUCERNE CROP.

THE next crop for consideration among our Forage Crops is the LUCERNE, which, although not cultivated to any great extent in this country, in warmer climates than our own arrives at such a luxuriant growth that it usually takes the first place in the estimation of keepers of any kinds of stock. It belongs to the same order as the clovers—*Leguminosæ*—and, indeed, is closely allied to the genus *Trifolium* in all its leading botanical characters. It is a native of Southern Europe, and has become acclimatized to the warmer districts of this country, and been cultivated from a very early date. Lucerne was well known in Roman husbandry: nearly all of the old Roman authors speak of it in high terms. Columella especially praises it, and estimated it as the choicest fodder, because it lasted many years as a crop, and could be cut down four, five, and often six times each year. It enriches, he says, the land on which it grows, fattens the cattle fed on it, and is often most valuable as a remedy for any beasts that may be sick. He tells us that a "measure of land" equal to about three-fourths of an imperial acre was abundantly sufficient to keep three horses during an entire year.[1] Palladius speaks of it in precisely the same terms.[2] Pliny agrees with Columella and Palladius in respect to the number of cuttings which the crop gives in the course of the season, but differs from them as to the time that it lasts; and asserts that, instead of ten, it will

[1] Columella, lib. ii. cap. xi.

[2] Palladius, lib. v. tit. i.

stand and be productive for thirty years.[1] Each of these authors gives copious directions as to the cultivation of the crop so highly valued by them—directions which are equally applicable at the present day, and upon the observance of which, indeed, the permanence and the produce of the crop mainly depend. They all agree that the land should be deeply ploughed and got into fine tilth, all stones and rubbish removed, manure liberally applied, and the seed sown carefully, and rolled in lightly, so that it be not too deeply buried. Strict injunctions are given to extirpate the weeds, as they come up during the whole duration of the crop, which ought to be cut only once the first year; and in after years it may be cut four, five, or six times, especially if water be given to it after each cutting. It is recommended not to sow the seed until the end of May, so that the young plants, which are very tender, may run no risk of injury from spring frosts; and although the practice of the Roman agriculturists was to sow it broadcast, it never exceeded the rate of five pecks to the imperial acre.

We find lucerne mentioned by several of our own early agricultural authors as being known to them, and as having been met with in cultivation in small plots; but we have no evidence of its being subjected to regular field cultivation in England prior to the seventeenth century. The introduction of artificial grasses and their companions—the clovers and other leguminous plants—into Scotland was at a much later period. The Earl of Haddington and Mr. Cockburn of Ormiston are supposed to have been the first who introduced Red clover into East Lothian, between the years 1720 and 1730; and Lord Stair is entitled to the credit of having introduced both lucerne and sainfoin into West Lothian, about ten years afterwards. Although cultivated only to a limited extent in England, and still less in

[1] Plin. *Nat. Hist.*, lib. xviii. cap. xvi.

Scotland, where the climate is more suitable to other leguminous forage plants—the vetch, for instance—it is extensively grown in all southern climates—in parts of France, Italy, Spain, in South America, Peru, in India, Persia, &c. In the Channel Islands it may be seen in full vigour of growth, equalling the descriptions given of its produce by the old Roman authors.

Botanically, lucerne belongs to the order *Leguminosæ*, and constitutes the distinct genus *Medicago*, of which there are several species, though only two or three enter into cultivation in this country. Of these the most important is the *Medicago sativa*—Common Lucerne (*see woodcut*)—an erect-growing perennial plant, sending down its roots to a great depth in a suitable soil. The flowers are in racemes or clusters, and of a purplish-blue colour—appearing in June and July, when the plant reaches a height of about 3 feet. Under proper management, and in a suitable soil and climate, the produce is very great, and, owing to its perennial habit, the annual outlay for labour is proportionally small. It is never advisable to cut the crop the first year: in the succeeding season it generally yields a good bulky crop; but it does not arrive at full maturity until the third year, after which it will sustain its full vigour of growth for six or seven years more, when the roots begin to show symptoms of decay, and the vigorous habit of the plant declines.

MEDICAGO SATIVA—Common Lucerne.

Medicago lupulina—Yellow Clover or Nonsuch—is frequently mixed in small quantities with clover and other seeds, and sown down for artificial grasses. Its seeds, which are produced in much greater abundance, are consequently cheaper than those of any of the clovers; and it is questionable whether this circumstance may not contribute to the extensive cultivation which it receives, more than any real merit which it possesses. Although the produce is bulky, cattle are not generally fond of it, either in a green or a dry state, and only eat it when mixed with any other more palatable varieties of forage plants; therefore it is advisable that it should enter only very sparingly into mixtures.

MEDICAGO LUPULINA—
Yellow Clover or Nonsuch.

Medicago maculata—Spotted Medick or Hedge-hog Plant—is an annual, a native of this country and of Europe generally, and also of North and South America. The sandy districts bordering the sea line in the latter countries, which in the dry season present the appearance of sterile wastes, are, on the return of rain, almost immediately covered with the luxuriant verdure of this and of other allied species, so as to form rich sheep pastures; but their prickly pods often prove a considerable annoyance to the animals, and injury to the wool, by becoming so firmly entangled in it as to be separated only by hand-picking, which entails a considerable loss upon the producer for labour. With us the plant grows freely, even from seed imported from South America, without being influenced by the great change of climate. The stems are trailing, and much branched; the flowers are generally in pairs, small and of a bright yellow colour; the seed-pods closely, spirally twisted, with sharp curved spines thickly arranged on their exterior margin, so as to form round-shaped bristly balls, slightly flattened at the ends.

Medicago falcata—Yellow Lucerne—is a favourite species in Switzerland, some parts of Germany, and in the more mountainous districts of France. This species differs from the "*sativa*" principally in three particular characteristics, viz., in being of a more strong or more woody upright habit of growth—in the colour of its flowers, which is bright yellow instead of purple—and in its pods, which are only bent or sickle-shaped, instead of being spirally twisted, like those of the common lucerne. The only point of superiority which it possesses is its suitability for cultivation on inferior soils. Under equally favourable conditions of growth, it is neither so productive as the common species, nor so valuable as a forage plant for cattle, owing to its coarse and woody habit of growth.

Lucerne is more particular in its choice of soils than most of the preceding crops. It delights in soils of a deep, dry character, in which its tap-root can penetrate low down into the subsoil, and find its necessary supplies of food and moisture. This class of soils would naturally be of a light description: vegetable moulds, sandy loams, and even gravels, will carry good crops, especially if a moderate proportion of lime be present, without which none of the leguminous plants will thrive. Probably the best description of soils for the crop are the calcareous loams; for instance, where the green-sand formation comes in contact and is mixed up with the marls of the lower chalk. Here we find all the desirable conditions for the development of the plant: the soils are deep, dry, sufficiently free-working, and contain a good percentage of lime, besides the other fertilizing substances always met with, in greater or lesser proportions, in marls.

The alluvial deposits on a sandy substratum, and the warped soils of estuary formations are generally well adapted for the crop. The stronger soils, as the clays and clay loams, are not suited in this climate for lucerne; they are not only too compact to allow the roots to develope themselves freely, but they are too moist and cold for its growth, which generally is of a very unsatisfactory character. On the Continent and in good climates large crops are frequently obtained, even on clay lands; but in all cases, and everywhere, the lighter class of soils is that most suitable to its growth.

Lucerne can hardly take a regular place in the rotation, as the principal feature in its cultivation, and that which distinguishes it from the other forage crops, and indeed gives it a distinct value, is its permanent habit, which enables it to continue as a productive crop during the whole period of our longest rotation. It is generally, therefore, grown for its own intrinsic value as a forage crop of a very productive character, and receives a special treatment, according to the object for which it is cultivated. As the crop is generally grown for home consumption only, the breadth cultivated is not very large, rarely exceeding a few acres in extent. Where grown, however, for sale, as in the neighbourhood of large cities, the cultivation is frequently on a more extensive scale.

In preparing the land for lucerne, the point of greatest importance is to effectually clear it of all weeds, whether annual or perennial, as unless this be thoroughly done before the crop is sown, they can never be eradicated afterwards, and will speedily become rivals in the field with the cultivated plants, and, owing to their superior vigour, in the course of two or three years will obtain mastery over them, and greatly diminish their produce. In order to secure this and the other necessary conditions for the growth of the plant, it is strongly recommended either to subsoil, or, better still, to trench the land intended for the crop, say 16 to 18 inches deep; the grubber, then passed well through the soil, and followed by the harrows, will reduce the soil into a good tilth, and effectually clear it of all rubbish, which should be collected and burned on the field in the usual way. This operation is no doubt attended with a considerable expense per acre; but whatever may be the amount, it is money well laid out, when its results are compared with those where the work has been neglected, and the crop has been got in in the ordinary manner.

On farms where the land has been kept in good order and regularly cleaned, it is best to take a straw crop before lucerne. In that case, the autumn gives a good opportunity of cleaning the stubbles, and also of subsoiling or trenching, as may be determined upon, and the stubble serves to keep the land open during the winter fallow. When, however, the land intended for lucerne has been neglected, and is in a dirty condition, it is better to take a fallow or root crop instead of the straw crop; the land has thus a good chance of being cleared of its weeds during the growth of the roots, and of being left in a more fit state for the succeeding crop. In such case it is perhaps best to feed the roots off on the land, either in part or in whole, by which an equivalent amount of farmyard manure would be saved. In the spring, previous to sowing, the land should be again carefully gone over with the grubber and harrows, and, if necessary, with the plough, so as to get it into the required state. When this is satisfactorily accomplished, the manure intended for the crop should be distributed and covered in by the plough in the way already described. The proportion of manure should be, of course, determined by the nature and condition of the soil. On the lighter class of soils it is desirable, as a rule, always to give the manure in smaller quantities and at shorter intervals than on the stronger class of soils; and of course a soil in low condition requires more assistance in the shape of manure than one that has been kept up in a state of high fertility. In any case it is important that the land intended for lucerne should be in good heart as well as in a fine tillage condition, as much of the subsequent productiveness of the crop depends upon the earlier stages of its growth. If these be favourable, the plant gets well rooted in the soil before the winter sets in, and in the following spring throws up stout vigorous stems and leaves, which cover up the spaces between the rows, keep down the annual weeds, and furnish a supply of green food ready for use at a time when it is so valuable for all kinds of stock. If the tillage preparation of the soil, however, has not been duly attended to, and if its general condition has been neglected, the plant will be thin and stunted in its growth: the first winter will tell its tale upon the more weak and sickly plants, while those that survive will have to struggle on, during the rest of their period as a crop, with the natural denizens of the soil, which are sure to take full toll out of any manures that may from time to time be applied, and in the course of a few years to replace them in the field.

For all the purposes of the crop no manure is so well adapted as good farmyard dung, which may be applied either in a rotted or in a green or fresh state, and either at the time of the autumn or of the spring preparation of the land—remembering always to make a due allowance for the proportions necessary when applied in these two different conditions, and also that dung, in its green state, contains a less proportion of fertilizing matter immediately available to the crop than when it has been well rotted, and consequently needs some addition in the shape of a readily soluble artificial manure. For this purpose nothing is better than Peruvian guano, to which gypsum (sulphate of lime) may always be added with advantage, as it not only dilutes the guano and assists in its more equal distribution over the surface (see p. 302 and 420, vol. i.), but is in itself a valuable manurial application to the crop. Where a fair dose of farmyard manure has been given, from 2 to 3 cwts. of Peruvian guano, carefully mixed with from half a ton to a ton of gypsum, will generally be sufficient, and may either be broadcasted at the time of sowing and harrowed in, or may be drilled in with the seed in the usual manner.

The best time for sowing is the latter half of the month of April; if sown earlier it is very likely to be checked, or even destroyed, by the frosty nights and mornings so frequent in this climate at that period of the year. Some care is required in the selection of seed, which is always of foreign growth, and therefore more open to mixture than if grown under the inspection of our own seedsmen. It is most important that it should be well matured and quite fresh; even the second year a considerable percentage refuse to germinate, and thus necessitate a larger quantity per acre to insure a plant, than if fresh seed were used. The Dutch and French seed are the best. The seed is larger in size and paler in colour than clover, and should always be plump and of a bright appearance. Adulterations may be detected in the manner already described in regard to clover seed. The quantity to be sown per acre varies according to the mode adopted. For drilling, from 7 to 10 lbs. are sufficient; for broadcasting, about double that quantity—15 to 20 lbs.—are generally used. For all purposes, however, drilling is always preferable to broadcasting; only half the quantity of seed is required, it is more equally distributed and deposited in the soil, and affords an opportunity of using the hoe more freely and more economically in keeping down the weeds, thus securing more productive returns.

Lucerne is sometimes raised in a seed-bed and transplanted into the field, a practice which has been recommended by some of the earlier authors as producing in rich deep soils even greater returns than by the ordinary method of drilling. On such soils it is recommended to nip off the main tap-root to about 8 or 9 inches long, so as to induce the formation of lateral roots that should ramify through the upper layers of the soil. On the Continent this practice is still followed in many places; it can, however, only be admitted where either the breadth to be planted is very limited or manual labour very cheap; at the same time a small patch of lucerne raised in the garden is very useful to furnish plants for any blanks that may occur in the field.

In our present advanced system of farming, lucerne is generally sown by itself as a distinct crop, so that it may receive the tillage treatment so important in its early growth. The old practice, however, was to treat it in the same manner as clover, and to sow it down with a straw crop, and thus get a return from the field during the unproductive period of the lucerne crop.[1] On light dry soils this practice is probably less objectionable than on rich deep soils, as the growth of the grain would shade the young plants from the action of the sun, and at the same time preserve the surface in a more moist condition. These advantages would, however, be shared equally by the weeds, from which it is so desirable to protect the young plant of lucerne. Where this mode is practised the straw crop should be drilled at wide distances—say 12 inches—and oats would probably be better than barley, as being less liable to be laid by the effects of weather. The seed, which should be only very lightly covered, germinates very quickly, the young plants appearing, under favour-

[1] *Annals of Agri.*, vol. xxv.

able conditions of soil and weather, in seven or eight days above the ground. Where grown by itself and drilled, the rows should be not less than 15 to 18 inches apart; if broadcasted, it is a good plan to send in the horse-hoes and cut them out into rows at about the same intervals.

The after treatment of the crop is very simple. The hoe should be freely used during its early growth, and the drills kept as clear as possible of every weed. It is generally more advisable not to touch it the first year, but if it has been got in early, and the growth be vigorous, and the plant very strong and healthy, it may be cut late in the season—say the end of August or September—taking care not to cut too close to the growth, but to leave two or three inches of stem untouched; under no circumstances, however, ought it to be pastured by any description of live stock, which we so frequently see turned on the clovers to their great injury. The following spring the growth commences early, and under ordinary circumstances admits of being cut the first week in May. This may generally be repeated a second and a third time, beyond which it is not prudent to take more in the second year. In after years, however, if due attention be paid to the crop both as regards tillage and manuring, four, five, and even six cuttings, from 12 to 18 inches high, may be obtained in the course of the season, of a rich and succulent herbage, of a highly nutritive character, and much relished by all descriptions of cattle. To obtain these results the crop must be kept as free as possible from weeds, and should receive a liberal dressing of good farmyard manure in the winter, or an equivalent in Peruvian guano mixed with gypsum as a top-dressing in the spring, to keep up the condition of the field.

The crop reaches its maximum productive power at about the fifth year, after which the weeds, even with the greatest care, are sure to increase, and the value of the crop to diminish in equal ratio, so that generally about the seventh or eighth year it ceases to be sufficiently productive, and is ploughed up to make way for some other crop. To take the full advantage of the crop it should be cut green, and carried at once to the yards or stables for the cattle or horses. If fed off by sheep or cattle, care should be taken not to feed it too close, as if the crown of the root is injured, the plant generally dies off during the next winter. In cutting it for soiling purposes, it is best to divide the daily supply, and cut it morning and evening as may be required, spreading it out as soon as cut. If cut all at once and left in a heap, it is apt, owing to its succulent nature, to heat and become less palatable to the cattle. Indeed, lucerne is, under any circumstances, apt to slightly purge cattle when first given to them; therefore it should be given sparingly, and increased as they become used to it; if allowed free access to it, they eat it with avidity, and are very liable to get "hoven" from it. These two casualties may, however, always be prevented by limiting the quantity, and by not allowing them to eat it until three or four hours after it has been cut. Lucerne is sometimes, but very rarely, made into hay, when the same precautions as to cutting and making should be taken as were recommended for the clover crop. Owing to the large proportion of moisture it contains it requires great care in stacking, and even where well got up, its bulk is smaller and its quality inferior to that made from clover, sainfoin, or vetches. It is very rarely grown for seed in this country. When a seed crop is desired, it should be taken at the end, immediately before the land is ploughed up again, as after the plants have once seeded, they never resume their former productiveness.

The gross produce per acre of green food when the crop is in full bearing is very large, from 25 to 30 tons being readily obtained, where attention has been paid to the cultivation and the plants kept clean and well manured. There are a great number of reports recorded in some of the older works on agriculture as to number of horses and of other stock kept upon the produce of a given area under this crop, and also of its value as a food substance for milking cows. We can readily form our own estimate on these points when we know its organic composition, and the weight per acre of the produce; we then can judge pretty correctly as to its real feeding value and what amount of stock it ought to keep.

Lucerne seems to be less affected by *disease* than the clovers. It is a far more delicate plant, and therefore will not grow successfully in the same climates. The peculiar disease which, in our ignorance of its causes, we term "clover sickness" has not been noticed; while, owing to the great depth to which the roots of the lucerne penetrate, it rarely suffers from drought and its consequent form of disease, "mildew," which tells so severely at times on the clover crop. Indeed, when lucerne is well rooted in the soil, it looks fresh and green, even during the hottest weather, when all around is parched and suffering.

The *insect* injuries to which it is subject resemble those described in regard to the clover crop. Slugs and snails are its chief enemies during the early stages of growth, the remedies for which have already been described. The common turnip-fly is also said, by Arthur Young, and others, to be very destructive to the young plant; to avoid which it has been recommended to set the seed in at the beginning of April, before the insect is about our fields. The same caterpillars which attack the clover are equally injurious to the lucerne, which also suffers from a beetle —the *Colaspis atra*—which, both in its perfect and the larva state, eats off the young leaves as they grow; the footstalks alone remaining; so that, instead of four crops, only perhaps two inferior cuts can be obtained.

This insect is very destructive on the Continent, and is a worse enemy to the lucerne than the *Apion apricans* is to the clover plant.[1] The lady-birds, especially the *C. impunctata*, are said to be injurious to the lucerne and clover crops, in their larva state, according to Hammerschmidt and Heeger, consuming the cellular tissue of the leaves. These insects, however, even if they do a little injury here sometimes, are known to be the farmer's friends, as their chief and favourite food is the *Aphides*, which so numerously and so prejudicially infest his crops.

The *chemistry* of lucerne does not appear to have received the same amount of attention in this country as that of most of the preceding crops, owing, no doubt, to the very limited character of its cultivation here. We have, however, several analyses to refer to by continental chemists—Sprengel, Hertwig, Buch; and we have also analyses of its composition by Mr. Way and by Dr. Anderson, which are quite sufficient to give us a correct estimate of its feeding and manurial qualities.

The organic composition of the fresh plant is given by them as follows:—

	Medicago sativa.	Medicago sativa.	Medicago lupulina.	Medicago lupulina.
Compounds containing nitrogen,...	3·83	3·01	5·70	4·48
,, not containing nitrogen, as				
Gum, sugar, &c.,...............	13·62	}	7·73	}
Fatty matters,..................	·82	} 14·37	·94	} 13·95
Woody fibre,...................	8·74	}	6·32	}
Ash (mineral matters),............	3·04	2·49	2·51	2·00
Water,................................	69·95	80·13	76·80	77·57
	[2]100·00	[3]10·000	[4]100·00	[5]100·00

The composition of the mineral matter or ash, which ap-

[1] *Ann. Ent. Soc. de France*, 1844, p. 271. [2] Mr. Way.
[3] Dr. Anderson. [4] Mr. Way. [5] Dr. Voelcker.

pears to average between 2·5, and 3 per cent. of the fresh plant, is thus given by Dr. Anderson and Dr. Voelcker:—

	Med. sativa.		Med. lupulina.	
Potash,	24·49	33·16	32·48	28·50
Lime,	18·31	24·79	20·14	22·80
Magnesia,	4·64	6·28	9·80	10·22
Peroxide of Iron,	1·98	2·68	1·64	1·05
Phosphoric acid,	5·75	7·80	5·64	8·77
Sulphuric acid,	4·27	5·79	5·03	5·42
Chloride of Potassium,	10·35	14·02	13·67	14·68
,, Sodium,	1·70	2·30	9·53	7·32
Silica,	2·34	3·18	2·07	1·24
Sand,	10·62	...	...	...
Charcoal,	·35	...	...	...
Carbonic acid	15·02	...	...	...
	99·83	100·00	100·00	100·00

These analyses would show that lucerne possesses feeding properties fully equal to the clovers in every respect, while at the same time its mineral requirements from the soil are not such as to affect its fertility so much as those of many of our other farm crops. Again, if we look at it in its simple agricultural relations, and compare it with our other forage crops, we see that it possesses the great advantage of giving for a long period of years a very large amount of produce for a very small comparative outlay of labour or manure; for, although the cost of preparation for the crop, if properly executed, is considerable, it is of but trifling amount when spread over the duration of the crop, and compared with the annual outlay required by an ordinary rotation. If the land be kept clean, and the produce of the lucerne crop be returned to the field, there can be no doubt that, at the end of the crop, the soil would be materially richer than it was at the commencement, as the habit of the plant is to strike its roots deep down into the subsoil, and bring up from it the mineral matters necessary for its growth, which are then left to add to the fertility of the surface or agricultural soil.

THE LUPINE CROP.

ANOTHER member of the leguminous family has lately been introduced to us as a forage plant—the LUPINE, which, however, although new to this country, has been in cultivation on the Continent for many years past, and, indeed, was well known to the Romans, being mentioned in the works of several of their agricultural authors. In this country the lupine has long been known as an ornamental flower plant in our gardens, but until quite recently, has never been grown as a regular "Forage Crop."

On the Continent, however, where the climate is generally more suitable for leguminous plants, and where large tracts of light sandy soils are met with, requiring a special cultivation, the lupine has been grown for a long period, and made use of either as a forage plant, or for ploughing in as a green manurial substance, according to the requirements of the district or farm on which it was cultivated. For this latter purpose its habit of growth particularly adapts it, as its long tap-root strikes at once deep into the lower strata, and brings up from the subsoil the mineral ingredients necessary for its own development, which are then left to decompose and enrich the surface or agricultural soil, and are thus placed immediately within the reach of the shallower rooted crops for which it is intended to be a preparation.

Lupines, of which there are many distinct species, belong to the order LEGUMINOSÆ, of which they constitute the genus LUPINUS. Several of these species are cultivated as field crops in different parts of the Continent. In this country what little has been grown has been confined to the *Lupinus albus*—white lupine. In a recent paper[1] on the cultivation of the lupine, we find that in Prussia the blue and the yellow species—*L. angustifolius* and *L. luteus*—are preferred to the white, and that various other species are being experimented with. The two species mentioned are thus described:—"The yellow lupine has yellow flowers; the whole plant is more succulent, with more and larger leaves, and with a softer stem; the seeds are smaller, and of a lighter yellowish colour, with darker speckles. The blue lupine has blue flowers; the plant is stiffer and harsher; the leaves smaller, and not so plentiful; the seeds somewhat larger, and of darker colour. Both plants have nearly the same conditions of vegetation. What makes them important for agriculture is their growing luxuriantly on light, poor, sandy soils, in situations where no other of our leguminous plants could live. We have some districts, in the northern parts of Germany and Prussia, where a miserable crop of rye was nearly the only production, and where even buckwheat would fail in dry seasons; and it is in such situations that farming has become profitable by the cultivation of lupines, and where, in consequence, the rents have been much more than doubled."

The practice on such lands appears to be to sow the lupines pretty thick about May or June, either broadcast or with the drill, and, directly they come into flower, to roll them down, plough them in as quickly as possible, so as to preserve their moisture, and then to sow a corn crop at the usual period, by which time the green manure would have passed through its stages of fermentation, and decomposition have been fairly set up. If the condition of the land does not necessitate this treatment, sacrificing, as it does, the entire forage value of the crop, the sowing

[1] *Roy. Agri. Soc. Journal*, vol. xx. p. 106.

may take place somewhat earlier, about the end of April, and the crop be fed off on the land in the manner described at page 229, vol. i., in reference to the bean crop.

Being an annual, the lupine is well suited for a rotation plant—as a substitute for clover, for instance—on our light, sandy soils. It is rather delicate, and should not be sown until the period of spring frosts has passed, as one night's frost would effectually destroy it. One bushel of seed is quite sufficient for an acre, which should always be drilled in rows from 15 to 18 inches apart, so that the hoe may be freely used during their growth, which is the only attention they require. The growth of the crop is extremely rapid. In about ten weeks, if the weather be genial, they are usually in flower, when, if used for forage purposes, they should be cut and consumed as speedily as possible, as after that process has commenced their feeding properties diminish, and they begin to exhaust the soil. The leaves and stems, although less nutritive than the seed-pods, are more relished by sheep and cattle, the seed-pods being bitter in taste and generally at first refused by them.

If intended for hay, the crop should be cut at the same period of its growth, and the same precautions should be taken as already recommended for clover. For all "soiling" and hay purposes the yellow species would appear, from the accounts given, to be better adapted than either the blue or the white. For seed purposes, however, the blue is recommended as being a larger cropper; in this case, the crop should be got in as early as possible; when its growth is about half completed it may be cut for forage, and then allowed to stand for seed, care being taken that the seeding is not delayed too late for the produce to mature properly in the field. It is cut and treated in every respect like beans, and should be ready for harvesting by the first or second week in August.

THE SAINFOIN CROP.

Sainfoin is another of our "forage crops," belonging to the same order as the foregoing, and greatly resembling it in its agricultural character. It is a perennial, deep-rooting plant, with branching, spreading stems, and leaves consisting of many pairs of oblong-pointed leaflets, which are sometimes a little hairy on their under surface. The flower-stalks attain a height of from 2 to 2½ feet, and stand out beyond the leaves, carrying spikelets of pinkish-red flowers, which are succeeded by flat, hard pods containing the seed. It is said by some to be a native of this country, as it is found growing wild on the calcareous soils in different parts of the country, and it is also commonly met growing under the same conditions in most of the countries of Middle Europe. It has been long cultivated on the Continent, but was only introduced as a field crop into this country about the middle of the seventeenth century. Aubrey mentions it as a crop well known in his time (1673). It was introduced from France, and was first called "French Finger-grass." Several of our earlier agricultural authors speak of sainfoin, and describe the soils and mode of cultivation best suited to it. Tull gives a long account of it, and speaks in high terms of the advantages it offers on poor light soils; Boys, in his *Survey of Kent,* addressed to the Board of Agriculture, enters somewhat at length into its cultivation; Arthur Young, in his *Communications to the Board of Agriculture,* says that, on soils proper for its cultivation, no farmer can grow too much of it; and Marshall, in his *Rural Economy of the*

Southern Counties, gives details of its cultivation, and recommends it strongly to the notice of all light-land farmers. Sir J. Sinclair, in his *Code of Agriculture,* terms it "one of the most valuable herbage plants we owe to the bounty of Providence."

The only species met with in cultivation in this country is the Common Sainfoin—*Onobrychis*[1] *sativa*—of which the botanical characters have just been described. A variety differing but slightly from the Common was introduced in 1834, under the name of *O. sativa bifera,* from France, where it is known as the *Sainfoin à deux coupes.* It appears to grow a little faster, and to flower somewhat earlier than the Common, but has not superseded it to any extent. More recently a large variety, to which the name of "Giant Sainfoin" is given, has been introduced. The price, however, of the seed is much higher than the old sort, and has checked any very extensive trial of it.

The sainfoin is a plant essentially suited to dry, light, and shallow soils, particularly those of calcareous formations; in such it will probably give a more productive return than could be obtained from any of our other cultivated plants. It has, however, a considerable range of soils, and will grow on almost any soil, provided lime be present, and no stagnant water be met with. This is as fatal to the healthy existence of sainfoin as of either lucerne or clovers. The soils containing large proportions of clay are unsuitable to its cultivation, besides which, soils of this class can always be more profitably occupied in the cultivation of other crops. To the poorer and lighter class of soils sainfoin is a valuable plant; indeed, extensive tracts of thin soils in the rounded hills of the chalk and oolite formations, too bare and close to the rock to carry the ordinary crops, have been brought into beneficial cultivation by being laid down in sainfoin for a course of years.

[1] From ονος, an ass, and βρυχῶ, to bray—asses being particularly fond of it.

ONOBRYCHIS SATIVA—Common Sainfoin.

The vigorous roots of the plant ramify through the clefts and vertical fissures of the subjacent rock, carry down with them both the air and rain-water from above, and abstract from them and bring up to the surface large supplies of mineral food, for the purpose of supporting their own development. Being fed off on the ground, the soil becomes deeper every year, while the fibrous growth of the crop holds it firmly together, and prevents its being washed down to the valleys by the action of the winter's rains. By the time the sainfoin crop ceases to continue productive, a soil is generally formed sufficient for the cultivation of our more shallow-rooting plants; barley, for instance, follows it with great advantage, and rape or mustard may take the place assigned to the cruciferous crop. On the thin bare soils of the limestone formations turnips rarely thrive, owing to the want of sufficient moisture, whereas rape or mustard drilled pretty close—say at 12 to 15 inches—grow quickly up, and shelter the surface from the effects of either the sun or the wind, and thus materially check the evaporation, and retain the natural moisture in the soil.

In the preparation of the land for sainfoin, the same care should be taken in thoroughly cleaning it of weeds as has been recommended for lucerne. This, for a crop which is intended to remain down for several years, is a most important consideration, and cannot be too strictly attended to. The soils and general agricultural conditions under which it is grown, however, prevent the necessity of that deep tillage which is so essential to the productive development of lucerne. Here we have a far hardier plant to deal with, less particular as to climate, and satisfied with a very inferior class of soils. At the same time we must recollect that although the feeding properties of the two are about the same, the gross return per acre of the lucerne is fully double that of the sainfoin.

The principal districts of the sainfoin cultivation are in Hampshire, Wiltshire, Berkshire, and Gloucestershire, upon the soils of the chalk and oolite formations, where it forms a regular feature in the husbandry of those sheep-farming counties. The usual practice upon the best managed farms is to sow down the sainfoin with the barley crop after turnips, by which an opportunity is afforded in the regular rotation of thoroughly cleaning the land, and also of giving it, according to the way in which the root crop is disposed of, any amount of manurial matter that may be desired. This of course must be determined mainly by the condition and the character of the soil. As a rule it is generally more advisable, on thin and light soils, to apply manures in small quantities and at short intervals, than larger quantities at longer intervals; and as the land intended for sainfoin is generally of this class, a forced condition at sowing time is not so important or so productive to the farmer, as that the land should be thoroughly clean and in fair condition at starting, and should be kept so by the occasional addition of fertilizing applications during the continuance of its growth.

The annual yield of the crop mainly depends upon the condition in which it is sustained. If mown, as it too commonly is every year, and the second growth merely fed off without any compensating manure being applied to it, the cultivated plants gradually become weaker, and the indigenous plants rapidly become more numerous, until they gradually displace the others, and the land becomes a mere mass of weeds. If, however, it be kept regularly pastured down, or even if it be mown for hay and fed off afterwards with cake or corn, or an equivalent in manure—say 10 or 12 tons of good farm dung per acre—be added at any convenient time during the winter, the condition of the land will be kept up, the plants will continue their usual vigorous growth, and the weeds, if the field was properly cleaned at the commencement, will not increase to any practically detrimental extent. On the Continent experiments have been tried with several saline manures applied as top-dressings to the sainfoin crop[1]—crude sulphate of lime (gypsum), sulphate of soda, and carbonate of potash, being those giving the best results. Gypsum may in all cases be advantageously applied, as even on the soils of calcareous formations, the addition of the sulphur of the gypsum is always beneficial to plants of this order.

When sown down with a straw crop, it is desirable that this latter be drilled thinner and at wider intervals than is the usual practice. The drills should not be less than 12 inches apart, and from 4 to 6 pecks of seed will be quite sufficient to insure a strong plant in the ground. From 3 to 5 bushels of rough sainfoin seed are usually allowed to the acre, and are sown by the ordinary drill, in rows from 9 to 12 inches apart, across the line of the straw crop drills. Attention should always be paid to the quality of the seed used, as, owing to the roughness of its natural covering, it is very difficult to clean it of the various seeds which are to a greater or lesser extent always mixed with it. Various contrivances have been resorted to for the purpose, consisting chiefly of sieves and brushes arranged for effecting their separation. In some cases the seeds are decorticated or "milled," as it is termed, by being passed slowly through a pair of millstones, set wide, so as not to injure them. The winnowing machine then readily separates the husks and small seeds, and leaves the milled seed quite clean. It is generally considered that "milled" seed germinates quicker than the rough, but is not so safe to secure a plant. When it is used, the quantity sown is much smaller than that first given, about ½ cwt.[2] being found in most

[1] In the *Agri. Gaz.*, 1851, p. 59, details are given of a series by M. Isidore Pierre.

[2] Equal to about 2 to 3 bushels in the rough state.

cases sufficient. It is always of importance to use fresh seed. The quality may readily be determined by opening the husk and cutting the seed across the middle. Good seed should be plump, of a light gray colour outside, and of a greenish tint inside; if of a dark colour, it has either been badly matured, or else has been injured in the stack, and is so far of an inferior character. It requires to be deposited in the soil a little deeper than the clover seed. A double turn with the seed harrows and the light roller then finishes the operation.

In the southern and south-western counties referred to, it is the practice to leave the sainfoin down for a long period—eight, ten, or twelve years—and to follow it with a regular rotation, commencing usually with wheat. In the eastern counties, where sainfoin is also met with in cultivation, it is treated in a very different way. There on the light sandy and calcareous soils, it frequently takes the place of clover in the regular rotation, and remains down in some cases only a single year, when it is fed off and the land ploughed up for wheat. By others, again, it is allowed to remain a second or a third year, thus prolonging the usual rotation, when it is treated exactly as the clover crop, mown the first two years, then fed off with corn or cake, and succeeded by wheat, for which it forms an excellent preparation.[1] On some of the light thin soils it is left down for four years; in such case there is no break in the regular "four-course shift," and the ordinary cropping is resumed. For these short periods, the Giant sainfoin—var. *bifera*—is generally recommended.

When the straw crop is harvested, and the field cleared, the plant speedily covers the ground; and the same precautions should be taken as have been recommended for the clover crop (p. 107), to preserve it from in-

[1] *Roy. Agri. Soc. Journal*, vol. x. p. 54.

jury during the early stages of its growth. If it be intended to remain down several years, it is better to cut it for hay than to feed it off the first spring, as it is important to let the plants root themselves well in the soil before they run the chances of injury from sheep or cattle; the after-growth may of course be fed off in the usual way. Where it is merely a substitute for clover in the rotation, it is treated in the same way as that crop would be on the farm.

Like the preceding subject, lucerne, it takes about three years to arrive at its maximum of production; and if the condition of the soil be sustained by proper treatment, and the crop be kept clear of weeds, it will keep up its rate of produce pretty well for about five years, when the increase of the natural grasses generally tells upon the crop, and shows that it is time to plough it up, and give the land the benefit of a rotation before it is again laid down in sainfoin. In order to protect the crop as much as possible from the natural grasses, it is a good practice to give it a good turn with the harrows at the close of the winter, which will displace the shallow-rooted weeds, and then to apply the manure, by which the growth of the cultivated crop will be encouraged. The plant generally comes into flower about the middle of June, when it should be cut if intended for hay, as its nutritive value decreases as the flowering process proceeds. In cutting for hay, it is indeed very important that it be cut directly the flowering commences, as the plant has then attained its maximum value, and every day's delay, while it decreases the feeding qualities of the crop, has a tendency also to diminish the vital powers of the plant, which frequently dies out altogether, if from any cause, intentional or accidental, such as wet weather, the cutting be delayed until the seed is formed. It seems indeed to be almost a law of nature with our cultivated herbaceous plants, that although perennial in their general habits, when once they have perfected their seeds their powers of continuous development receive a severe check, from which they recover but slowly, and if adverse conditions should supervene, are very likely to succumb altogether. The chances of future growth depend greatly upon the point of maturity the crop had reached at the period of cutting. If the flowering had barely commenced, but little injury would have been sustained; but if it had made much progress, it would be advisable not to attempt another crop for hay until two or three seasons had given it time to recover its lost vigour of growth.

The mode of cutting and of making is carried out in the same way as that already described (p. 108). The same care should be taken not to disturb it more than can be helped while lying on the ground, and not to cart it for stacking until it be sufficiently dry. At the same time, it is very desirable that it should not be left out on the ground too long, as it runs the risk of injury from rain; and the fibre of the plant, when too much dried, becomes less palatable and less digestible as an article of food. Although less liable to heat in the stack than most of the other leguminous plants, it is more liable to injury from rain. Even a slight shower while lying on the ground affects it, as the fistular character of the stems induces a capillary attraction, and the moisture is speedily sucked in, and renders the plant liable to mildew in the stack. The precaution of stacking it with layers of straw intermixed with layers of the crop, enables it to be stacked much earlier than it otherwise would be safe to do, and renders it in all respects better for fodder purposes.

When intended for a seed crop, and this is never advisable, for the reason just given, except with the last crop before breaking it up, the early growth in the spring is usually fed off by sheep; the field is then shut up about the end of April, and about the latter part of July the seed is fully matured and ready for harvest. The proper time for cutting requires a little consideration, as not only the flower-heads are formed and ripen unequally, but the seeds in the individual spikes also come to maturity unequally, the lower seeds, which are the plumpest and best, being always some days in advance of those upon the upper part of the spike. As soon, therefore, as these lower ones are fully ripe, the crop should be cut, and the remaining portion allowed to mature on the stems, which they will do, more or less perfectly, according to the condition they were in at the time of cutting. In order to prevent the matured seed from being shaken out in the operation of harvesting, it is always best to cut the crop either early in the morning or late in the after part of the day, so that the stems may be moist and less liable to break off than during the heat of the mid-day. The swathes should be disturbed as little as possible on the field, but as it is essential that the crop should be quite dry before it is stacked, the swathes should be gathered up into large heaps or cocks, and left a day or two in this shape before being carted off the field. From 2 to 3 quarters per acre are generally considered an average crop, and the stems may be carried with advantage to the feeding yard, for the stock to pick over and consume.

Undoubtedly the most economical way of consuming sainfoin would be to cut it green, in the same manner as lucerne, and carry it to the feeding sheds or stables for the cattle. In such case, if kept well manured every winter, it would probably yield three or four cuttings in the course of the season, and give a far larger produce than when treated in the ordinary way.

The *diseases* incidental to the crop have not received any special attention; those affecting clover and the other leguminous forage plants, no doubt, are equally capable, under certain conditions, of exerting an influence over this. The injuries the crop sustains arise chiefly from the natural grasses and other weeds getting possession of the soil, and consuming the available mineral food, which would otherwise go towards the development of the cultivated plants. This may in a great measure be remedied by the careful preparation of the land before sowing, and keeping up its condition during the growth of the crop.

The *insect* injuries have not been so well studied as those affecting the clover crop. There is but little doubt, however, that the same class of insects which infest the one, are also capable of inflicting injuries upon the other. The slugs and small weevils already described are its principal enemies in its early growth, after which it rarely suffers to any noticeable extent, though no doubt each spring the early shoots are more or less devoured by the same class of insects. One weevil is peculiar to the sainfoin, and has been consequently named the "sainfoin weevil"—*Apion hedysari.* It differs somewhat in colour and general appearance from those already alluded to, but its habits and mode of attack are exactly the same.

For what we know of the *chemistry* of sainfoin, we are indebted to Mr. Way and Dr. Voelcker. In the green or natural state, it contains on the average about 75 to 78 per cent. of water, and 1·5 to 2 per cent. of ash. Its organic composition is given as follows:—

Compounds containing nitrogen,.........	4·32	3·512
,, not containing nitrogen, as gum, sugar, &c.,..........	11·43	17·438
,, as fibre,........................	5·77	
Ash (mineral matter),......................	1·84	1·730
Water,..	76·64	77·320
	[1]100·000	[2]100·000

[1] Mr. Way. [2] Dr. Voelcker.

The composition of the ash or mineral matter has been thus determined by Mr. Way:[1]—

	In flower.	In seed.
Potash,	31·90	29·61
Soda,	...	1·25
Lime,	24·30	29·67
Magnesia,	5·03	4·59
Peroxide of Iron,	·61	·58
Phosphoric acid,	9·35	7·97
Sulphuric acid,	3·28	2·33
Carbonic acid,	15·20	17·36
Chloride of Potassium,	6·24	...
,, Sodium,	·78	3·12
Silica,	3·22	3·49
	99·91	99·97

The mineral constituents of sainfoin greatly resemble those of the foregoing plants—clover and lucerne—the most marked features of which are the large proportions of lime and of sulphuric acid, and the comparatively small proportion of phosphoric, they require to carry on their growth. In all cases a calcareous soil, rather than a soil rich in phosphates, appears necessary to their healthy development; and as both lime and sulphuric acid are cheap fertilizers, they may always be added in liberal proportion to the soil in which these crops are intended to be cultivated.

[1] *Roy. Agri. Soc. Jour.*, vol. ix. p. 142.

THE VETCH CROP.

The Vetch or Tare claims precedence of all our forage crops, as being the earliest of which we have any record in the annals of agriculture, and as having been in cultivation in this country long before the clovers or plants of more recent introduction were known. All the principal Roman authors refer to the crop, and agree very closely in their recommendations as to its cultivation and mode of consumption. Cato and Columella advise that it be sown at two periods, in the autumn and early in the spring, in order that the cattle may have a second supply ready when the first is consumed. Pliny recommends three sowings; the first early in the autumn, which is to be fed off at the end of the season, and then allowed to stand for a seed-crop the next year, and the second and third at the periods already alluded to. They all appear to agree as to its good effects on the land, and class it with lucerne and lupines in that respect—that, if cut green and used for soiling purposes, it rather benefits than exhausts the soil.[1] We could readily subscribe to this opinion were the crop consumed on the ground, or were the resulting manure returned from the feeding sheds or yards to the field; otherwise our modern ideas of the manurial debtor and creditor account between a field and its crop would look upon the balance as being rather against the field where the crop was carried off, and only the roots and stubble returned to the soil. The concluding

[1] "Et vicia pinguescunt arva."—*Plin. Nat. Hist.*, lib. xviii. c. 15.

directions, that "the land be ploughed up for the succeeding grain crop directly the vetches are cut, for if that be delayed they are of no benefit to the crop that follows,"[1] would lead us to look for the beneficial action of vetches as a preparation for the wheat crop, rather from their close growth checking the growth of weeds and sheltering the surface from the drying action of the sun and wind, thus keeping the land clean and with sufficient moisture for the germination of the seed-corn, than from any direct fertilizing effect they could have produced. This condition of the soil was of great importance in a country like Italy, where the action of the autumn sun rendered the surface dry and parched, and where their practice was to sow the wheat crop early, in order to enable it to get well rooted before the winter season set in.

Vetches seem to have been grown as a crop for "forage purposes" in this country from a very early period: most of our early writers on agricultural subjects speak of them. Gerarde (1593) describes several species, and Ray (1686) informs us that in his time they were commonly cultivated in almost every country of Europe as a field crop—that they were mostly sown in England, mixed with oats and pease, for horses, but that they were also grown separately for soiling cattle, and were reputed to make milch cows yield much milk.

Although grown in most countries on the Continent as a crop, they appear to have been more generally cultivated at home than abroad, as Thaer and others quote English writers as their authorities for information and directions of cultivation.

Botanically the Vetch belongs to the order *Leguminosæ*, forming the distinct genus *Vicia*, of which more than one hundred species have been described, most of which are

[1] "Ut si protinus sublata messe earum proscindatur, nihil in segetibus, quæ deinceps in eo loco seminari debent, profuturum sit."—Col., lib. ii. cap. 14.

known as common weeds, those entering into cultivation being comparatively very few in number. The name *Vicia* is said to be derived from the Latin word "vincio," to bind, owing to the tendrils the plants possess, by which they attach or bind themselves to other plants. The vetch is indigenous to this country, as well as to most others in Europe: it has also been met with in many other countries, especially in China and Japan. Dr. Lindley tells us that the genus is distinguished from the pea, which it mostly resembles in its appearance and habit of growth, chiefly by the style, which is filiform, and either hairy all round in its upper part, or with a tuft of hair underneath the stigmate. The leaflets are also more numerous in each leaf of the vetch than in most of the allied genera, while the common leaf-stalk ends in a point or tendril, which always seeks some erect body to which to attach and support itself. Although all the numerous species are wholesome and suitable for cattle food, the following only are those which enter into cultivation for that purpose.

1. *Vicia sativa*—*Common Vetch* or *Tare.*—Of this species there are *two* principal varieties, known as the *winter* and *summer* vetch or tare. Under favourable conditions, the vetch grows to the height of 3 to 4 feet, carrying from six to ten pairs of leaves on a tender succulent stem, and forming flowers of a purple and blue or reddish colour, closely sessile, or on very short stalks in the axils of the leaves. The seed-pod is slightly hairy, splitting in two valves, and containing several dark-coloured globular seeds.

The vetch being used entirely by us for forage purposes, it is of course desirable, as a general rule, to keep up the supply of food by a succession of crops coming to maturity at different times, so that the one shall be ready by the time the other is all consumed. The two varieties of the common vetch give us great facilities for this method of cropping; for although the vetches are generally delicate plants, the "winter variety" enables us to prepare in the

VICIA SATIVA—Common Vetch or Tare.

autumn a crop which comes to maturity earlier in the spring than we could otherwise obtain. The "summer variety" is more delicate in its habit and quicker in its growth than the winter variety, and consequently only adapted for spring sowing. The winter variety, as its name imports, will sustain the lowered temperature of our winters without injury, and is suitable for autumn sowing. Both of these varieties are liable to be influenced considerably in their characters and habits of growth by cultivation; at present they have distinctive characters of some value to us, the one being hardy and of slower growth, the other being more delicate, but of more rapid growth. By sowing the summer variety in successive years earlier in the season, it becomes more hardy, but loses its rapidity of growth; and by sowing the winter variety repeatedly in the spring, it acquires a more rapid power of growth, but at the same time loses the hardy nature upon which its value to us as a variety depends. Therefore it is of great importance in sowing winter vetches, *that we secure for seed not only the produce of the true winter variety, but also of that variety sown in the autumn.* In general appearance the two varieties greatly resemble each other; the winter variety, however, may be distinguished by being usually of smaller growth, by its pods being more smooth and cylindrical and containing a greater number of seeds than the summer vetch, and by being in its general habit more like the wild variety.

Another variety of the *V. sativa*, called the *Hopetoun* or *White-flowered Vetch*, was discovered some twenty years back in Scotland, growing in an ordinary field crop of vetches. It has since been cultivated to a considerable extent, and has well-nigh displaced the common variety altogether. The produce, both in seed and stem, is fully double. The flowers are white, and the seed of a lightish blue or green colour, and possess hardly any of the strong taste peculiar to the seeds of ordinary vetch or tare. The "*white-seeded vetch*" or "*lentil of Canada*"—*V. sativa alba*—is sometimes cultivated for its seed produce chiefly, its dwarf habit of growth rendering it very inferior to the ordinary varieties, where forage purposes are alone considered. The seed produce is, however, much larger, and, owing to their mild flavour, they are in some countries extensively used, both in a green and in a matured state, in soups and other dishes as articles of human food, for which their highly nitrogenized composition renders them very valuable. They are of a pale yellowish white, or cream colour, and are known and sold by the name of *Lentilles du Canada*. The Canadian Vetch—*V. sativa canadensis*—is distinguished from the ordinary varieties by the dull or pale pinkish colour of its flowers, as well as smooth, shining, light green foliage, and dwarf habit of growth, which, together with its later habit of flowering, render it inferior, for the general purposes of cultivation, to the preceding varieties.

2. *V. biennis—Biennial* or *Siberian Vetch* or *Tare*—is a native of Siberia, and was introduced to this country in the year 1753. Although strongly recommended by Miller shortly after it was introduced, it never appears to have been much cultivated in this country; in some parts of Germany, however, it is largely grown on the lighter class of soils. It possesses a vigorous habit of growth, reaching the height of 6 to 8 feet. The stem is slender and branching; leaflets small and sharp-pointed; flowers, which appear in July and August, are of a light purplish pink colour, on long peduncles or foot-stalks. This species is generally very productive, yielding a large bulk of fodder, while it has the advantage also of withstanding the effects of our most severe winters.

3. *V. cracca—Tufted Vetch*—is occasionally met with in cultivation as a forage crop. It yields a considerable bulk of provender, much relished by stock, and of a very nutritious character, owing to the proportion of water being less than in the common vetches. It has the disadvantage, however, of not ripening a sufficient quantity of seed to render it easy to be grown as an annual crop, and it is not productive enough to be valuable in permanent pastures. It may be commonly met with growing by the

sides of plantations and in hedgerows, to the height of 4 to 5 feet, and carrying numerous flowers of a bluish or

VICIA CRACCA—Tufted Vetch or Tare.

purple colour, in tufts or racemes as long or longer than the leaves, and closely arranged along the peduncles or footstalks. The root is small, creeping, and perennial.

4. *V. villosa—Hairy* or *Russian Vetch.*—This species at first sight is apt to be mistaken for the preceding, which it very much resembles in flowers and foliage, but differs essentially from it in having an annual root, while that is perennial. The whole plant, too, is more villous or hairy, of a taller and more branching habit of growth, and pro-

duces a much greater quantity of pods, which are also larger and broader than those of the *V. cracca.* It is generally considered as a productive species; and, owing to the small percentage of water it contains, it forms excellent and nutritious keep for cattle, by which it is much relished, either in a green or in a dry state. Compared as a crop with the common summer vetch, it comes away rather slower at first, but its actual weight or produce per acre, when fully matured, is generally nearly double that of the other.

VICIA LUTEA—Yellow-flowered Vetch or Tare.

5. *V. lutea—Yellow-flowered Sea-side Vetch*—is met with growing naturally on stony and gravelly soils on

the sea-coast, and offers, in an agricultural point of view, some advantages for cultivation in such situations, where it is generally capable of giving a better return than the ordinary clovers do under similar conditions. It is not strictly a perennial plant, though it lasts for several years in full vigour. The root is fibrous; the stem branching and prostrate, about 2 to 3 feet in height, with flowers of a dull yellow colour.

6. *V. sylvatica—Wood Vetch*—is a perennial species, with a slightly creeping root, smooth stem, elliptical leaflets, tendrils large and branching, and flowers in loose bunches, on long stalks, of a variegated pinkish colour. It grows naturally on stony and inferior soils; it is also met with flourishing within the influence of the sea breeze, and even when subjected to the salt spray arising from the waves. It is very hardy, being found growing wild even within the arctic regions, and is met with in cultivation in the most northern countries. It furnishes excellent fodder either in a fresh or a dry state, and is readily eaten by cattle; but although it yields a large bulk of herbage on soils and in situations where few other plants would thrive, its cultivation has been hitherto entirely neglected in this country. The irregular manner in which it ripens its seeds, is no doubt an obstacle to its general cultivation as a crop, as there would be a difficulty in obtaining the seed in any sufficient quantity, unless they were collected by hand-picking as they arrived at maturity. As the pods ripen they become detached from the stems, drop down, and are thus lost.

Another obstacle to regular cultivation exists with this as with the preceding perennial species—the difficulty of securing any strong erect-growing plants of similar duration to grow amongst them for their support, and which would also serve for cutting at the same time for forage purposes. The habit of the vetch is to attach itself, by means of its tendrils, to some other plant for support; its slender and succulent stem not being able to keep it off the ground, it would, without this support, be injured and speedily destroyed. When the common vetch (annual) is sown no difficulty is experienced, as a small proportion of either of our cereals is sufficient to keep the crop off the ground during the period of its growth. In Germany and in France, where the biennial vetch is cultivated, the custom is to sow it with a proportion of one or the other melilots—either the *Melilotus officinalis* or *M. macrorhiza*—whose strong, erect habit of growth and similarity of duration render them suitable for the purpose; but where any of the perennial species are cultivated, some consideration is required as to the best means of securing a support for the crop, in the shape of a plant which in itself shall be suitable for forage purposes. Beans have been recommended; but although they might succeed very well for the first or second year, they, like all other annual plants, would speedily deteriorate by being sown year after year in the same land; while the vetches would, at all events for the first few years, increase in luxuriance of growth. It has been suggested to sow the perennial species in wide drills, so that the intervals might be dug and ploughed every winter, and thus, by the addition of manure, rendered capable of growing the plants necessary for the support of the vetches in the intervening spaces. By this method the cereals or other plants might alternate with beans in the system of cropping.

7. *V. angustifolia—Narrow-leaved Vetch*—is largely grown in Germany, where it is also met with in the woods and hedgerows as a native plant. It is said to yield a large bulk of excellent fodder, and, although an annual, to be sufficiently hardy to withstand the frosts and wet, and keep good to quite the end of the season.

It grows to the height of 3 to 4 feet, and is readily recognized by its narrow leaflets and reddish-coloured flowers.

8. *V. Narbonensis—Narbonne* or *Broad-leaved Vetch.* —This is an annual species, a native of France, and is largely cultivated in some parts of the Continent as a forage plant. It differs considerably in appearance from the preceding. It has a strong habit of growth, from 2 to 3 feet in height, not requiring much support from other plants. The stems are branching, stout, soft, and hollow; the leaflets, about six on each leaf, are large, roundish, and entire; the flowers are of a reddish purple colour; and the seed-pods are either without any, or with very short foot-stalks. It yields a large and close-growing crop of excellent fodder; if sown in the autumn, it is sufficiently hardy to withstand our winters well, and grows very fast in the early spring months, at which period it comes in very usefully; and cattle are fonder of it and eat it more readily at that time than when the clover season comes on. It is found to retain its greenness in winter in a remarkable degree, and to yield an abundant crop in the spring.

The *V. serratifolia—Saw-leaved Vetch*—and the *V. platycarpus—Large-podded Vetch*—which are both cultivated on the Continent, greatly resemble the *V. Narbonensis* in appearance and general habit of growth. Indeed, they seem to constitute a distinct division of vetches by themselves, forming, so to speak, by the broadness of their leaves, the thickness and succulency of their stems, and their stout and erect habit of growth, a connecting link between the ordinary slender-stemmed, climbing vetches, and the stout, erect-growing bean, or *V. faba,* as it was formerly termed, but which has since been separated by modern botanists into a distinct genus —the *Faba vulgaris,* as it is now called.

The range of soils in which vetches may be grown is fully as wide as with either of our other forage crops. Naturally they are found preferring dry, stony, and gravelly places, though they always exhibit a greater vigour of growth when met with in soils of a higher quality; and that power of increased development we find to exist when they are seen in a cultivated state among our "Farm Crops." Although they will grow, and are grown in well-nigh every description of soil under cultivation in this country, still they always thrive better in the stronger than in the lighter class of soils, and indeed are, from their general mode of cultivation and consumption, better calculated for such soils than most of the other forage crops are.

Vetches are grown for early forage or soiling purposes; either for consumption on the land by sheep, or in the yards or stables by cattle. If the former, they should be cut and given in racks to the sheep, folded on the open dry stubble; and if the latter, each day's supply should be cut separately, and carted off to the homestead as long as the crop lasts. This is generally from the beginning of May till the end of June or July, during which time even the strongest clay soils would in ordinary seasons suffer no injury, even should the entire crop be consumed on the land. The cultivated vetch being a quick-growing plant, and having large fibrous roots, which spread themselves through the soil in search of food, is better suited for the medium description of soils, known as loams, than for either the lighter, where the sand predominates, or the heavier, where the clay gives the distinctive character to the soil. Deep soils are, of course, *cæteris paribus*, always better than shallow ones; the vetch, however, owing to its roots being of a more fibrous character than those of the sainfoin, lucerne, or even clover, does not require so deep a soil, and thrives in soils too shallow for their successful cultivation. Moisture is generally congenial to its growth, but, like all our other cultivated plants, stagnant water is injurious to it, and will materially, even in the short time it occupies the ground, check its healthy development. The benefits of thorough draining are now so generally understood, and the facilities offered for carrying it out so great, that but very few districts, comparatively speaking, are to be met with where this bane and preventive to anything approaching improved farming still is allowed to exist. The vetch, then, from its cultivation and mode of consumption, we should class as the leguminous forage plant most suitable for the strongest class of soils, or clay loams and clays; the lucerne for the medium class, or ordinary loams; while the clovers and the sainfoin are the plants best adapted for the lighter class—the sandy loams, chalks, and gravels—the latter plant offering the great advantage of possessing a habit of growth and a power of supporting itself under conditions of the soil which neither of the other plants could successfully contend with.

Vetches can hardly be regarded as a regular rotation crop; they only occupy the ground a portion of the year, and thus a second crop may, under good management, be obtained the same season. Their proper place, however, is between two straw crops; and although they do not offer the same advantages for cleaning the land as the ordinary root and fallow crops, still if the land be moderately clean at the time of sowing, and the surface be well cleared with the horse-hoe when the plants have made a little progress, they will soon cover up the spaces between the rows, and thus check the growth of the weeds, while those that do spring up will be cut with the crop, and be consumed before they seed. On farms where vetches are regularly grown each year, it is generally the practice to sow one portion in the autumn for early spring keep, and the other in the spring, so as to come to maturity about the time the first is consumed. In this case the order of succession in the system of cropping is somewhat interfered with. The winter vetches generally succeed a straw crop, and being consumed early in the summer, leave the land ready for a root or fallow crop; while the spring vetches may be sown either upon the winter fallow, or after late turnips consumed on the land, or early ryegrass cut for soiling. These again are ready for cutting about the end of June, and allowing a month for the consumption of the crop, there is ample time to get the land ploughed up, and a crop of some quick-growing plant, as mustard or buckwheat, fed off on the land before the time for sowing the grain crops arrives, for which either of these plants forms an excellent preparation.

Although the vetch crop is cut early in the season, before most of our ordinary annual weeds have formed their seed, which are thus prevented from perpetuating their growth, still it is of equal importance in the preparation for this crop as for others that the system of autumnal cultivation already described should be attended to, and that the land should be carefully and thoroughly cleaned. When this has been accomplished, the manure intended for the crop should be applied; and for this purpose nothing is better than good farmyard dung, which may be used either in a fresh state or fermented, as may be most convenient for the other requirements of the farm, always recollecting the equivalent proportions of dung in the different states of decomposition, and that vetches being gross feeders, and capable of giving a large return if well fed, seldom find the condition of the soil too high for their growth. The nitrogenous manures are generally better adapted for leguminous plants than the phosphatic; therefore, if there be any deficiency of farmyard dung for the crop, it should be made up by Peruvian guano, which should be mixed with some diluting substance, as already recommended (p. 420, vol. i.), and either applied broadcast at the time of ploughing in the manure, or by the drill at the time of sowing. If fresh dung be used, from 20 to 25 tons per acre should be applied; if it has been partially fermented, from 10 to 15 tons, with the addition of from 2 to 5 cwts. of guano, would be a satisfactory equivalent.

The winter vetches should be got in as early as possible after the land is cleared of the grain crop, and the stubble is well cleaned, as it is of importance that the plants get well rooted before the winter sets in. This can generally be done in September, when, although the temperature of the air is decreasing, that of the soil remains still very high, and greatly assists the germination of the seed, and the early growth of the young plants. *Great care is required that the seed sown be not only the true winter variety, but also the produce of that variety sown in the autumn and not in the spring.* If these points be not attended to, and the ordinary vetches be sown, or even the produce of spring-sown winter variety, the plant will be sure to suffer considerable injury from the cold and wet of the winter, and generally die out and disappear altogether before the spring comes round. It is equally desirable that in sowing the spring crop the seed used should be the produce of the summer variety, which, although more delicate in its nature than the winter vetch, is more rapid in its growth, and also of a bolder and more vigorous habit. The time of sowing should be so arranged that the second or summer crop should come to its maturity about the time the first or winter crop is all consumed, so as to keep up the supply of green food for the sheep and cattle. Probably the end of March or the beginning of April would, under ordinary circumstances, be the best time for this purpose; the crop would then be ready for use about a month after the winter-sown portion, which would generally be sufficient time for its consumption, as the area of each portion sown should be determined by the number of stock kept, and of days or weeks it is intended to furnish the supply of food.

About 2 bushels of seed are generally allowed to the acre for each sowing, as it is desirable to sow the winter lot pretty thick, in order to compensate for any injuries the plants may sustain during the winter. It is very rare indeed to see vetches sown broadcast; the ordinary drill of the farm is suitable for the purpose; and the rows should not be less than 12 inches apart. When the perennial species are sown, it is recommended to drill them at wider distances, so that the ground may be worked by the horse-hoe or "cultivator" between the rows some time during the winter season. For winter sowing it is advisable to deposit the seed deeper than in the spring; for this latter, from ½ inch to 1 inch below the surface is quite sufficient. With the common vetches it is desirable always to mix and sow a proportion of grain of some sort; for the winter variety, either wheat or rye may be used; for the summer variety, oats, being stouter and more herbaceous in their growth, are perhaps preferable to either of the others. The main object of this practice is to furnish supports to which the vetches can attach themselves, the erect growth of the one counteracting the trailing tendency of the other, and thus, by keeping them off the ground, preserving them from the injury they would otherwise sustain.

But little can be done for the crop during its growth, beyond perhaps one hoeing, as if the land be in good condition, and the plants get a good start, they speedily cover the ground between the rows, and thus keep down the weeds. For food purposes the vetch attains its maximum value as soon as the seed-pod is formed; therefore, if the crop were intended to be consumed all at one time, it would be advantageous to wait until it had arrived at that period of its growth before commencing its consumption. This condition only can occur when it is intended to use it in a dry state, as hay, for which purpose the crop can be allowed to remain standing until it has reached the desired growth, and then be cut, and its further maturity entirely arrested, thus securing the whole of it in its most nutritive condition. As the crop, however, is commonly required for consumption in a green state, and for a continuous period, a little consideration should be given as to the most advantageous period of commencing to use it, so that it shall all be consumed before it has passed the period of its maturity, and decay and depreciation has commenced. To do this successfully requires an estimate of the probable produce of the crop, and of the quantity required for each day's consumption. If this be carefully considered, a pretty correct calculation may generally be made as to how long the crop will last, and then it may be allowed to continue its growth until it is required for use. It is clearly as unprofitable to commence using it too early, as to leave any of it standing too late. In each case a certain amount ot food is lost, which a little observation and judgment on the part of the farmer can readily prevent.

Whether for soiling cattle in the homestead, or for feeding sheep on the ground, it is always better to cut the required supply at two periods, morning and evening, each day, than all at once, as if allowed to remain lying in a heap, it is very liable to ferment and heat, and in that state is always less palatable to the cattle, and a portion of it is sure to be refused and wasted. In folding and feeding it off by sheep, it is far more economical to cut it and serve it to them in racks on the stubble of the previous day's patches, than to fold them on the growing crop. The sheep not only feed much more satisfactorily upon the fresh untrodden fodder served in the racks, but the crop carries them much longer, by being more perfectly and economically consumed, the manure is more equally spread, and the ground generally left in a far better state of preparation for the succeeding crop, which advantages very much more than compensate for the small additional amount of labour involved. If, however, they be consumed on the field as they stand, the form of hurdle described and figured at p. 229, vol. i., will be found very suitable for the purpose, and a great improvement upon the ordinary method of treating them.

When cut for hay, vetches require to be turned frequently over in the swathe, and left lying as loose and hollow as possible, that the sun and air may have good access to them, and evaporate their surplus moisture so as to render them fit for stacking. The practice already recommended (p. 109), of mixing layers of straw with them in the rick, is equally applicable here. It enables the crop to be carried a little earlier, and thus reduces the risk of injury on the ground, preserves its organic constituents in a more moist and assimilable condition, and at the same time secures it from the chance of fermenting and heating in the rick, which it is so difficult to guard against in crops of the same succulent character. If the hay be subsequently cut up into chaff, the straw present greatly assists the operation; and if supplied whole in the racks, the straw has so imbibed the juices and general flavour of the dried vetches, as to render it equally palatable to the cattle, by which it is readily consumed. The early crop (winter sown) is generally cleared off by the middle or end of June, when the land may be ploughed up in good time for turnips, or any other cruciferous fallow crop. If the vetches have been fed off on the land, no other manuring will be required; if they have been cut and carted away for "soiling," some artificial manure—guano or superphosphate, for instance—should be applied at the time of sowing, in preference to farmyard dung, as it is of importance at this season to stir the soil as little as possible, so that its natural moisture may be preserved. The second or spring-sown portion occupies the ground about a month or six weeks later, which frequently renders it impracticable as regards time, or inconvenient as regards the labour required, to take another crop off the ground before the preparations are made for the succeeding grain crop. If the land be in satisfactory condition, it is always better that it should be occupied than lying fallow at this season of the year; therefore, some quick-growing plant, as mustard or buckwheat, may generally be advantageously sown, and a considerable amount of valuable keep for the sheep stock, and of good manure for the next crop secured, at a very little outlay, either for seed or for labour.

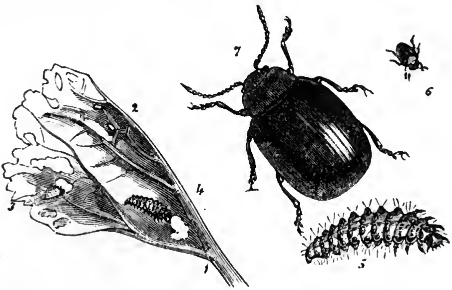
When it is intended to grow vetches for their seed, the tillage treatment should be somewhat different from that recommended for forage purposes. For the latter the land can hardly be in too high condition; we want to force a luxuriant growth of herbaceous matter, which is rarely accompanied by an equal power of seed development, the vigour of the plant declining when it has reached its full growth and commenced its period of flowering. For seed purposes we care but little about the bulk of the crop; our object is to secure a sturdy, branching plant, capable of sustaining its vigour of growth until its natural functions of flowering and maturation are completed, when, in the ordinary course of nature, its life ends and it withers away. We, therefore, in our preparations for the crop, should be more sparing in the quantity of manure applied, and should give the preference to those of the inorganic rather than of the organic class—for instance, to guano and superphosphate in preference to farmyard dung—and should diminish the quantity of seed used, and sow it at wider distances apart, in order that the plants may have more room on the ground, and the sun and air penetrate more freely. Even with these precautionary arrangements successfully carried out, the seed crop is a very precarious one. In unfavourable seasons a large proportion of the produce is frequently destroyed by a few wet days at the time the seed is being matured; while, again, if everything goes on favourably, large returns are sometimes obtained.

To insure good seed, the practice followed in the north, of sowing vetches in the drill with the beans, is strongly recommended. The same soils and general conditions of growth are equally suitable to both plants, which come to maturity at about the same time; they are cut and harvested together, and when thrashed out, the seeds are readily separated by the riddle, while the addition of the stems adds greatly to the fodder value of the bean straw. The winter variety may be sown with the winter bean, and the spring variety with the earlier varieties of the ordinary beans. During their growth, the erect and stout stem of the beans offers a ready support to the slender vetch, which exhibits a luxuriance of growth and a power of seed development very rarely met with, even in selected plants, from a crop grown in the ordinary way.

The *diseases* incidental to vetches have not excited so much attention as those of our more regular rotation crops. Mr. Berkeley, to whom we are mainly indebted for most that we know of these very important matters in agriculture, tells us[1] that they are frequently much injured by a parasitic fungoid plant peculiar to the vetch, which is termed *Botrytis viciæ.* The foliage and stem are attacked by it, and gradually acquire a reddish or reddish brown tinge; the general health and vigour of the plant is immediately affected, and the produce either partially or wholly destroyed. In late-sown crops "mildew" sometimes makes its appearance, when it is advisable to cut or otherwise consume them as quickly as possible.

[1] *Agri. Gaz.*, 1846, p. 226.

The *insect* enemies which vetches have to encounter during the comparatively short period they occupy the land, have been made known to us by Curtis and other entomologists. During the whole period of their growth they are infested by multitudes of insects, the larvæ chiefly of moths, beetles, and flies, which frequently effect great injuries to the crop, whether cultivated for forage or for seed purposes. In their earlier stage, the slugs and snails, with which in some districts and some seasons our fields abound, commit great ravages. At a later period the plants are often visited by a small beetle—*Phœdon polygoni*—and its larvæ, both of which feed upon the



1. Portion of a leaf with (2.) eggs. 3 and 4. Larvæ of beetle in a young and full-grown state. 5. Do. magnified. 6 and 7. Beetle; nat. size and magnified.

leaves and stems, and do great injury to the crop. This beetle has been noticed in the fields from early spring to midsummer, infesting the docks, sorrel, and knot-grass, whence it moves off to any vetch crop within its reach. It is of a shiny blue colour on the back, with a dark red-coloured thorax, and a greenish blue head, with strong mandibles or jaws for biting. In 1850, entire fields in Cambridgeshire and Hertfordshire were destroyed by this beetle. A peculiar aphis, named the *Aphis viciæ*, is in some seasons abundantly met with, during the months of May and June, on the vetch crop. Curtis also tells us that soon after flowering has commenced the flower-heads are often distinctly distorted, and on opening them numbers of maggots are found concealed in and amongst the calyces or cups of the flowers, where they eat into the base, and entirely consume the incipient pod. These little larvæ are of an orange colour, tapering to the head, and blunt at the tail. In all probability they are the offspring of some species of *Cecidomyia* allied to the wheat-midge. Vetches are also seriously injured by the maggots of a little weevil—the *Apion pomonæ*—"the vetch or tare weevil." These insects are found, early in the season, on the common white-thorn, and are met with abundantly until the autumn on heaths, fir-trees, and oaks. They inhabit the hedges, and are always at hand, ready to

1. Distorted flower-head of *V. sativa* infested by the "weevil." 2. Seed-pod, showing injuries inflicted by it. 3 and 4. "Weevil'—*A. pomonæ*—nat. size and magnified.

visit any suitable crops sown in our fields. In July and August, when the vetch crop has seeded, their presence may be detected by the distorted appearance of the flower-heads and young seed-pods. On opening them (*see woodcut*) the seeds will be found to be partially eaten, some with only a hole in them, surrounded by abundance of brown and white excrement; other seeds are hollowed out, and a cell formed in each of them of an oval form, but irregular. In these cells is found either a fat maggot or a pale ochreous pupa, which in due time reproduces the original insect. The weevils at first are of a dirty ochreous tint, but eventually become of a dark brown or black colour.

The *chemistry* of vetches has received but very little attention either from our own or from continental chemists. They usually contain in their natural state about 80 to 82 per cent. of water, 16 to 18 per cent. of extractive organic matter, and about 1·5 per cent. of mineral or inorganic matter. Their organic composition is given as follows:—

	Dr. Voelcker.	Mr. Way.
Compounds containing nitrogen (flesh-formers),	3·56	4·04
,, not containing nitrogen (heat-givers and fat-formers),	12·74	11·95
Ash, or mineral matters,	1·54	1·11
Water,	82·16	82·90
	100·00	100·00

The only analyses we have to refer to of the composition of the inorganic matter or ash of the plant, is by Sprengel,[1] which, in default of any more recent one, we now give:—

Potash,	35·28
Lime,	38·33
Magnesia,	6·35
Peroxide of Iron,	·18
Protoxide of Manganese,	·16
Phosphoric acid,	5·49
Sulphuric acid,	2·39
Silica,	8·66
Chloride of Sodium,	2·67
	100·00

[1] *Annales Agricoles de Roville,* tome viii. p. 209.

These two analyses—the one of its organic, the other of its inorganic constituents—would show that while vetches possess a high feeding value in their fresh or green condition for cattle, they may be cultivated at a very small expense to the soil in regard to its phosphatic fertilizing ingredients, and thus compare equally favourably with clover in their mineral requirements from the soil. Their nutritive or feeding value is fully equal to that of the best clovers. The bulk produced from the same area of land is considerably in excess, while the time they occupy the ground as a crop is much less, and gives the farmer an opportunity of getting two crops from his ground in the same season.

The seed is very rarely used as an article of food. Although we have no reliable analysis of its exact organic composition, we may fairly class it with the seeds of our other leguminous plants, whose composition is well known to us. They all contain the nitrogenized compounds in large proportions, and are extremely valuable for the development of flesh and muscle in feeding and in working animals. According to Levy,[1] vetch seed contains 2·4 per cent. of inorganic matters, which are thus constituted:—

Potash,	30·37
Soda,	9·81
Lime,	4·76
Magnesia,	8·45
Peroxide of Iron,	·75
Phosphoric acid,	37·82
Sulphuric acid,	4·07
Silica,	2·00
Chloride of Sodium,	1·97
	100·00

[1] *Annalen der Chem. und Pharm.*, v. Liebig und Woehler, 1845, No. 6.

THE GORSE CROP.

THE last of our leguminous "forage crops" that we have to describe is GORSE, or WHINS, as it is more generally termed in the northern parts of the kingdom. It is indigenous to this as well as to the other temperate countries of Europe; and is very commonly met with growing at the sides of roads, and occupying any waste places where the soils are light and dry. Even those of the most worthless descriptions, provided they possess the physical characters named, are sufficient to provide a home for this hardy plant. In the more northern parts of Germany it is less commonly met with; and on the Scandinavian side of the Baltic, in Russia, and even in Poland, it ceases to appear.

In many of the poor, hilly districts, both at home and abroad, it has been known as a cattle food, and to a certain extent cultivated, for two or three centuries past, and appears to have been introduced into more regular notice as a forage plant at the beginning of the last century. In a letter from Colonel Charles Cathcart to the Scottish "Society for Improving in the Knowledge of Agriculture," dated London, April 6, 1725, we find it mentioned "that the sowing of whins for feeding of cattle takes mightily about London now," and that "this improvement comes from Wales, where it has been practised these hundred years." Dr. Anderson, in his *Essays*, and other writers of the last century, speak in favour of its suitability for cultivation on poor soils and hilly districts, which thereby may be made to produce not only a large amount of valuable food materials for stock, but also a considerable amount of valuable fuel for the purposes of the house, which in such districts is generally a scarce and costly material. At the present time we find gorse under regular cultivation in several parts of the country as a forage crop, the produce being given either to milking cows, for which it is highly thought of, or to sheep or working horses. In other parts, it is cultivated for the purposes of affording shelter or cover for game; here it is also regularly cut, and the produce sold for fuel purposes, for which there is generally a ready sale. Again, there are large areas covered by gorse of indigenous growth, left entirely in an uncultivated condition, affording a scanty herbage to straying cattle, and shelter to a few rabbits. These generally are sedulously preserved in their wild state, the plants renewing themselves from seed as the old ones die off from age or injuries, to which in such places they are always liable.

Botanically speaking, the gorse belongs to the order LEGUMINOSÆ, of which it forms a distinct genus—ULEX—three species of which are known to us as being met with in cultivation, or at all events as being capable of furnishing food for stock. These may readily be recognized by the following characters:—

Ulex europæus—Common Gorse, Furze, or *Whin*—is usually seen as a branched and bushy green shrub, in which the leaves and young shoots are converted into short, thick, spreading, and very intricate spines or prickles. The flowers are yellow, and characterized by the yellowish calyx, nearly as long as the petals, and divided to the base into two broad, concave, nearly equal leaflets, and by the ten stamens all united above the middle into a sheath round the pistil. The pod is oblong-flattened, not much longer than the calyx, hairy outside, and contains usually three or four seeds. This is the Spring-flowering species, commonly cultivated in this country; and which, in a suitable soil, and carefully attended to, produces a large return of a nutritious and palatable food, green and succulent throughout the winter as well as

ULEX EUROPÆUS—Common Gorse.

other periods of the year, and much liked by all kinds of stock. It is a very hardy plant, and may be grown successfully in this country at an elevation considerably above the limits of cereal cultivation. The only drawback to its use is the necessity that exists for bruising or crushing it, in order to reduce the spines or prickles with which it is covered, and which materially affect its use for forage purposes. A variety of machines have been introduced for effecting this, so that now the question is merely one of cost for the extra labour required in its preparation.

Ulex nanus—Dwarf Gorse—resembles the foregoing in its botanical characters, the only difference being that this species flowers in the autumn, and is indeed frequently termed the Autumn-flowering gorse. It offers no advantages over the former, save that it will grow on even a poorer class of soils and at higher elevations, and therefore would furnish a supply of food or of fuel under conditions of soil and climate in which the Common gorse could not be cultivated. It is readily distinguished from it by the later period of its flowering, by its generally smaller and more delicate structure, and by its reclining habit. It rarely grows higher than 3 or 4 feet, whereas the *U. europæus*, under favourable circumstances, will attain a height of 10 to 12 feet.

Ulex strictus—Irish Gorse—differs materially from either of the foregoing, in being of a much more erect and compact habit of growth, and in its spines and shoots being so soft and tender that cattle of any kind can eat them without their undergoing any preparatory operation of crushing or bruising. One great objection to its extensive cultivation is the necessity of propagation by cuttings, as the plant rarely flowers, and is thus not capable of supplying seeds for the purpose of reproduction. Where, however, it is desirable to grow gorse for feeding purposes, it will fully repay the extra attention and labour required to strike the cuttings, and transplant them to their intended place. If planted in a well-prepared bed of light sandy character, shaded from too much sun and light—at the back of a wall, for instance—any time during the month of August, they will strike readily, and in the following spring and summer send out roots, and be quite ready for planting out either in the autumn or the following spring, as may be most convenient. This species was discovered on the Londonderry estate in the county Down, and has been cultivated to some extent for forage purposes both in Ireland and in Wales. Another species, the *Ulex provencialis*—*French* or *Provence Gorse*—was introduced some years ago into this country, but did not succeed so well as the indigenous species; and in a recent work (*Flore du Morbihan*) by a French botanist, M. Le Gall, a new species is described as being well adapted to general cultivation, to which the name of *U. Gallii* has been given.

Although the gorse is naturally a very hardy plant, and will grow in well-nigh every description of soils, still, like all other plants, it has a certain individuality of character, and will succeed far better in some than in others; while its peculiar and most valuable feature—its aptitude of growth, and indeed natural selection of poor dry soils and exposed places—renders it a more suitable plant for cultivation in poor than in rich soils, which can be always more profitably occupied by other crops. Gravels, sands, and the detrital soils of the chalk formation, are those perhaps best suited to its natural growth. In any of these, provided they be free from stagnant water, the plant will thrive, and if moderate care be bestowed upon it, produce a very remunerative crop. Indeed, it seems to hold the same position in reference to the "forage crops" that the Jerusalem artichoke does in reference to the "root crops," namely, to occupy and give a good annual return from lands of the poorest description, and which, under the ordinary cropping of the farm, would hardly repay the expenses of cultivation at all. Under such circumstances, we cannot look upon gorse as a rotation crop, but merely as a crop producing a return in soils and under conditions of cultivation unsuitable to our regular farm plants.

In preparing the land for this crop, the two principal objects to be attained are freedom from stagnant water and from weeds. The class of soils usually selected for gorse rarely suffer from wet, save when they contain interstratified beds of clay, in which case a good system of drainage, carried across the clay strata, will always relieve the land of the surplus moisture, and render it fit for the crop. As regards weeds, the ground ought to be as effectually cleaned as has been recommended for the lucerne and sainfoin crops, as the young gorse is an extremely delicate plant, and is liable to be greatly injured if they are allowed to accumulate during its early growth.

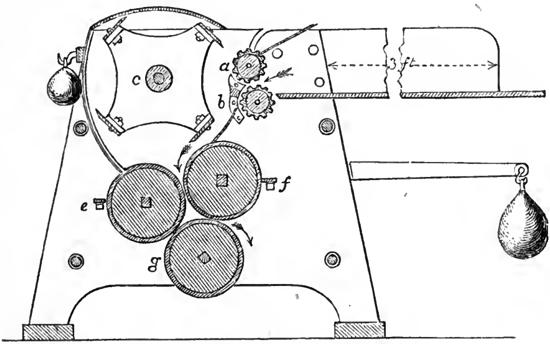
Gorse may either be sown by itself, or treated like the foregoing plants, and sown down with the grain crop. If the former method be adopted, it should follow a straw crop, by which ample time would be afforded in the autumn for thoroughly cleaning the land, while the stubble would assist in keeping it loose and open to the winter's frosts and rains. If the soil be good enough to render the latter mode desirable, the same precaution should be taken as to the width of rows of the straw crop that have been already recommended. In either case, the seed should be deposited by the drill, in rows from 18 to 24 inches apart, and about 1 inch deep. Where a grain crop is taken, the rows of the two crops should cross each other at right angles, the harrows and light roller finishing the operation. From 8 to 10 lbs. of seed per acre are sufficient to insure a thick plant; and the latter end of March or beginning of April is the best time for the purpose of sowing.

The only attention the crop requires the first year is to be kept clear of weeds by means of hoeing; this, where a green crop has been taken, will hardly be necessary, if the land was well prepared and cleaned previous to sowing. The young plants, however, are extremely delicate, and require to be carefully protected from weeds; it is also of great importance that they should not be allowed to be touched by sheep or cattle, as any want of attention to these two points would be sure to be followed by a proportionate failure in the crop. The practice of sowing the crop broadcast is still followed in some districts, chiefly in Wales; it possesses, however, no compensatory advantages, as double the quantity of seed is required, and the difficulty of keeping the crop clear of weeds during its early growth, which is the great obstacle to its success as a crop, is considerably increased. As the crop is intended to be of some years' duration, it is always desirable to have some spare plants to fill up any blanks that may occur in the drills, a small patch should therefore be kept as a seed-bed, to furnish the supply that may from time to time be necessary in the field. The blanks should be carefully filled up as soon as the winter is fairly over; then the only attention the crop requires during the spring and summer months is that it be kept free from weeds. In the autumn of the second year the plants are sufficiently advanced to give a crop, which may be mown with a scythe in the usual manner. After the first cutting, it is recommended by some to cut every alternate row only each year, thus giving each row a two years' growth, and at the same time better access to air and light than if grown and cut down altogether. In this case the crop has to be cut with the hook instead of the scythe; this, however, is but of small importance as regards the labour, as it is desirable not to cut more at a time than sufficient for a day or two's consumption, and the hook will do this as quickly as the scythe. Others, again, consider it best to sow the plant in wider rows, and mow the whole crop every year, as the shoots are more tender, and there is less bottom and dry stems than in the two-year old plants.

The great advantage that gorse offers as a forage crop is the supply it furnishes during the winter, when any succulent green food is extremely scarce, and, of course, proportionately valuable. Where it is regularly grown for feeding purposes, it generally comes into use in November, and lasts until the end of April or beginning of May, when, having flowered and matured its seeds, it becomes less succulent and palatable to the stock, and by which time, indeed, the Italian ryegrass, winter vetches, or some other early keep, ought to be ready to take its place. Where gorse is grown for cover merely, it is advisable not to let it stand too long without cutting, as it is apt, after seven or eight years' growth, to get too open at the bottom, and thus be more or less unfit for the purposes of food and shelter, for which it was intended. If a portion —say a seventh part of the area—be cut down every seven years close to the ground, and the soil well stirred and cleaned between the rows of stumps, a vigorous growth of shoots will speedily make their appearance, and the ground will soon be covered again closer than it was before, while the annual produce of faggots thus obtained will produce something like a rent for the whole acreage occupied.

In some of the districts in Wales, where gorse is largely used for feeding purposes, it is customary to grow it on the banks or earth divisional fences of the farms. The seed is sown in drills along the top and on both sides of the embankment; and owing to the conditions being favourable to the growth of the plants, the soil being light, deep, and dry, they generally exhibit a luxuriant growth, and produce large returns. At the same time, they are liable to be greatly injured by the occasional browsing of the stock pasturing in the fields, which always checks the growth of the shoots, even if it does no greater injury, while the banks themselves, sheltered as they are by the gorse, furnish an excellent cover for rabbits, rats, and other vermin.

The mode of using gorse for food is either to cut it into small lengths with the chaff-cutter, or to bruise or grind it, by submitting it to some kind of crushing power; as without some preparation of this kind cattle will very rarely face it. There have been from time to time several "crushing machines" introduced for the purpose by our leading firms, simple in construction, and very efficient in operation; they all, however, require a certain amount of power to work them, and are generally rather higher in price, owing to their necessarily powerful construction, than other machines for ordinary farm purposes. The accompanying woodcut will illustrate the general principle upon which the most approved machines are made, and the arrangement of the different parts of the machine for effecting the purpose desired.



The "gorse-crushing machine," of which a sectional view is given, is fed in the same manner as a chaff-cutter, the gorse being taken from the feeding-trough by the toothed feed-rollers (*a* and *b*), the upper of which is kept pressed upon the under by a lever weighted in the ordinary manner. As the gorse is drawn in by the feed-rollers, it is brought in contact with the cylinder (*c*), which, being armed with knives, and driven with great velocity, cuts it into short lengths. These fall down, and are received by a double set of rollers, through which they are drawn, and are passed out at the bottom in a thoroughly crushed state. The rollers admit of being set at any required degree of crushing power, by means of the weighted lever acting upon one of the rollers (*f*), which is moveable, while the other two rollers (*e* and *g*) are fixed. When a simple chaff-cutter is used, some difficulty is usually experienced in feeding the machine with the gorse. This is greatly lessened, and the work rendered much more regular, by keeping the floor of the feeding-trough covered with straw, and laying the gorse upon it, by which it is carried readily into the feed rollers, and then acted upon by the knives.

The old and simple form of gorse-bruiser is still met with in many of the places where it is used for cattle food. The woodcut readily explains the arrangement of the apparatus,

The butt of a tree usually forms the block on which the gorse is laid, and the mallet used is plane on one face, and on the other has crossed, stout cutting-blades. A few blows with this latter side cut up the gorse into pieces, which are then bruised or crushed by the other end before they are carried to the cattle. In all cases it is important not to allow the food to remain long after being crushed, as fermentation is immediately set up, and deterioration ensues. It is a good practice to mix it at once with cut straw or hay chaff; the juices are absorbed, and it will keep good for at least thirty-four hours.

In one of the earlier volumes of the Royal Agricultural Society,[1] there are two papers on the cultivation of gorse, which give the evidence of a large number of practical farmers both as to the most successful method of cultivating, and also of using it for feeding purposes. All appear to speak very favourably of it, especially when given to milking cows and to working cattle. Several instances are given of the money produce per acre of the crop, which generally, if allowed to stand for two years' growth between the cuttings, will average 20 tons per acre—2000 bundles of 20 lbs. each, or 36 two-horse cart-loads, being an ordinary return. The author of one of the papers alluded to speaks of £16 per acre being obtained for gorse grown on land not worth at the highest estimate more than 7*s.* to 8*s.* per acre; while he also tells us, and names the growers of crops fetching, to his own knowledge, £20, £30, and even the enormous price of £40 per acre.

From the Continent also we have confirmatory evidence of its hardy growth and suitability for poor light soils, and also of its value as an article of food. The details given by M. Saint-Martin[2] of his experimental trials of gorse, the produce of the imperial domains of the Landes, on a soil hitherto looked upon as perfectly barren, show that its feeding value may be considered as nearly equal to ordinary hay; that the working horses preserved their condition on half the usual rations of oats when gorse was given to them; and that the produce of the dairy cows fed on gorse was equal, both in quantity and quality, to that when they were fed on hay; while the cost of the substance

[1] *Roy. Agri. Soc. Jour.*, vol. vi. p. 390 and 522.
[2] *Journal d'Agri. Pratique*, 1859, tome ii. p. 420.

itself, the gorse, was not much more than one-fourth that of the hay, for which it was found to be such a satisfactory substitute.

Gorse has never assumed such a position among our cultivated crops as to call attention to the *diseases* to which it, like all other plants, is more or less liable. At present our cultivation has caused it to depart but very little from its own natural condition; it is as we advance in cultivation, and depart from the normal conditions of a plant, that it begins to exhibit a debilitated constitution, and a disposition to be influenced by circumstances which in its natural state would probably not have produced any injurious effect upon it. We know, however, that it is liable to be attacked in its wild state by the "common dodder" —*Cuscuta europæa*—one of those curious parasitic plants which have already been described and figured at p. 123. This would occasion considerable loss were it to find its way into a regularly cultivated field of gorse, as, owing to the growth of the plant, it would be well-nigh impossible to extirpate it except at the sacrifice of a considerable amount of the crop.

About the *insect* injuries we have but little to say, more than that it is probable that some of the insects already described as infesting leguminous plants are also capable of injuring the gorse, though the particular individuals or their mode of action have not been pointed out by our entomologists.

The *chemistry* of the crop is also in a rather unsatisfactory state. We have no very reliable analysis of its organic composition. Those given by Sprengel and by Waldie,[1] are detailed so differently to the present practice of chemists, as to have but little value for our purpose. The only information we have upon the subject is from

[1] *Roy. Agri. Soc. Journal,* vol. vi. p. 397.

Professor Johnston's analyses,[1] which give us the following as the average composition of young gorse:—

Water,	77·40
Organic matter,	21·21
Ash,	1·37
	100·00

The ash or inorganic matter was composed of the following substances:—

	Furlong.	M'Calmont.	Mean.
Potash,	20·13	16·49	18·31
Soda,	6·75	8·33	7·54
Lime,	16·80	15·25	16·02
Magnesia,	5·27	8·31	6·79
Phosphates of Lime, Magnesia, and a little Phosphate of Iron,	27·15	24·34	26·74
Sulphuric acid,	6·07	7·50	6·79
Silica,	5·44	5·72	5·58
Chloride of Sodium,	12·39	12·00	12 23
	100·00	100·00	100·00

These analyses, though not so perfect as we could wish, show that gorse contains a much larger proportion (fully double) of solid substances, than either turnips, mangold, or carrots, the ordinary crops we rely upon for succulent food during the winter months; while, from its belonging to the order Leguminosæ, we may fairly infer (in the absence of a proper analysis), that its nitrogen or flesh-forming constituents exist in equally increased proportions. The inorganic constituents—the proportion of salts of potash and of phosphoric acid—which its peculiar powers enable it to abstract from soils of the poorest description, add to its importance as an article of cattle-food, by the valuable fertilising materials they leave in the manure.

[1] *High. Soc. Transactions*, 1847, p. 586.

THE RYEGRASS CROP.

NOTWITHSTANDING the Grasses of themselves constitute, perhaps, the largest portion of our forage crops, none, with the single exception of RYEGRASS, is of sufficient value singly to form the subject of a special cultivation for that purpose. This valuable addition to our "Farm Crops," although known to our agriculture for the last two centuries, has only at a comparatively recent period attracted attention, as being a plant admirably suited, both in its speedy growth and large returns, to the requirements of our improved system of farming.

Although we find some members of the genus to which ryegrass belongs mentioned in the ancient authors, they were only noticed as noxious weeds, detrimental both to the farmer and to those who partook of the crops with which they were mixed. The *Lolium album et rubrum* are specified, and are probably those referred to by Ovid in his first book, *Fastorum*,[1] as affecting the eyes, causing dimness of sight, and other unpleasant effects, to persons eating bread made of corn in which they were mixed. Dioscorides and Galen, in speaking of the Lolium (then termed αιρα), attribute noxious properties to it—an opinion which has been handed down to our own times, and attached to one particular species, the common darnel (*L. temulentum*), which is a weed frequently met with in corn fields, ripening its seed about the same period as wheat, and as frequently found mixed up with it in badly-dressed samples, especially of imported grain.

[1] "Et careant loliis oculos vitiantibus agri."

Ryegrass does not appear to have been known in this country until about the middle of the seventeenth century, a period marked in the annals of agriculture by the first cultivation of any of the true grasses for hay or pasture, which is thus recorded in Dr. Plot's *Oxfordshire*, published in 1677:—"They have lately sown ray-grass, or the *Gramen loliaceum*, by which they improve any cold, sour, clay-weeping ground, for which it is best, but good also for dry upland grounds, especially light, stony, or sandy land, which is unfit for sainfoin. It was first sown in the Chiltern parts of Oxfordshire, and since brought nearer Oxford by one Eustace, an ingenious husbandman of Islip, who, though at first laughed at, has since been followed even by those very persons who scorned his experiments." Mention is frequently made of it in several works on rural affairs that appeared at the close of the seventeenth and during the eighteenth century, from which it appears to have made good progress in the opinion of the farming public, and to have been very generally grown, either by itself or mixed with clovers and other grass seeds. The repeated sowing, however, of ryegrass seed from the first crops by the earlier growers resulted, towards the end of last century, in the prevalence of a short-lived variety, afterwards termed "annual ryegrass," and unfit in many cases for the laying down of lands to two or more years' pasture, which naturally directed attention to the selection of a more lasting variety. Accordingly, we find that this desideratum was soon supplied by Mr. Pacey, of Northleach, whose perennial ryegrass, as it is still called, has since become known throughout the whole country.

The successful results of Mr Pacey's careful experiments soon stimulated other cultivators, each of whom discovered, or fancied he had discovered, a variety possessing new or additional merits; so that prior to the publication of the *Hortus Gramineus Woburnensis* (1824), Dickson's, Ruck's, Russell's, Stickney's, Whitworth's, and others, had been introduced to public notice. These perennial varieties, though, from their superior vigour and more permanent characters, well adapted for permanent pastures, and for mixing with seeds that were intended to be kept down for two or three years, as is practised frequently in the longer rotations of the north, were neither suited for the shorter rotation of the light soils, farmed upon the Norfolk system, nor for cultivation by themselves as a crop for forage purposes. The success of a "perennial variety" originated the necessity for a superior "annual variety," which should come to its maturity in one year, and thus supply the wants of immediate use as successfully as the improved perennial was acknowledged to do for those of a permanent character. This want was supplied by the introduction of a new species, the "Italian ryegrass," for which, as indeed for many other of our farm plants, we are indebted to Messrs. Lawson, who in 1831 obtained the first lot of seed from the Continent, and whose imports have increased enormously each year since.[1] Although it cannot, perhaps, be regarded strictly as an annual, it has the advantage of coming to its full maturity in the first year, which is all that is desired in its cultivation; while the perennial species is not strictly perennial, as it rarely stands for more than four or five years, unless

[1] Foreign-grown Italian Ryegrass imported by Messrs. Lawson:—

			s.	d.	
In 1831,	160	bushels,	42	0	Selling price per bushel.
,, 1832,	320	,,	35	0	,, ,,
,, 1836,	1,000	,,	15	0	,, ,,
,, 1840,	5,000	,,	10	6	,, ,,
,, 1850,	25,000	,,	7	6	,, ,,
,, 1851,	28,500	,,	7	6	,, ,,
,, 1852,	30,000	,,	6	0	,, ,,
,, 1853,	40,000	,,	5	6	,, ,,
,, 1854,	32,900	,,	5	6	,, ,,
,, 1855,	35,000	,,	5	0	,, ,,

allowed to renew itself by seeding on the ground. Since the system of irrigation has been introduced to our farms, the cultivation of the Italian ryegrass has largely increased, as no other grass is so suitable for that mode of treatment, and none is likely to give the same large returns.

Ryegrass, as its name would import, belongs to the order GRAMINEÆ, forming the genus LOLIUM, of which three species only are of any interest to the farmer. Of these there are several varieties entering into cultivation, all of which, however, possess the same botanical characteristics, and are readily distinguished from the other grasses of the farm. The entire genus *Lolium* is well marked by the many-flowered sessile spikelets being arranged edgewise, and alternately upon a zigzag rachis (*see woodcut*), and supported by a single herbaceous glume, arising from the base and pressing against the outer edge: occasionally, a second rudimentary glume interposes between the spikelets and the rachis.

1. *Lolium perenne—Common Ryegrass* (*fig.* 1)—is a perennial plant indigenous to this country, growing, under ordinary circumstances, to the height of 2 feet. It has many-flowered spikelets, much longer than the glume; the roots are perennial, and of a fibrous character; the stems tiller freely in good soils, with conspicuous bent joints near their base. Although termed perennial, it does not appear to be naturally of long duration, generally dying off by the fourth or fifth year. Like most others of our plants which have been largely cultivated, several different varieties have from time to time been introduced to public notice, of which the following are the most important:—

Common Perennial or *Scottish Perennial* is the sort most commonly employed for sowing on lands which are subjected to rotations in which the land is left down in seeds

Fig. 1. Fig. 2.

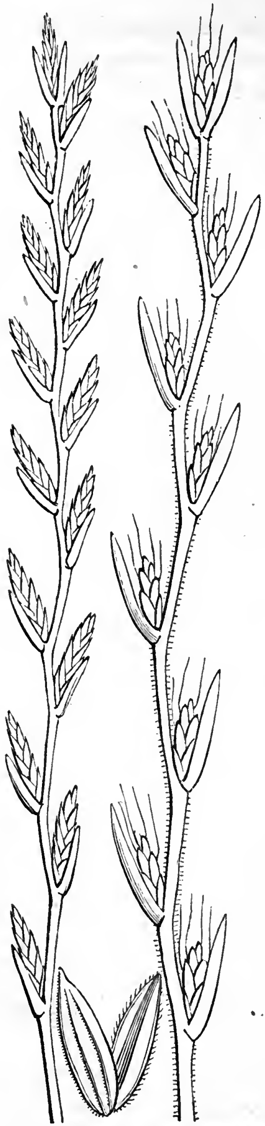


Fig. 1. LOLIUM PERENNE—Perennial Ryegrass.
Fig. 2. LOLIUM TEMULENTUM—Common Darnel.

or grass for two or more successive seasons. For such cases the seeds should be obtained from plants of at least two years' standing, by which means the produce is of more permanent duration than that of seed saved from the crop of the first season; indeed, so much does the duration of ryegrass depend on the previous manner adopted in saving the seed, that it is the produce of seeds saved successively from the first year's crop which constitutes the "annual ryegrass"—a variety which, from the comparative shortness of its duration, is generally so termed. This *annual ryegrass* differs from the more permanent varieties by having fewer root-leaves and a greater quantity of culms or stalks, which are rather longer, and furnished with a smaller proportion of foliage, than those of most of the perennial varieties. From the quantity and length of its stalks or culms, this sort has been considered as yielding a greater bulk of crop the first season, and therefore better adapted for single crops of hay than the perennial sorts; but the result of recent experiments tends to show that the quantity of root and stalk-leaves which these last produce fully compensates for any deficiency which may arise from the weight of their culms, besides rendering the hay less wiry and more palatable than that of the annual ryegrass, which, in fact, seems to possess no superior quality, save perhaps that it yields a greater quantity of seed.

Evergreen.—This variety is much esteemed in some districts, its perennial nature, hardy habit, and productive character, rendering it a favourite with many growers.

Molle's variety is also a favourite in some places. It is rather of a slender habit of growth, reaches a good height, and gives a very bulky crop.

Orkney or *Pollexfen's* variety takes its distinctive name from its introducer, Mr. Pollexfen, of Kirkwall, Orkney, who for many years devoted much attention to ryegrass, and obtained this valuable variety. It has all the good qualities of the preceding, and is somewhat darker in colour, with more than ordinary permanence of duration.

Pacey's produces an abundance of foliage both at the roots and on the stalks, which, although rather broader and not so fine in appearance as Whitworth's, is also, from its perennial character, well adapted for pleasure grounds and permanent pastures. The characteristics of this variety, when allowed full room for its development, are its forming much-branched and bushy plants, with shortish and somewhat rigid stems, upright spikes, and short, compact spikelets. Its seeds are short, plump, and generally heavier than those of other varieties. This variety may be considered as the first successful attempt to select improved varieties of the natural grasses for cultivation, and had acquired a considerable reputation both in Scotland and in England before the commencement of the present century.

Russell's.—A variety named in compliment to the late Duke of Bedford, who first noticed and pointed out the original plant from which the stock has been raised to Mr. Holdich, at that time editor of the *Farmer's Journal*. It was found to be of a much stronger habit of growth and to yield a heavier crop than either Pacey's or Whitworth's; besides which it combines early spring growth with a late and vigorous growth in the autumn. How far the Russell ryegrass of the present day is identical with that of whose good qualities we have evidence in the *Hortus Gramineus Woburnensis*, it is difficult to say. Although we are inclined to admit it as a superior variety, general experience hardly assigns to it the very high qualities therein claimed for it.

Spreading (L. stoloniferum) was introduced from Germany by Messrs. Lawson & Son, in 1834. It is a remarkable stoloniferous variety, of strong, early growth, pushing out long prostrate stolons or shoots, with an abundance of foliage, so that one plant, by the time the spikes begin to appear, will form a close tuft, extending from 2 to 3 feet in diameter. These stolons or shoots, however, although lying close on the ground, never attempt to strike root until the end of the season, and then only very sparingly. It does not appear to offer any great inducements for cultivation. Its height is about 15 to 18 inches from the ground, but the entire length from the root to the point of the spike is often from $2\frac{1}{2}$ to 3 feet. It is generally about a fortnight longer in seeding than the other varieties of ryegrass, and produces comparatively few flower-stalks.

Stickney's variety is so called from the name of the original grower, Mr. Stickney, of Holderness, and has always since its introduction been held in high estimation by growers of ryegrass. It resembles Molle's a good deal in its habit of growth, but is of a more perennial nature, and grows stronger and more freely both in the beginning and at the end of the season. Its chief distinguishing characteristics are its peculiar light-green colour, and more than ordinary length of stem.

Thick-stalked Perennial Ryegrass was originally obtained (1833) by Messrs. Lawson from Vilmorin, Andrieux, & Co., of Paris, under the name of *Lolium grossum*. It differs greatly from the preceding varieties; its stiff and upright habit of growth rendering it nearly as remarkable as the spreading ryegrass is for its slender stoloniferous habit. It grows to the height of about 18 to 20 inches, carrying a very broad spike about 8 inches long; the spikelets are very long, and placed so that the end of one reaches to the base of the next above. The experimental trials of it do not appear to have been very satisfactory—not, at all events, sufficiently so to give it a preference over the varieties already in cultivation. Its spring growth, for which ryegrass is so valued, was late and deficient; and although it was found to stand well at the end of the season, it was not so permanent in duration.

Whitworth's is the name given to a variety of ryegrass selected by Mr. Whitworth, of Acre House, from an experimental collection of about 60 varieties of perennial ryegrasses, as being the one possessed to the greatest degree of the qualities of growth and produce most desirable in the plant for general forage purposes. In the "experimental grass garden" at Woburn this variety was found fully superior to Russell's, and was then called the "stoloniferous" ryegrass, as surpassing all others in the number and vigour of its barren or leafy root-stems, a characteristic of permanence in duration exemplified in its suitability for permanent pasture in the most ungenial, cold, and wet soils. It has the character of possessing in an eminent degree the properties of early and of late growth, and to be of such a perennial nature, or so tenacious of life, that the ground requires two or three ploughings to overcome its vivacity, so as to prevent it injuring the succeeding crop. Its foliage and general growth are remarkably fine, which renders it suitable as a mixture for sowing pleasure-grounds.

The above, says Mr. Lawson, from whose "Synopsis"[1] the descriptions given are chiefly derived, are the most esteemed varieties of *Lolium perenne;* but there are many more of inferior importance, as the Holstein, Broad-spiked, &c., and possessing less permanent characters. Those of the most perennial habits, which are distinguished by their yielding a greater abundance of root-leaves and fewer stalks and stems, are denominated *perennial;* and those of shorter duration, which generally

[1] The details of the experimental trials at Woburn are all given in Sinclair's *Hortus Gramineus Woburnensis.*

produce a smaller quantity of root-leaves and a greater quantity of culms, are termed *annual* ryegrasses; but even these last will, under favourable circumstances, last two or three years, while, under unfavourable circumstances, the most esteemed perennial varieties will scarcely exist more than one year. Of those termed annual, there is only one variety in cultivation. But even sorts which are most permanent in their characters, or such as are most capable of producing the same sort from seed, have become so much changed in habits and characters, from the effects of continued culture upon different soils and under different circumstances, as no longer to retain any traces of the properties for which they might have been originally distinguished.

2. *Lolium italicum—Italian Ryegrass.*—This species differs from the foregoing (*perenne*) in its more vigorous growth, and in its bearded spikelets containing many more florets. The whole plant is of a lighter colour, it grows more erect, tillers much less, and is hardly more than a biennial under the ordinary circumstances of cultivation. By some botanists it is classed merely as a variety of the *L. perenne*, as the presence or absence of the awn in the Gramineæ does not properly constitute a sufficiently permanent specific character, as it is frequently caused by the effects of climate, soil, &c. The farmer, however, has less hesitation or difficulty in their respective classification than the botanist. They possess other distinctive characters, which, although of but small consequence in the estimation of the man of science, are (some of them, at all events) of considerable importance to the man of practice, the farmer.

Compared with the ordinary varieties of the Common ryegrass (*L. perenne*), the Italian ryegrass affords a stronger braird, arrives sooner at maturity, has a greater abundance of foliage, which is broader, and of a lighter or more lively green colour; grows considerably taller, is more upright, or less inclined to spread on the ground. Its spikes are longer, spikelets more thinly set, and upon the whole producing a less bulk of seed, which is of a smaller size; has the characteristic awn (before alluded to) adhering to it, and is generally but little more than half the weight per bushel of that of the Common perennial ryegrass when grown under similar circumstances. Another of its distinguishing characters is that it is preferred by cattle to any of the common sorts, a fact which has been proved by numerous experiments in various parts of the country; while it yields early, bulky, and quickly-succeeding herbage, which renders it an invaluable grass for alternate husbandry. Its comparatively limited duration fits it well for sowing in mixture with the other grasses intended for permanent pasture, as it dies out, and gives place to the weak or slowly-maturing perennial sorts, which are destined ultimately to fill the ground. An experience of nearly thirty years since our first introduction of the Italian ryegrass to this country enables us (Messrs. Lawson) to state, that in respect to duration it may be termed a sub-perennial, beyond which title even the most permanent varieties of the *L. perenne* have no claim. In most instances, two seasons of Italian ryegrass are all that can with any degree of certainty be depended upon; and in very wet, cold, spongy soils, it will often exhibit but a very thin stock the second season. Instances have, however, occurred in which as many as five and even six successive years' produce has been obtained from the same field; but this has no doubt arisen more from the ground having been re-sown by the seed shed at harvesting the crop, than from the actual duration of the original plants, the seeds being remarkably easily separated from the stems, even although not perfectly ripe, which fact always causes the harvesting of them to be attended with considerable care and difficulty. Although the natural tendency of the Italian ryegrass is to produce many stalks or stems from the same root, yet from its upright habit of growth it by no means forms a close sward; hence the propriety of sowing with it a mixture of other grasses of a different habit, which, by filling up the interstices, will add considerably to the weight of produce. Different opinions are still entertained as to the real merits of the Italian ryegrass; but perhaps the best proofs of its excellence is the great and yearly increasing demand for its seeds. Like all other plants subjected to artificial culture, the Italian ryegrass is productive of numerous varieties. In this country no attention has, however, as yet, been devoted to the selection and cultivation of any variety possessing permanency and superiority of character, if we except the following:—

Short-awned Italian Ryegrass—L. italicum submuticum—which differs from it principally in having larger spikelets, and bearing florets with short awns, whence its name. The seeds are heavier and thicker, and the produce greater than that of the Common Italian ryegrass.

3. *Lolium multiflorum—Many-flowered Annual Ryegrass*—differs from the preceding species in being of shorter duration, or *strictly annual.* The two following varieties of this species were introduced by Messrs. Lawson from France in 1837; but as they were not found to be superior to those commonly cultivated in quality or in bulk of produce, while they were both so strictly annual as to yield no grass after being cut for seed, their cultivation cannot be recommended.

Brittany Many-flowered Annual Ryegrass is indigenous to the province of that name, where it was first noticed in 1835 by M. Rieffel, Director of the Farm School of Grand Jouan, who found it particularly useful for growing as a single crop, being only of annual duration, and eminently suited for such soils as he farmed, viz., high, wet, moorish lands of considerable tenacity, and such as do not retain the clovers throughout the winter. His practice was to sow it in September, at the rate of 40 lbs. per acre; and he reports that it yielded him very large returns of forage and of hay. This probably might be a serviceable description to sow in the autumn on any portions of a field where the young grass may have failed, from luxuriance of the corn crop, or from other causes. The other variety is known as—

Bailly's Short-awned Annual Ryegrass, takes its distinctive name from that of a leading agriculturist in the department of the Loire, who first introduced it into cultivation. It differs from the preceding variety by having only those seeds towards the extremity of its spikes slightly awned, which circumstance, together with the form and great weight of the seeds, as well as its shortness of duration, gives it the appearance of a hybrid between the *L. italicum* and *L. arvense.* Besides having much heavier seeds, it is shorter in growth, as well as thicker in straw and finer in foliage, than the last. M. Bailly, in his description of the variety, states that he has obtained as much as 6000 lbs. of seed from an acre. If anything like this rate of seed-produce could be secured, it surely is a variety worth the attention of those farming in favourable climates, as the amount of nutritious food it would supply, assuming the seed to be of equal value to that of the ordinary ryegrass, is far beyond the average of our usual crops.

The last species to which we have to refer is

4. *Lolium temulentum—Bearded Darnel* (*fig.* 2, p. 206) —a most pernicious weed, growing chiefly in wheat fields, where its presence is always indicative of the backward condition of the agriculture of the district. It is annual in

its habit, and ripens its seeds at about the same time as the wheat, from which it is with difficulty separated at the time of thrashing, owing to the size of the seeds being much the same. Happily, however, it is rapidly disappearing in this country before the march of improved husbandry, though, from the proportion of its seeds met with in most samples of foreign wheat, it would appear still to hold its place in the corn fields of the Continent.

Although its effects upon the human economy when eaten mixed in the wheaten bread are not so disastrous as those produced by ergot (see page 181, vol i.) when consumed under similar conditions, it exerts a prejudicial action, which in some instances has led to fatal results. Cases may still be occasionally heard of country districts where, in years of scarcity, the inferior samples of foreign corn have been largely used for bread purposes; and Parnell, in his *Grasses of Britain*, records a recent case of poisoning caused by this grass, wherein the symptoms produced were somnolency, convulsive tremors, and coldness of the extremities. The plant itself may be distinguished from the common ryegrasses by its erect habit of growth, the stems being stout, and from 2½ to 3 feet high, and feel rough or serrated on drawing them through the fingers upwards. The presence of darnel in the meal or flour of wheat may be detected by Ruspini's test, which cannot be made too generally known, viz., "that the adulterated flour may be readily detected by digesting it in alcohol, which, when *L. temulentum* is present, assumes a characteristic green tint."

Lolium arvense is the *Beardless Darnel*, a variety only of the other, which it resembles in its habits of growth, but from which it differs in having only very short imperfect awns and a smooth culm or stem. It is said to possess the same noxious properties, and appears to be the variety mostly met with in samples of wheat from the southern countries of Europe.

Although ryegrass may be grown in almost any description of soil, from the light sands and gravels to the strongest loams and clays, it has a certain preference of soils, by which its natural growth is greatly influenced. The numerous varieties of ryegrass, possessing in themselves habits of growth more or less differing from each other, however, afford opportunities for adapting the crop, to a great extent, to the particular class of soil intended to be sown. Thus a little consideration beforehand as to the respective suitabilities of the crop and of the soil will enable us to avoid those unsatisfactory results that so frequently are heard of where these points have not been attended to. Climate, too, exerts a considerable influence on ryegrass, hardy though it be, and indeed limits its cultivation to countries where no great excess of temperature, either high or low, is met with. Although indigenous to all the countries of Europe, it is never met with growing beyond the range of the cultivated grasses, cereals; neither can it be grown beneficially at higher elevations. Its fibrous shallow roots, deriving their nourishment from the upper portions of the soil, would indicate that a temperate climate and a moist soil are most suitable to its growth. The excessive heat and aridity of the tropical regions are equally unfavourable to its growth as the excessive cold of the higher latitudes; and, indeed, in countries of the temperate zone, where summer and winter extremes exist, it cannot be successfully cultivated. In the United States, Canada, and some parts of the Continent of Europe, the climatal conditions of the countries are generally unsuitable to its growth, the heat and dryness of the summer rendering the surface too parched for such a shallow-rooted plant, while the extreme cold of the winter penetrates often lower than the roots of the plant descend, and is thus equally prejudicial to its existence.

We find even the differences of climate on our own coasts exerting a marked difference on the plants we cultivate as crops. On the east coast, where the rainfall and the humidity of the air are less, our root and forage crops are generally less vigorous in their growth and productive in their returns than on the west coast, where the rainfall and humidity are greater. Again, for crops which require less moisture for their growth and a drier air for their maturation—the cereals, for instance—the climate of the east coast is generally more favourable than that of the west. If ryegrass were grown for its seed alone, the produce of a crop grown on the east coast would probably, in a course of years, bring a better return per acre than of a similar crop on the other side of the country; whereas we all know full well that merely for herbaceous growth—for forage purposes—the produce of the crops grown on the western side are greatly superior to those obtained on the eastern coasts. Thus we see that the climate of one side of the country is better adapted than that of the other for the cultivation of crops which, either from their deeply-penetrating roots or other natural characters, can thrive in a comparatively dry soil and atmosphere; while the comparative humidity of the other side renders it more suitable for the cultivation of herbaceous and shallow-rooted crops, whose power of development would be proportionately checked if placed in the same conditions under which the other classes of crops thrive. And this we see practically is the case. In England, the eastern counties—take Norfolk and Suffolk—are noted for their grain, and the western counties—say Devonshire and Somersetshire—for their dairy produce and breeds of cattle. In the north, East Lothian and Fife on the east coast, and Ayrshire and Galloway on the west, fully support this natural arrangement of our farming system.

The ryegrasses are used more commonly for mixing with other seeds, either for permanent or for rotation purposes, than for cultivation as a distinct crop. The Italian ryegrass is the only one which by itself assumes the character of a "forage crop," and to this we shall chiefly confine our attention in the present case. This species thrives best in the stronger class of soils. The loams and alluvial and warped soils are those which, from their physical as well as chemical constitution, are best adapted to its cultivation. It, however, has been grown with great success in the strong soils of the London clay formation. The clay is no doubt the most important agent in rendering soils of this description suitable to the crop, as this substance not only contains in its chemical composition the mineral ingredients required by the crop for its healthy and vigorous growth, but it also imparts to the soil the mechanical property of absorbing and of retaining the moisture so necessary for herbaceous growth, and which, at the same time, so materially assists a fibrous shallow-rooted plant to obtain its food-materials in a readily assimilable condition. Too large a proportion of clay in the soil would, however, under ordinary circumstances, render the soil too close and compact to allow of that free ramification of the roots which it is so desirable to secure to the plant, while it would also tend to keep the temperature of the upper portion lower than if the air and rain had freer access to it.

In the preparation of the soil it is important to recollect that the success of the crop depends greatly upon the conditions, favourable or otherwise, it meets with in the soil. Its growth is rapid and its produce large where these have been properly attended to; if they have been neglected, the results are, as they ought to be, indeed, less satisfactory. Deep cultivation is the basis of large returns. None of our cultivated crops can thrive where stagnant water lies in the soil. The more finely the particles are divided, the more likely they are to be acted upon by the air and the rain, and the greater the range of feeding ground becomes; and the cleaner the land is kept of weeds, which we neither eat nor sell, the more food there is for the growth and increase of the crop that we cultivate for one or other of those purposes. All these points ought to be attended to as carefully in the preparation for Italian ryegrass as for any other of our crops, and no money is better laid out on a farm than that expended in the judicious preparation of the land and selection of the seed for a crop.

This latter point, the selection of the seed, to which we have frequently alluded in reference to preceding crops, has a peculiar bearing in the present case, as probably not one of the seeds we use in our ordinary crops is subject to the same amount of adulteration that is met with in this and the common perennial ryegrass. This, though well known to both sellers and buyers, seedsmen and farmers, and of course reprehended by both, is, however, practically supported by the latter, who too often look to the quantity rather than to the quality of the seed, and fancy that because it is offered them at a *low price* it must consequently be *cheap*. It is true that by increasing the quantity of seed allotted to the acre they increase their chance of getting a plant; but it should be recollected that they increase their crop of weeds at the same time; and it does not require much observation nor much time to show that bad seed is dear at any price that it can be purchased for. In a recent number of the *Agricultural Gazette*[1] a valuable article—one of a series on the adulteration of seeds—appeared, treating specially of the adulteration of ryegrass seed—both the Perennial and the Italian—which gives us the detailed results of examination of several marked samples of both species.

[1] *Agri. Gaz.*, 1860, p. 414.

The two tables now given show not only the proportion of adulteration, but the class of seeds found mixed up in the samples, most of which are well known in our fields, and put us every year to no little trouble and expense to get rid of:—

TABLE I.—ANALYSIS OF RYEGRASS SEEDS.

Sample.	Copy of Label	Weight per Bushel.	Weight of 2 oz. by Measure.	No. of Weeds in a Bushel.	REMARKS.
		Lbs.	Grains.		
1	Light Ryegrass.	14½	184	444,800	Holcus lanatus, . . 6400; Bromus mollis, . . . 500; Ranunculus repens, . 50; 6950 in a pint.
2	Ryegrass.	16	216	430,080	The same kinds.
3	,,	18	240	288,000	The same, with Festuca bromoides.
4	,,	20	264	184,320	The same as 1 and 2.
5	,,	22	276	73,680	,, ,, ,,
6	,,	24	289	102,400	The same, with the addition of Myosotis arvensis and smaller weeds.
7	Perennial Ryegrass.	24	296	56,320	Chiefly Holcus lanatus.
8	,,	26	320	76,800	The same as No. 1.
9	,,	28	352	10,240	,, ,,
10	,,	28	360	6,400	Ranunculus and Plantago.
11	Extra fine short do.	28	368	15,360	Tolerably pure sample.
12	,, ,,	30	380	6,400	Very pure sample.
13	,, ,,	30	382	10,240	Weeds all Holcus.
14	,, ,,	32	402	3,200	Difficult to find a weed.
15	,, ,,	32	400	12,800	Mostly Ranunculus and Sherardia.
16	,, ,,	34	404	25,600	,, ,, and Holcus.
17	,, ,,	36	480	20,280	,, ,, ,,
18	,, ,,	38	520	40,960	The plump grains of the grass very large and freed from the glumes.
19	,, ,,	40	544	20,480	Bromus mollis absent.
20	Common Ryegrass.	40	544	32,000	Ranunculus repens and others chiefly.

"In this table, we may remark, in the first place, upon the great difference in the weight of a bushel of ryegrass seed. The lowest weight here tabulated is 14½ lbs. per bushel; but we have examined even lighter. Of course, in these cases the preliminary test of weighing ought to satisfy any one that if of less weight than 20 lbs. per bushel—and this is quite a low quotation—the seed is not worth buying. This is a matter which can easily be approximately ascertained from as small samples as 2 oz. by measure; and for ourselves we would say that we would not look at a ryegrass sample of 2 oz. of it *by* *measure* which did not weigh as much as at least 270 grains."

Of course, in estimating the weight of samples, says the author (Professor Buckman), it is always necessary to see that it is made up of the proper seed, as, if it be full of plump grains of *Bromus mollis* (soft brome or lop), *Triticum repens* (couch grass), or, as is frequently done purposely to add to the weight, of *Plantago lanceolata* (rib grass), its weight will be greatly increased, and unfortunately in such a way that the grass will be too poor to grow, but the weeds will be sure to succeed. We have seen fields sown with ryegrass, in which the only crop visible has been plantain or rib grass; and we must recollect that both plantain and brome grass are strictly annual plants, and will have sown their seeds freely, while even the barley with which the "seeds" may have been sown down is being harvested. The point we would here advert to is, that the table demonstrates that for the most part the lighter samples of seed are fullest of weeds. This may arise from the carelessness of its growth on the one hand, and the impossibility of cleaning mere chaffy stuff on the other. As may be expected, the heavier samples of seed have been more carefully grown, it being next to impossible to obtain the best samples by a dirty cultivation; and then, again, the heavy grains are more plump and rounded, the chaff fits to the seed, is not so pointed, and therefore not so liable to entanglement, so that these can be separated with tolerable ease. That clean samples can be obtained is obvious from our samples 10, 12, and 14, in which the weeds were remarkably few in number, and such as could readily be separated. That the heavier samples of ryegrass seed are the cheaper we can state from repeated experiments, as we have sown the lighter ones, in which scarcely a genuine seed would germinate, whilst of the heavier samples only a slight proportion fails. If we had to appraise the value of the samples examined merely from the evidence afforded by the table, we should estimate them almost in multiple proportions to their respective weights—the lower numbers as next to nothing in value, and the higher ones at fully ten times their worth. Of this the following may offer an approximative example:—

Nos. of Samples.	Weight per Bushel.	Proportional of Value.
	Lbs.	
1 to 3	14 to 18	5
3 to 7	18 to 24	15
7 to 13	24 to 30	25
13 to 16	30 to 34	40
16 to 20	34 to 40	50

In all the lighter samples of ryegrass a varied quantity of Italian ryegrass was met with. This, Professor Buckman continues, is of course mixed in the way of direct adulteration, usually being old, worn-out Italian ryegrass, aiding immensely in filling up the measure, from the looseness derivable from the long awns of this variety; and this circumstance, of course, aids greatly in decreasing the weight per bushel. The evil of this is much more than at first appears, as, although the Italian would grow and make a great appearance the first year if at all worth anything, yet the fact of its being annual is fatal in any position where perennial growth is required, and more especially in the permanent pastures.

These tabulated analyses tell their own tale, and show the great importance of a careful selection of the seed about to be sown, either for a rotation or a perennial forage crop. Although adulteration is carried on in the seed of our other crops—let us take turnips for instance, and of this we have already spoken (p. 299, vol. i.)—it is rarely carried to anything like the same extent, or attended with such injurious consequences as in the present case. In our

TABLE II.—ANALYSIS OF ITALIAN RYEGRASS SEEDS.

No. of Sample.	Copy of Label.	Weight of 2 oz. by Measure.	No. of Weeds in a Bushel.	Remarks.
1	Imported Italian Ryegrass.	212	73,216	Ranunculus repens, Plantago lanceolata, and Bromus.
2	,, ,,	216	261,120	,, ,, with Holcus lanatus.
3	,, ,,	216	79,240	,, ,, ,, ,,
4	,, ,,	224	81,929	Bromus and Holcus.
5	,, ,,	...	204,880	,, ,,
6	,, ,, 15 lbs.	...	102,400	,, ,,
7	,, ,, cleaned and re-cleaned, 15½ lbs.	204	79,240	Ranunculus repens, ... 320; Holcus mollis, ... 120; Plantago lanceolata, ... 160; Caryophyllaceæ, ... 360 — In a pint.
8	Foreign as received.	...	23,040	Bromus mollis, ... 240; Others, ... 120 — In a pint.
9	,, cleaned for sale.	...	1,280	Bromus absent.
10	Heavy Italian.	...	1,600	Clean, good sample.
11	Home-grown from Lombardy seed.	240	5,120	Not fully cleaned.
12	Imported Italian.	212	92,160	Ranunculus repens chiefly.
13	,, ,,	216	39,240	,, ,, ,,
14	,, ,,	224	14,336	Bromus mollis and Holcus.
15	,, ,,	216	261,120	Ranunculus, Holcus, and Plantago.
16	,, ,,	172	140,800	Very poor sample.
17	English Italian Ryegrass.	...	196,800	Sherardia arvensis, Arenaria, Scabiosa columbaria, &c.
18	,, ,,	...	25,000	Might be better.
19	Imported Italian, cleaned.	...	162,400	Bromus mollis, &c.
20	,, ,,	...	450,560	Ranunculus repens, Bromus mollis, &c.

seed-grains, weeds are readily detected by their difference in size, and as readily got rid of; in the fallow crops they may be sown with the seed and germinate, and are then disposed of by the hoeings the crop receives. But with the ryegrass, whether sown for a single crop or for permanent purposes, they are placed under exactly the same conditions as the cultivated plants; and as they are generally more vigorous in their habits, and more hardy in their nature, a struggle for possession of the ground takes place between them and the ryegrass, and the weakest soon goes to the wall. Although there does not appear to be that great difference between the weights of the various samples of Italian ryegrass, which to a certain extent indicates quality, that is noticeable in the Perennial, the amount of adulteration in the former is always much greater than in the latter, as the greater portion of the seed is imported, and, unless well cleaned, is very foul indeed, neither the mechanical arrangements, nor the propensities of foreign seed-growers seeming to lead in that direction. A *clean* sample of Italian ryegrass, weighing from 16 to 20 lbs., may be considered as good, so far as the weight is concerned. This, however, may be considerably increased by the mixture of some of the heavy weeds already named.

The quantity of seed to be sown varies much, as might be expected, in seed so liable to adulteration, and consequently to variation in its produce—from 2 to 4 bushels to the acre may be taken as the range of quantity. If the seed be good and fresh, the former is ample to secure a fine plant. A difference of opinion exists as to the best time for sowing ryegrass. Some are accustomed to lay it down in the same manner as "seeds" with a straw crop, and thus sow it in the spring; some, again, recommend that it be sown by itself, and not with a straw crop, but as soon after harvest as possible; while others, recollecting that ryegrass belongs to the *same order, and has the same food requirements as the straw crop,* consider it would be more consistent with *principles* were it to follow any other crop, rather than one to which it is so closely allied. This latter practice, which certainly is the most philosophical, gives a greater selection of time for sowing it than either of the other two—one of which is bound to the early spring, the other to the late autumn. If sown early in the autumn, in favourable seasons it will sometimes give a cutting before winter, or, at all events, it will be ready for use early in the spring; and if sown in the spring by itself, it will be ready for cutting or stocking by the middle of June, and continue growing until the end of the year; if sown down with a straw crop, it will rarely afford any keep worth remark until a month or six weeks after the crop is harvested and the field cleared. It may be sown, in fact, at any period that either the mode of cropping or the labour arrangements of the farm render most convenient; the particular object for which it is sown, and the intended duration of the crop on the ground being the principal points to be considered.

In the preparation of the ground for the seed it should be borne in mind that ryegrass being an erect-growing, fibrous-rooted plant, requires the surface soil to be in a more compact and consolidated condition than it would do if it were a creeping or a tap-rooted plant; therefore, after the land has been well tilled and cleaned, it is always desirable to run the roller over the surface, in order to give it that mechanical condition which we know to be favourable to the growth of the crop. The seed is usually sown with the broadcast barrow already described (p. 105), and should be merely brushed in with the bush-harrow, and then left to germinate. It is important that the seed should be covered as thinly as possible; therefore, if seed-harrows be used, they should be of the lightest description, and if the surface require it, it may again have a turn of the light roller over it. Where ryegrass is sown with other seeds—which it commonly is to a large extent, both with the clovers for rotation crops and other grasses for permanent use—the quantities sown and the treatment it receives differ of course from the foregoing. For "seeds," as the clover crop is usually termed, from 1 to 2 bushels of Italian ryegrass are mixed with from 12 to 20 lbs. of the clovers, and used in the four and five course systems. Where the seeds are intended to be down a third year, the perennial ryegrass is mixed with the Italian in about equal quantities; when used for mixing with other grasses for permanent pastures, from 10 lbs. to 15 lbs. per acre is an ample proportion; of this about one-fourth or one-third may be Italian, and the remainder of the perennial species. The Italian comes to maturity and furnishes a supply for the first, and perhaps second years, when it dies out and makes room for the perennial grasses, which have then acquired their full development, and furnish the future supplies. When sown singly as a crop, no tillage treatment is required after the land has been properly prepared and the seed is sown; all that then remains to be done is to consume it in the most profitable and advantageous manner.

There is but little doubt that all our forage crops give a much larger available produce when they are carefully cut and carried to the cattle, than when the cattle are turned in to feed them off on the ground, and that a large growth of herbaceous matter can only be supported where a large proportion of moisture can be obtained by the plants from the soil and atmosphere in which they grow, or is supplied to them by artificial means. Although these points are generally acknowledged, and although, under the ordinary conditions of farming, ryegrass is a very advantageous crop, and furnishes a large amount of early and nutritious keep, whether cut for "soiling" or stocked with sheep in the usual way, we were hardly prepared for those enormous returns which Mr. Dickenson made known to us some fifteen years ago, when he first gave us the results of his mode of treating ryegrass by frequent cuttings, followed by the application of liquid manure. His practice, of which the details were published[1] and fully discussed at the time, was to apply strong ammoniacal manures in a liquid form immediately after each cutting, and by that means he was enabled to render the growth so rapid as to obtain as many as ten cuttings in the course of the year, averaging from 8 to 9 tons each to the acre, or the enormous total of from 80 to 90 tons of green produce to the acre. His land for ordinary farming purposes was of a

[1] *Roy. Agri. Soc. Jour.*, vol. vi. p. 576; vol. viii. p. 573. More recent details are given in the *Agri. Gaz.*, 1858, p. 95, and in a pamphlet entitled *Instructions for Growing Italian Ryegrass.* Ridgway, 1856.

very unsatisfactory description, being on the London clay; but for this particular cultivation it certainly was not ill adapted, as clays contain larger proportions of potash, and absorb and retain both ammonia and moisture to a greater degree—all of which are essential to the growth of the ryegrass—than soils of a lighter class.

The great success that followed this practice, and the general admission of the beneficial action of liquid manures on growing crops intended for forage purposes, soon led other cultivators to follow and improve upon it; and in a few years we find it forming the keystone of the system of management on more than one farm, while on others, where it was carried out, it added largely to their productive resources. The conditions of Mr. Dickenson's farming were somewhat exceptional: he kept a great number of carriage-horses, who required a large amount of green food, and whose liquid secretions furnished the manure, which was carted out and distributed liberally on his forage crops. His followers, however, were practical men, who took the matter up purely as a question of productive farming; and being satisfied as to the principle, made their arrangements for carrying it out by means of fixed pipes and distributing apparatus, instead of the more costly and less efficient mode of horse labour. The different farms where this practice has been in operation are so well known, and their arrangements and details of management have been before the public, and so often discussed, both at agricultural meetings and through the medium of the press, that we need say but little about them here: those to whom the subject commends itself we would refer to the valuable practical paper "On the Cultivation of Italian Ryegrass" read by Mr. J. C. Morton at a meeting of the Central Farmers' Club, in March, 1855,[1] in which a description and full details

[1] Condensed report given in *Agri. Gaz.* for 1855, p. 158.

are given of the Ayrshire farms of Myremill, Cunning Park, Lagg, and others, where ryegrass is grown and irrigated by fixed pipes and apparatus. On these different farms, soils varying from stiff clays down to a light sand were being successfuly cultivated, the system of irrigation transforming completely the character of the usual farming of the district.

The expense attending this addition of pumps, pipes, and other fixed apparatus, to the usual working "plant" of the farm, must of course be taken into consideration, and charged against the crops. These, however, taking an average estimate of them, show such a large balance in favour of the system, as to leave little doubt as to its advantages wherever circumstances are favourable to its adoption. Mr. Dickenson's annual produce was stated at 80 to 90 tons per acre; and this has been practically confirmed by the occupiers of the farms just mentioned, who, although they do not take so many cuttings in the course of the year from their crops, obtain a proportionate amount of produce. The expenses of tanks, pumps, pipes, &c., are of course affected by local circumstances, by the extent of the work, and by the price of materials; from £3 to £5 per acre, however, would give a range sufficient to meet all probable contingent outlay.

The enormous produce obtained, and the rapid growth of the crop, by this system of irrigation, would lead us to consider that the increased bulk was due in a great measure to an increased proportion of water in the plant, and that it must not be looked upon as of equal nutritive value. This is no doubt true, and when cut for hay the produce of dried hay is less, bulk for bulk, than that made from ryegrass grown in the ordinary manner. These points have been examined by Dr. Anderson, who found not only that the irrigated plant contained a larger percentage of water, but that its constituents varied in their relative proportions during the different periods of the growth, which results have been rendered practically available on the farms alluded to, according to the purposes for which the ryegrass was cultivated. Dr. Anderson found that young Italian ryegrass, seventeen days old, and 17 to 18 inches high, and weighing about 9 or 10 tons per acre, contained 86 per cent. of water; and the same ryegrass, when five weeks old, from 3 to 3½ feet high, and weighing about 20 tons to the acre, contained only 74 per cent. In the former the nitrogen compounds existed to the extent of about 3 per cent., while in the latter they were reduced to 2·5 per cent.; but the latter contained 10·5 per cent. of starch, sugar, and other solid compounds, while the former only contained 5·5 per cent. of the same substances: therefore, in the mode of treating and of consuming the ryegrass, some consideration should be paid to the object you have in view. If the object is to form flesh and muscle, as in growing or in working animals, Mr. Dickenson's plan of frequent cutting is perhaps the best; but if the object is the production of milk, or to feed and prepare animals for the market, then it would appear that the system adopted on the Ayrshire farms, of longer intervals between the cuttings, so that the plants may be in a more mature state, is the most advantageous to pursue.

For dairying purposes this system of farming is particularly suitable, as securing, during about nine months of the year, a regular supply of nutritious and succulent food. Cows will consume about 100 lbs. a day, with the addition of 2 or 3 lbs. of corn or cake each, according to the quality of the dairy. In feeding cattle, the same quantity of grass, with a proportionate increase of cake, should be allowed; while for sheep from 10 to 15 lbs. per day are generally found to be sufficient. All cattle are fond of it, and are said to tire of it less readily than of clover or other green food.

The Italian ryegrass is never left down longer than two years. The first autumn it will usually give one cutting, which, if late in the season, should not be too close to the ground; the following year it is in full produce, and may be cut as frequently as the growth will admit of it; the next spring it will generally bear cutting once or twice, and should then be ploughed up and the ground rendered available for another crop, or it may be allowed to stand for a seed-crop, when the hay is made and harvested in the usual way.[1] The seed, which separates from the stem very easily, may either be thrashed out by the flail, which is the usual way, or by the machine. The produce in favourable seasons is sometimes very large, though in weight that of the Perennial species greatly exceeds it.

The Perennial ryegrass is more or less subject to most of the *diseases* which have been described as affecting the cereal grasses: the only one, however, which has been noticed as injuring it to any practical extent is the ergot (see p. 179, vol. i.), which in some seasons, especially in low-lying or heavy undrained soils, has not only completely destroyed its forage value, but rendered it very prejudicial to cattle pasturing on it.

The Italian ryegrass is generally free from this and the other similar forms of disease, as it remains down only a short time; and its growth is so rapid and pushed forward by the application of manures, that it is cut and consumed before the disease, if it exists, has time to exert much influence on it.

[1] Speaking of Mr. Dickenson's farm, Mr. Caird tells us:—"The demand for seed is so great that two crops are sometimes taken in a season (though that is not recommended in ordinary circumstances), the first crop yielding from 4 to 7 quarters the acre, the second about 3 quarters. In order to ascertain how much hay could be got from Italian ryegrass, the whole year's crop of one field was made into hay, and the produce of four cuttings on a field of 20 acres amounted to 130 loads of 18 cwts. each, or nearly 6 tons to the acre."—*Caird's English Agri.* p. 465.

For the same reasons, the *insect injuries* it sustains are comparatively few. Like the grasses generally, it is subject to the attacks of the numerous wireworms at every period of its growth, and the slugs and snails are very destructive to it in its earlier stages. The larvæ of the different crane-flies—*Tipulidæ*—(see p. 386, vol. i.), frequently commit great ravages in grass laid down for permanent use; under the system of irrigation, however, these effects are never noticeable.

Ryegrass was one of the series of grasses and forage plants whose chemical composition was investigated by Messrs. Way and Ogston, under the auspices of the Royal Agricultural Society. Beyond this determination, and that of Dr. Anderson, already alluded to, the chemistry of the crop does not appear to have received much notice.

The organic composition of the two species, the Perennial and the Italian, is thus given:—

	L. perenne.	L. italicum.
Compounds containing nitrogen (flesh-formers),..	3·37	2·45
,, not containing nitrogen (heat-givers, &c.), as fat,	·91	·80
Starch, sugar, gum, &c.,	12·08	14·11
Woody fibre,	10·06	4·82
Ash (mineral matters)	2·15	2·21
Water,	71·43	75·61
	100·00	100·00

These analyses refer to the composition of the crop grown under the ordinary circumstances. Under the forcing influence of liquid manuring, the percentage of water, as shown by Dr. Anderson, increases, and the solid constituents are reduced to smaller proportions Thus, although the bulk of produce is largely increased, the real amount of food produced is not in the same increased ratio. In this respect, ryegrass, under a forced cultivation, confirms the opinions advanced in reference to the turnip crop, and discussed at page 327, vol. i., where it is shown that it is possible for the smaller crop or bulk of produce to contain more nutritive matter than the larger, and thus to be actually the more valuable crop of the two.

The composition of the ash, or mineral constituents of the plant, is as follows:—

	Lolium perenne.		
	In Flower.	In Seed.	Hay.
Potash,	12·45	10·77	8·03
Soda,	3·98	·13	2·17
Lime,	9·95	12·29	6·50
Magnesia,	2·23	2·64	4·01
Peroxide of Iron,	·78	·30	·36
Phosphoric acid,	6· 4	6·32	12·51
Sulphuric acid,	2·82	1·31	...
Silica,	59·18	60·62	64·57
Chloride of Sodium,	2·27	5·58	...
	[1]100·00	[2]100·00	[3]98·05

The only point for remark in reference to the inorganic constituents of the ryegrass is the large proportions of silica it requires to carry on its growth. About three-fifths of the whole of the mineral matters are composed of silica. Therefore, taking a medium crop under the irrigation system of 50 tons to the acre, about 12 cwts. of silica in a soluble condition would be abstracted from the soil by the growing crop, in addition to the potash and phosphoric acid.

Surely, with these mineral requirements, ryegrass ought neither to succeed nor precede a straw crop; and yet, in common practice, we too generally see it doing both.

[1] and [2] Way and Ogston, *Roy. Agri. Soc. Jour.*, vol. ix. p. 144.
[3] R. D. Thomson, *Researches on Food of Animals*, p. 80.

THE CHICORY CROP.

Although Chicory is more generally cultivated for its roots than for its leaves and stems, still it possesses qualities which entitle it to more consideration than it has hitherto received as a crop grown for forage purposes. It differs widely, both in its botanical and agricultural characters, from those "forage crops" which have preceded it, and on that ground alone is worthy of our notice, as offering to our use a plant which is capable of supplying a large amount of nutritive keep under circumstances which might possibly be unfavourable to the cultivation of those more commonly relied upon for that purpose. At all events, it offers us the means of substitution, should our ordinary crops, from any natural or unforeseen causes, fail us.

Chicory or succory is one of our indigenous perennial plants, and is met with growing freely in a wild state in many of the light soil districts in England, and also in other countries of Europe possessing similar climatal conditions. It prefers the light soils of the calcareous formations, into which its long tap-shaped root can penetrate in search of food. Although well known to the ancients, it would appear, from a passage in Horace,[1] to have been cultivated by them for culinary, rather than for forage uses. Pliny also speaks of its cultivation, and of its many virtues.[2] He terms it the wild endive—*Intybum erraticum.* In Gerarde the plant is figured and described, but no mention is made of the purposes for which it was grown.

[1] "—— Me pascunt olivæ,
Me cichoria, levesque malvæ."—*Horat.*, lib. i. car. 31.

[2] *Nat. Hist.*, lib. xix. cap. 39, et lib. xx. cap. 29.

It has been long known and cultivated on the Continent[1] as a field crop for forage purposes, and also in the gardens as an edible herb, its close alliance with the endive (*C. endivia*) rendering it very valuable for early salads and other culinary uses. In this country its cultivation was limited to the kitchen garden until towards the close of the last century, when we find Arthur Young growing it extensively on his own farm, and introducing and recommending it for general field culture, as a crop admirably adapted for the light deep soils, and capable of furnishing a greater amount of keep than could be obtained from any other crop under similar circumstances. Being a perennial plant, of a hardy habit, and indigenous to this country, it will remain productive for a greater number of years than either of the other perennial crops already described—the sainfoin and lucerne being both comparatively delicate plants, natives of other countries, though susceptible of cultivation under favourable conditions in this. The annual amount of produce is very large, as the plant grows rapidly to a good height, and will bear cutting three or four times in the season. Its root-produce, too, for which, indeed, it is more commonly cultivated, adds greatly to its value as a crop. This when dug up, sliced, dried, and roasted, gives, on infusion in boiling water, a sweet, dark-coloured extractive matter, and is largely used in this country for mixing with coffee, while in some parts of the Continent, especially the inland districts, it is used as a substitute for it altogether. We are indebted for our acquaintance with this valuable property of chicory, as we were for the sugar-producing capabilities of beetroot (see p. 456, vol. i.), to the celebrated Berlin and Milan decrees of the first Napoleon, which forbade the admission of colonial produce, and thus

[1] It is so commonly met with in waste places in some countries on the Continent, as to be known in Germany by the common name of "Wegwart."

forced the peoples under his rule to seek for home-grown substitutes for those substances which custom had rendered indispensable to their daily requirements for food or comfort.

Chicory belongs to the order COMPOSITÆ, which, although a very large order, and most extensively distributed over all parts of the world, containing a vast number of plants serviceable in different ways to the wants of man, furnishes but two plants to the agriculture of this country, and

COMMON CHICORY OR SUCCORY—*Cichorium intybus.*

neither of which enter into our regular cultivation. It forms a distinct genus—*Cichorium*—of which two species are cultivated by us—the *C. endivia*, the Common Endive of the garden, and the *C. intybus*, the Chicory or Succory, which we have now to describe. This is a native perennial plant, met with growing to the height of 2 to 3 feet on soils of a light calcareous nature. The stem is stout, deeply furrowed, branched, and hairy. From the lower portion milky leaves, not unlike those of the common taraxacum, are thrown out. The uppermost leaves sit closer to the branches, and are of a different shape. The flowers, which are of rather a large size, are of an intense blue colour, and generally grow in double heads, one opening always some days before the other. The root is long, tap-shaped, fleshy, sometimes branching, and contains a milky juice, which indeed pervades the whole plant. The leaves, if treated in the same manner as those of woad—*Isatis tinctoria*—give a similar dye substance, which is manufactured from them in some countries.

Chicory being a very hardy plant, of a perennial habit, of indigenous growth, and very productive even upon inferior soils where moderate care and attention are bestowed upon it, offers more than ordinary advantages for cultivation as a field crop for forage purposes. The tillage treatment it requires during its existence as a crop is very small, compared with those crops of only annual duration; its leaves and stems afford a large supply of keep, much relished by sheep and cattle, especially in the early part of the year, before the regular crops come into use; and its roots, for which it is chiefly grown in this country, give, under ordinary circumstances, of themselves a good return to the grower. On the Continent it enters far more generally into the farm crops than with us. In Holland, Belgium, France, and Germany, it is grown for both purposes; in the south of France and Southern Italy, it furnishes a considerable proportion of their forage for all sorts of cattle.

Although chicory may be cultivated on well-nigh every description of arable soils, its natural tendency is decidedly in favour of the lighter and deeper soils, in which its long and fleshy roots may develope themselves freely, and penetrate deeply in search of their mineral food. Climate has naturally less influence upon it than upon many of our farm plants—the character of the soil mainly determining its suitability for cultivation in any particular district. Where the principal object is its *forage* value, it may advantageously be grown in loams even of the strongest class, provided, of course, a certain depth of soil be secured to it. When, however, the *root-produce* is the object of cultivation, the lighter class of sandy and calcareous loams would be preferable, as it is important that the whole of the root should be lifted from the soil. This is very difficult to effect on a strong cohesive soil, owing to the forked habit and brittle nature of the root, which very readily breaks short off, and leaves a portion of its substance behind. On alluvial soils, the warped lands of estuary deposits, the fen lands of Hunts and Lincoln, it grows luxuriantly, and gives very productive returns; and even in peats, gravels, and sands of an inferior class, it may generally be cultivated with success, and with a little attention be made a very remunerative crop. In all cases it is important to secure, as far as we are able, in the soil on which it is to be grown, those conditions which we know to be beneficial to it. Its habit of growth renders easy access to the lower strata of the soil necessary to its healthy and vigorous development. If this does not naturally exist, it should be obtained by subsoiling or trenching; and all stagnant water must be got rid of by draining, as neither this nor any other of our crops can thrive under circumstances which must affect them as soon as the roots penetrate the water-carrying stratum.

If chicory follows a grain crop, the autumn affords ample time to clean the land thoroughly before subsoiling or trenching for the winter; and in the spring little remains to be done except to get a good tilth for the seed-bed, which can usually be effected by running the grubber across the lines of ploughing, and finishing off with harrows and a light roller, if necessary, to reduce any roughness in the surface soil. Although the plant will grow in poor soils, it will grow far better in soils of better quality; therefore the state of the land should be properly considered previous to sowing, and its condition secured by the application of a sufficient quantity of manure. If farmyard dung be used, it should be in a decomposed state, for the reasons already given in reference to the ordinary root crops; the quantity will of course depend upon the nature and condition of the particular soil, and it may be applied either in the autumn or in the spring, in the usual manner. Peruvian guano is the best substitute for the dung, and should be deposited with the manure at the time of sowing, having previously been carefully mixed with about two or three times its bulk of coal ashes, sand, or some similar diluting substance.

From 4 to 7 lbs. of seed are usually sown to the acre, in drills or rows from 10 to 15 inches apart; when grown for forage purposes it is sown thicker and closer in the drill than when the root-produce is the object of cultivation. The seed is obtained from the Continent—Holland, Belgium, and France; and as it is somewhat dear in price, so it is liable to adulteration, and the buyer to disappointment, if due care be not taken in its selection. About the end of March is the best time for sowing it as a "forage crop." When grown for the roots alone, it is generally advisable not to sow quite so early—about May is recommended—as if sown earlier it is apt to run to seed, and thus injure the root-produce. Such plants are termed "runners," and are always carefully pulled up, otherwise they spoil the sample, and reduce its market value. When the young plants are well up in the drills, they should be "bunched" and singled out in the way described in the turnip crop (p. 303, vol. i.), to distances of 6 to 9 inches in the drills, after which the hoe should be regularly used to keep down the weeds. In some places they are grown in a seed-bed and transplanted; this is, however, a very expensive mode of growing, and has nothing but the old practice of the garden to cause its retention.

In October and November the work of harvesting the crop is commenced, and may be carried on at convenient opportunities during the winter months. As each root has to be carefully lifted, so that no portion be broken off and left in the ground, the operation is both tedious and expensive. The fork recommended for use, and described in the Carrot and Parsnip Crops (page 8), would be found a very efficient tool for this purpose, and the assistance of a boy to pull would aid the labour of the digger very materially. The subsoil plough has been used for the purpose; this no doubt reduces the cost of labour very considerably, but the roots are never so well got up as by forking, which at the same time, by deep stirring the soil, leaves it in a far better condition for the succeeding crop. It is not only a matter of importance to the produce of the present crop that the whole of the roots should be carefully got up, but also to future crops grown on the same ground, as the chicory, being a perennial, indigenous plant or "weed," will be sure to make its appearance the following year, should any portions of the roots be left behind in the soil. This indeed is one of the great drawbacks to its cultivation. The roots are carefully trimmed on the field, carted home at once, washed, and either sold in that fresh state to the dealer, who undertakes the subsequent processes of manufacture; or they are sliced and kiln-dried, and then sold, by which process the produce is reduced from 75 per cent. to 80 per cent. in weight, though its money value is proportionately raised in amount. The return per acre, both in weight of crop and in money, of course is subject to great variations. From 5 to 10 tons of the fresh root may be taken as the range under ordinary circumstances of farming, and the price ranges from 50*s.* to 100*s.* per ton.

We are not in a position to say anything in reference to the *diseases* to which the crop is liable; and for its *chemistry* we are indebted to Dr. Anderson, who has investigated the organic and inorganic composition of both leaves and roots.[1]

The organic composition of the leaves is thus given:—

Compounds containing nitrogen,	1·01
,, not containing nitrogen, as gum, fibre, &c.,	6·63
Ash (mineral matter),	1·42
Water,	90·94
	100·00

The composition of the ash or mineral matter is as follows:—

Potash,	44·38	46·60
Lime,	10·81	11·35
Magnesia,	2·44	2·57
Oxide of Iron,	·99	1·04
Phosphoric acid,	6·80	7·14
Sulphuric acid,	6·81	7·15
Carbonic acid,	19·57	20·55
Silica,	·77	·81
Chloride of Potassium,	1·55	1·63
,, ,, Sodium,	1·11	1·16
Sand,	2·80	...
Charcoal,	1·29	...
	99·32	100·00

The foregoing analysis would indicate that chicory possesses a considerable value as a forage plant, its organic constituents being but little inferior in their feeding value to those of our common turnips.

For forage purposes it should always be mown and given to the cattle or sheep; if fed off on the ground by

[1] *High. Soc. Trans.*, 1853, p. 63 and 555.

the latter, the sheep eat the leaves in preference to the stems, and a large portion is always wasted. It is a very quick-growing crop, and, if properly managed, will yield a large bulk of valuable keep, much relished by cows and pigs, and well adapted for a cottager's cultivation, while, when it ceases to be productive, the roots may be dug up and treated for home consumption in the manner described above.

The analysis of its inorganic ingredients shows the large proportion of potash that enters into its composition. This is abstracted by its long, tap-shaped root from the lower stratum of the subsoil, and being elaborated into its structure—the stems and leaves above the surface—and there consumed, its cultivation must tend very much to enrich the agricultural soil with the valuable matters it brings up from below. The organic composition of the fresh root was determined by Dr. Anderson as follows:—

Compounds containing nitrogen,	1·72
,, not containing nitrogen,	16·09
Ash (mineral matter),	1·31
Water,	80·58
	100·00

The results of his analysis of the ash are thus given:—

Potash,	42·60	55·27
Lime,	6·09	7·90
Magnesia,	3·15	4·09
Phosphoric acid,	10·02	13·00
Sulphuric acid,	4·80	6·23
Carbonic acid,	11·40	...
Peroxide of Iron,	·81	1·05
Silica,	·99	1·29
Chloride of Potassium,	1·78	2·31
,, ,, Sodium,	6·83	8·86
Sand,	1·12	...
Charcoal,	9·90	...
	99·49	100·00

In the second column of both the inorganic analyses, the results were calculated with the omission of sand, charcoal, and carbonic acid.

There are some few other plants, which we ought not to pass quite unnoticed, met with in occasional cultivation, either singly or mixed with others, although they do not assume the importance of being regarded as belonging to our regular "Farm Crops." Of these the more important are the Lentil, Melilots, Birdsfoot Trefoil, and Comfrey; and of these we shall only give a brief description, so as to enable those who may be disposed to give them a trial, to judge of their respective suitabilities to the soil and climate, and their relative values for the purposes of intended cultivation.

THE LENTIL.

The Lentil, although very rarely now to be met with in field cultivation in this country, is largely grown on the Continent, and in the various countries of the eastern hemisphere, as an article of human food. The use of lentils as a food grain can be traced back to the earliest periods of sacred history;[1] and from that period to the present day they have most probably occupied the same position in reference to the wants of the inhabitants of eastern countries. In India[2] they are met with growing abundantly in various districts; in Syria[3] and in Persia they

[1] On the authority of the book of Genesis (xxv. 30), lentils formed the mess for which Esau disposed of his birthright. "And Esau said to Jacob, Feed me, I pray thee, with that same *red* pottage," which, we are informed in verse 34, was "*pottage of lentils.*" Again they are spoken of in 2 Samuel xvii. 28; xxiii. 11; and Ezekiel iv. 9.

[2] Hooker's *Journal of Botany*, vol. ii. p. 267.

[3] Robinson's *Travels*, vol. i. p. 246.

are equally common; and on the Continent—in Italy, Sicily, France, and Germany—they enter into cultivation largely for food purposes. In Egypt and in other countries of the East at the present day they are commonly sold in a partially cooked condition, having been parched over a fire in an iron vessel, and in this dried state are considered by the natives as the best food to take with them on their long journeys. Owing to the large proportions of nitrogen compounds the seeds contain, they have been for centuries past, and are still, made use of largely in Catholic countries as substitutes for animal food in Lent and other periods of fasting; indeed, the name lentil is said to have a direct connection with the name given to that particular period of fasting and penitence of the Roman calendar, and that either the title of Lent was adopted from the practice of substituting this vegetable food for flesh at that period of the year, or that the lentil received its name from the ordinances of the Roman church.

Several of our early English authors speak of their cultivation in different parts of this country. They appear to have been introduced into this country about the middle of the sixteenth century. In Gerarde's time (the commencement of the 17th century) we find them being grown like vetches, their seed being either used in soup and other culinary preparations, or given to pigeons, and the straw used as fodder for cattle. Arthur Young states, at the beginning of the present century, that they were not an uncommon crop near Chesterford, on the borders of Essex, where they were grown both for their seeds and as a forage crop. He remarks that it is necessary to prevent the cattle drinking water while eating them, as they are apt to be hoven. Some few years ago attention was again directed to their cultivation, as offering a very nutritious and palatable substitute for potatoes, especially for the winter season, when other vegetables could only be procured at a price beyond the ordinary means of the labouring classes. The trials that were made, though upon a somewhat limited scale, were very satisfactory, and the crop was found sufficiently hardy to admit of cultivation even in the neighbourhood of Edinburgh.[1]

Botanically, the lentil belongs to the order LEGUMINOSÆ, and forms the genus ERVUM, of which there are numerous species, two of which, the *E. hirsutum* and *E. tetraspermum*, are indigenous to this; the others to the warmer countries of the Continent. The lentil very much resembles the vetch in its general characters, and is best distinguished from it by the long teeth of the calyx, which is equally narrowed to the base, and not protuberant at the base on the upper side. The following species are those chiefly met with in cultivation:—

Ervum lens—Common Lentil.—A vetch-like annual plant, with from eight to twelve oblong, blunt, nearly smooth leaflets to each leaf, which is terminated by a very short tendril. The flowers are small, pale blue in colour, in pairs, on long slender stalks. The calyx is divided, almost to the base, into five awl-shaped hairy teeth, as long as the corolla. The pods are quite smooth, short, and thin, and contain two seeds, of a flattened spherical shape, varying in colour from white to deep brown. It grows to the height of from 18 to 24 inches, and, owing to its erect branching habit, requires no support from other plants.

Ervum monanthos—Single-flowered Lentil—is a species which has been cultivated in France with great success on sandy soils of the poorest class, where it is sown in the autumn with a little rye or winter oats. M. Vilmorin, who speaks of it in the highest terms, distinctly

[1] *High. Soc. Trans.*, 1851, p. 337.

specifies silicious soils, and states that his trials of it on calcareous soils were unsuccessful. Speaking of it, he

COMMON LENTIL—*Ervum lens.*

says, "I have had an opportunity of witnessing the extreme utility of this plant for worthless sands, having both used it myself and seen it cultivated on a great scale by one of my neighbours, M. Vallentin de Cullion. The quantity of green food which he has obtained off this and the winter gray pea from land believed to be incapable of growing anything, gave him the first means of arriving by degrees at an immense improvement in his farms. Those who have poor sandy land, and require green food for their stock, would probably find the cultivation of this plant much to their benefit." The name it usually bears in France is *Jarosse* or *Jaraude*.

Although the lentil is indigenous to, and may be cultivated successfully in, soils of the lightest silicious character, still it follows the order of cultivation generally, and gives a larger produce in soils of a better quality. A sandy loam of a warm friable nature appears to be the best adapted to it. If cultivated for its seed produce, it is not desirable that the soil should be in too high condition, as that is apt to induce an herbaceous growth, which, although valuable for forage purposes, is rarely accompanied by a large produce in seed. When its cultivation, however, is chiefly as a forage plant, manure may be applied as to other crops of a similar character, and in such case nothing is better than good farmyard dung, liberally applied. Its agricultural treatment, in all respects, is the same as that of vetches. There is a winter and a spring variety; and the time of sowing, the quantity of seed, and mode of depositing it in the soil, are the same as have been already described.

On the Continent, in France especially, there are three varieties of the lentil cultivated for human food:—The *Small Brown Lentil*, which has the most agreeable flavour, and is accounted the best for soups and other culinary preparations. The *Yellow Lentil*, which is reckoned the next best, is somewhat larger in size, and separates very easily from its husks: it is largely used for grinding into meal, and in that shape used for various culinary purposes, and forms the basis of those preparations which have been so long and so successfully forced upon public notice under the names of "Revalenta," "Ervalenta," &c. The *Large, or Provence Lentil,* is of a whitish or cream colour, compressed shape, and about the size of a pea. The whole plant is of a more vigorous growth than the others, and is better suited for forage purposes than for cultivation for its seed.

The *chemistry* of the lentil has been, as might be expected, more attended to by continental chemists than by our own. The organic composition of the seed is given by Boussingault as follows:—

Nitrogen compounds,	22·0
Starch,	40·0
Gum,	7·0
Sugar,	1·5
Fatty matter,	2·5
Husk,	12·0
Water,	12·5
Ash (mineral matter),	2·5
	100 0

Gasparin[1] states that the grain contains 4 per cent. of nitrogen, equal to about 25 per cent. of flesh-forming compounds, and that the straw contains 1·01 per cent. of nitrogen, or about 7 per cent. of the same valuable compounds. The water in the grain he gives at from 9 per cent. to 14 per cent. Bracconot and Einhof[2] have investigated its composition with very similar results.

The composition of the inorganic or mineral matter is thus given:[3]—

Potash,	34·31	27·84
Soda,	13·3	10·80
Lime,	6·24	5·07
Magnesia,	2·44	1·90
Peroxide of Iron,	1·98	1·61
Phosphoric acid,	35·82	29·07
Silica,	1·31	1·07
Chlorine,	4·56	3·78
Carbonic acid,	...	15·83
Charcoal and loss,	...	3·03
	99·96	100·00

[1] *Cours d'Agriculture,* tome iii. p. 797.

[2] *Ancien Journal de Gehl,* tome vi. p. 542.

[3] Levy, *Revue Scien. et Indust.,* tome xxiv. p. 72.

The organic analyses testify to the high value of the food materials contained both in the grain and in the straw, while the determination of the mineral constituents show that the proportion of lime and magnesia are smaller than those contained by the allied cultivated plants, and confirm the observation of M. Vilmorin, that this genus is suitable for cultivation on soils containing only small quantities of lime.

THE MELILOT.

The MELILOT belongs to the same order as the lentil, and is still less commonly met in cultivation as a field crop, either in this country or abroad. It is frequently, however, grown as a mixture in other forage crops, to which, when cut, and made into hay especially, it gives a fine and agreeable aroma, resembling very much that given by the *Anthoxanthum odoratum*, or "sweet-scented vernal grass," in our meadow hay. It has been mentioned by some of the early authors, and recommended for cultivation. Ray, in his *History of Plants*, published in 1688, says that the yellow melilot was then sometimes sown for the food of kine and horses; but succeeding writers have generally included it rather among the weeds than the cultivated plants of agriculture.

The melilot forms a distinct genus—MELILOTUS—of which the following species are met with in cultivation for forage purposes:—

Melilotus officinalis—Common Melilot—is an annual plant, growing from 2 to 3 feet high, with yellow flowers, disposed in long, loose, one-sided clusters or racemes, which are succeeded by pendulous, elliptical pods, hairy and wrinkled. It grows naturally in dry pastures and waste places, and flowers in July, when it dies down and disappears. If, however, it be cut continually, and not allowed to flower, it frequently will last three or four years, and furnishes a good supply of tender, succulent keep, much relished by cattle when cut in a young state; but if allowed to arrive at full flowering, its stems become so woody and hard that the leaves and tops are alone fit for being eaten. Owing to this change in its structural constitution, and the small bulk it assumes, it is not well adapted for hay purposes, yet a small portion of it mixed with vetches, clovers, or other forage plants intended for hay-making, imparts an agreeable odour to them, and makes them more palatable to the stock. In France a variety is grown termed *M. officinalis altissima*, which grows rather more vigorously, and is later in flowering than the common sort. It is to the melilot that the famous Gruyére cheese owes its peculiar flavour. The flowers and seeds, after being dried, are bruised and ground, and mixed with the curd before pressing.

Common Melilot—M. officinalis.

M. leucantha is known in this country under the name of *Bokhara Clover*, or *Siberian Melilot*. It was introduced about twenty years since from Bokhara, by a gentleman, who stated that in that country it attained the height of 14 feet, and yielded several cuttings each year of a highly nutritious food, much relished by all kinds of stock. It is a coarse, erect-growing annual, resembling the common melilot in its herbage, but differing from it in size and colour of flowers, which are white. When intended for forage purposes, the plants should be cut young, when about 2 feet high, as if allowed to continue their growth, they become woody and of less value. Although the bulk produced on a given area is large, the cultivation has not been continued as a forage crop, its produce being too watery when young, and too woody when old.

M. cærulea is an annual, well known in our gardens under the name of *Sweet Trefoil*, and admired for its pretty blue flowers, by which it is readily distinguished from all the others. In Germany and parts of France it enters into regular field cultivation as a forage plant. Its rapid growth renders it suitable for sowing in places where clover has failed. In such cases it is always best to cut it green, or feed it off on the ground before it is in full flower, otherwise its hollow cylindrical stems become very woody and valueless. In Switzerland it is commonly met with in the pastures, and is the plant which gives its peculiar flavour to the well-known Schapziger cheese.

M. macrorhiza—Siberian Melilot—is a native of Hungary, and is met with in different parts of the Continent in cultivation on light sandy soils, for which it is extremely well adapted. It is a vigorous, erect-growing plant, with long, thick, carrot-like roots, and bearing white flowers. On the light sandy coasts of Holland, and of parts of France, it is either grown by itself or mixed with the biennial vetch, for which it forms a good support.

All these species are capable of growing on the poorer class of soils, and on soils of such description give generally a far better return than could be obtained from either lucerne, vetches, or even clovers. Deep cultivation, freedom from stagnant water, and from weeds, are the essentials to be regarded in the preparation of the soil. A small portion of seed of the *M. officinalis* might be added with advantage to our clovers or "seeds" intended for hay purposes.

BIRDSFOOT TREFOIL.

The Common Birdsfoot Trefoil—Lotus corniculatus—is frequently met with in our natural meadows, and is a perennial common to the open grassy pastures and dry places in this country. It is a small plant of a prostrate habit; its stems are slightly hairy, about 10 to 12 inches

Birdsfoot Trefoil—Lotus corniculatus.

high, rising from deeply-fixed woody roots. The leaves are trifoliate, and the flowers of a deep yellow colour, in clusters of from two to five, at the end of an erect, slender peduncle. Its pods are of a purplish-brown colour, long and slender.

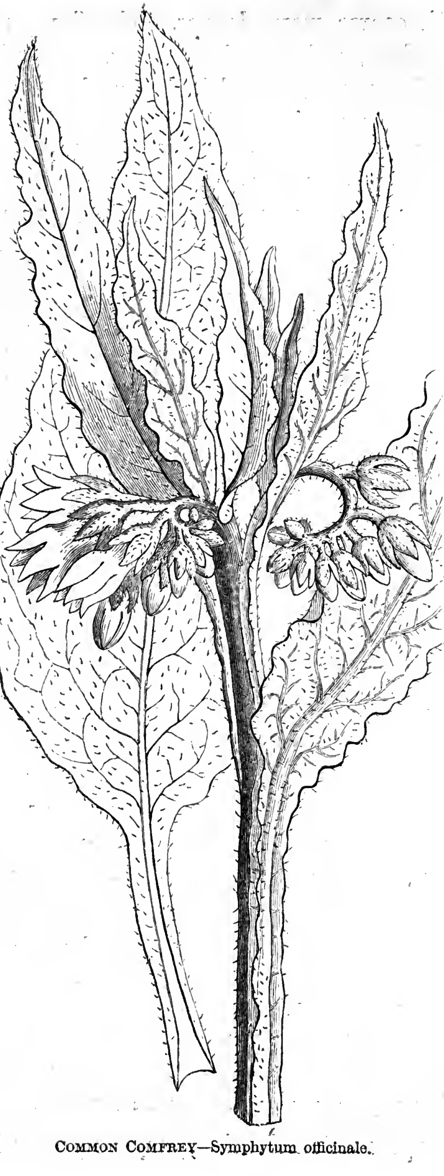
L. major differs from the former by being much larger in all respects, and by frequenting damp and moist places, as by the side of low-lying ditches, osier beds, &c., whereas the other selects only the driest spots. This species is said to yield a large quantity of good herbage, and is therefore entitled to some consideration, as being suitable for cultivation in places where leguminous forage plants cannot very successfully be grown.

They both belong to the order LEGUMINOSÆ, and to the genus LOTUS; and although only cultivated in this country to a very limited extent, and then always in mixture with other seeds for permanent pastures, they are met with in different parts of the Continent forming a distinct and separate cultivation. There are several other species indigenous to different countries, and met with in the natural grass lands or waste places. These, however, are chiefly of annual growth only. Although but little attention has been bestowed upon any of them, either abroad or at home, they no doubt possess feeding properties fully equal to our other forage plants, and from the manner in which the plants met with in our fields are always kept cropped down both by sheep and cattle, there is but little doubt that they are much relished by stock of all sorts.

THE COMFREY.

The last plant that we have to refer to in this section of our subject is the SYMPHYTUM,[1] or COMFREY, a plant belonging to the order BORAGINEÆ, and differing in every respect from either of those which have preceded it. The *Symphytum officinale*, or *Common Comfrey*, is a hardy perennial plant, found growing wild in wet places, by the side of ditches and sluggish streams. It has a long black root, from which rise winged, hairy, rough stems, 3 feet

[1] From συμφυω, to unite, and φυτον, a plant.



Common Comfrey—*Symphytum officinale.*

high, with coarse wavy leaves. The flowers are either purple or white, and grow in racemes. The plant pushes its vegetation very forward in the spring, and thus produces a great quantity of tender succulent shoots and leaves, which are readily eaten by cattle; cows particularly seem to do well on it.

S. asperrimum—Prickly Comfrey—which has been recommended as superior to the common species for the purposes of cultivation, is likewise a perennial plant, with thick, branching, and fleshy roots. The stem is thickly set with reversed prickles, and grows to the height of from 6 to 8 feet, with rough-stalked leaves, heart-shaped, and tapering towards the point, with blue flowers. It is a native of Siberia, and was introduced into this country at the close of the last century, and again had public attention called to it in 1830 by Mr. Grant, of Lewisham, who strongly recommended it as a forage plant. It is very easy of propagation by either seeds or roots, and, when once well established in a congenial soil, will continue to give a satisfactory return for a great number of years without deterioration. There are other species of *Symphytum* which no doubt would, under cultivation, be equally relished by cattle, but none of them appear to offer any advantages over the two now described. In all cases the plants should not be allowed to get too much growth before they are given to the cattle, as otherwise the stems get hard and woody, and are neither so palatable nor so digestible when eaten.

Unlike some of the preceding forage plants, growing naturally and capable of cultivation in the poorer class of soils, the *Symphytum* needs a deep and good loamy soil for its healthy growth, in which its branching fleshy roots can roam and find the necessary supplies of food. The prickly species, which certainly is superior to the common for the general purposes of cultivation, may be grown in suitable soils under the ordinary conditions of moisture; the common species requires a moister soil, and therefore is only suited for growing in peculiar localities. They are both easily propagated either by their seeds or their roots: the latter is the method usually practised, as the seeds seldom ripen in any quantity, and time is lost before the seedling plants arrive at maturity. The roots may be taken up and divided, and replanted in rows 2 feet apart, and at about 18-inch distances between each plant, the soil being previously prepared for their reception by deep cultivation, cleaning, and good manuring. If this has been well attended to, the crop requires no further care than that of hoeing occasionally to keep it clear of weeds. The first year's produce after planting is comparatively small, giving perhaps only two good cuttings. In subsequent years, if the condition of the land be sustained by the application of dung or other manures at the end of the season, three or four cuttings, of from 5 to 10 tons each to the acre, may generally be obtained.

The Comfrey is grown only to such a small extent as to have attracted but little attention in respect to the injuries to which it is subject from *disease* or the attacks of *insects*. Neither do we know much about its *chemistry*, or its real value for feeding purposes; the only evidence we have is in the shape of the following analysis by Sprengel:—

Organic composition of S. officinale in a fresh state.

Water,	88·00
Organic matter,	9·70
Ash or mineral matter,	2·30
	100·00

The composition of this mineral matter is thus given:—

Potash,	31·2	Phosphoric acid,	11·4
Soda,	10·8	Sulphuric acid,	3·9
Lime,	20·7	Silica,	17·2
Magnesia,	1·3	Chlorine,	3·1
Iron, Peroxide,	·4		
			100·00

THE FLAX CROP.

We now enter upon another section of our subject, and have to treat upon crops cultivated for *technical* or other *special* purposes. Although of not so direct an importance to human welfare as those furnishing us with our daily food, still, as a class, they assume a very high position, and claim consideration on account of the very general bearing they have upon the personal comforts and requirements of all civilized nations. When we recollect that fully nine-tenths of the human race are clad, either partially or entirely, in fabrics made from cultivated plants, of which flax and cotton are familiar examples—that every civilized people consumes every day in its national beverages the produce of other classes of plants alike entering into cultivation for this special purpose—take, for instance, tea, coffee, and cocoa—we must at once admit that a wide field is open, and an enormous and unceasing demand exists, for the produce of plants whose cultivation, from the various and important wants they subserve in the human economy, ranks second alone to those plants from which we derive our supply of daily food.

In some countries, where the soils and the climate are more suitable than our own, this special cultivation takes the first place in their system of agriculture, and forms the medium of exchange through which the inhabitants obtain from other countries those necessaries and comforts they cannot produce at home. In densely populated countries the most important object of cultivation is, of course, the production of food. This is the primary want of our nature, and must be constantly and regularly supplied. Our secondary wants,—clothing and other necessaries and comforts,—are neither so urgent nor so constant. Any irregularity in the supply is not attended with such serious consequences as in the supply of food; and it is far more politic and more advantageous to a country to secure, as far as possible, within its own resources, those productions which are essential to the daily existence of its inhabitants, than to rely upon the produce of other countries for assistance in making up the necessary supplies.

In this country our agriculture has, from many causes, tended rather to the cultivation of food-producing crops than of those ministering to the secondary wants of our nature; for these we have necessarily to rely largely upon the productions of other countries, as the area of our own is stationary, while our population and its wants are rapidly increasing; and although we have still a large portion of surface in an uncultivated state, its capabilities, even under an improved system of farming, would not probably be more than sufficient to provide the food-materials for which at present we are indebted to the agricultural resources of other countries.

Still, we have a few amongst our "Farm Crops" which have been for a long period, and are still, cultivated in this country for special purposes, and which form a marked feature in the agriculture of some districts. Of these FLAX is one of the most important. It certainly claims precedence of the others on the score of antiquity, as from the earliest periods of our history we have evidence of its existence as a cultivated plant. The important services that flax has rendered to mankind have secured for it a record from the earliest times. In the Bible we find frequent mention made of it, both as flax in its growing state and in its manufactured condition as linen; and on various Egyptian monuments the plant itself, and the preparation of its fibres, are represented. In the book of Exodus[1] it is noted as one of the principal crops grown in Egypt at that period (1491 B.C.). Being one of the principal crops and chief sources whence the Egyptians derived articles of comfort and luxury, it was selected by the Almighty for destruction when he sent the plague of hail as a judgment on that people. From the book of Joshua[2] we find that at about the same period flax was cultivated in Palestine, for it is stated that Rahab used flax to hide the spies sent by Joshua to examine Jericho.

In the history of Samuel[3] the reference to flax would show that not only its cultivation but its subsequent treatment for textile purposes must have been well understood. Many allusions are made to it in its agricultural and manufactured state[4] both in the Old[5] and in the New Testaments, all of which by the various commentators are admitted to have reference to the same plant which we now term flax, and which is the same as that known by the Hebrew name "Pishtah," and as "Linon" by the ancient Greeks.

The Greeks were well acquainted with the plant and the mode of treating it, as linen is more than once mentioned in the pages of Homer, as well as of other Greek authors. But it would appear that although reference is made to linen by both early sacred and profane writers, neither the Egyptians, Phœnicians, nor Greeks were accustomed to apply linen to the same vestiary uses as ourselves. Their underclothing was merely of a finer quality than their outer tunics, and linen was only worn by persons of a certain degree or on certain occasions, or was used for swathing the bodies of the

[1] Exodus ix. 31. [2] Joshua ii. 6. [3] Judges xv. 14.

[4] Mummies embalmed 1200 years B.C. have been found wrapped in swathing cloths of fine linen made from flax.

[5] Prov. xxxi. 13-19; Isaiah xix. 9; 1 Sam. ii. 18; 2 Sam. vi. 14; Jer. xiii. 1 1 Kings x. 28; 2 Chron. i. 6; Ezek. xiv. 3; Hos. ii. 5-9; and other places.

dead. It was not, indeed, until the period of the emperor Severus that linen under-garments were worn by the Romans, and even then, for centuries after, the practice was confined to a comparative few. We have, however, ample records of the cultivation of flax in Roman history, and curiously enough all the agricultural authors of that period agree in pronouncing a judgment upon it which has survived to the present day; for to no other better source can we trace the still very common opinion that flax is an exhausting crop. Columella[1] speaks of it as a hurtful crop which exhausts the land, and which, he says, "should not be grown unless there be reason to expect a very great crop, and one is tempted by a very great price." Virgil[2] joins it with oats and poppies, and says "that all these exhaust the soil." Palladius[3] expresses exactly the same opinions. Pliny,[4] while condemning it as a crop, moralizes over it, and asks, "What greater miracle than that there should be a plant which makes Egypt approach nearer to Italy; that there should grow from so small a seed, and upon so slender and short a stalk, that which, as it were, carries the globe itself to and fro?" By this we must infer that its use, both in the shape of sailcloth and of cordage, was not unknown to them; we also learn from succeeding chapters that many nations also used it as wearing apparel when it was woven into linen fabrics.

Although all the writers on Roman husbandry speak of flax and its cultivation, Pliny is the only one that enters minutely into the details both of its cultivation and subsequent preparation. He speaks chiefly of spring-sown flax. According to the other authors flax was sown usually in the autumn, in the months of October

[1] Columella, lib. ii. cap. 10.
[2] Virgil, *Georg.*, lib. i. v. 77, "Urit enim lini campum seges, urit avenæ."
[3] Palladius, lib. xi. cap. 2. [4] Pliny, *Nat. Hist.*, lib. xix. proœm.

and November, when 8 "modi"[1] of seed were sown upon the "jugerum" of land, whereas 10 were required for the spring-sown flax. In both cases the land was previously well manured. The harvesting and "steeping" appear to have been carried on much the same as at the present time; the "breaking" and "scutching" were performed by beating the steeped stems upon a stone with a mallet of a peculiar shape, and then drawing them through iron heckles. The tow was considered of little use except as wicks for candles. The "boon" or "shove" was used as fuel, and the cleaned fibre was bleached by being watered and exposed to the air and light in the usual manner.[2] He describes the Spanish flax as being of very fine quality, and mentions another sort, which was cultivated in Campania, whose fibres were so fine and so tough that nets were made of them to entangle wild boars, and so hard and strong as to resist the stroke of a sword. I have seen, he says, "these snares of such fineness as to pass with the ropes at the upper and under side through the ring of a man's finger; one man being able to carry as many of them as would encircle the hunting-ground. Nor is this the most extraordinary part, for each strand of them consisted of 150 threads." He relates also that in the temple of Minerva, at Lindus, in the isle of Rhodes, the breastplate of Amasis, a king of Egypt, was found made of this net, in which each strand consisted of 365 threads. This was taken by the consul Mutianus to Rome, where it was exhibited at the time Pliny wrote, as a specimen both of fineness and strength of fibre, and also of skill in preparing and spinning yarn. Certainly modern times have nothing to compare with it.

The absence of all agricultural records after the fall of the

[1] The Roman "modus" was about the same as the English "peck." The "jugerum" was equal to ·618 of an acre, or 98¾ poles.

[2] *Plin. Nat. Hist.*, lib. xix. c. 1.

Roman empire leaves a blank in our history until towards the end of the twelfth century, when we gather from documents relating to that period that flax was cultivated to a considerable extent in this country. As the country became more settled, and civilization advanced, the use of linen became more general; and we find that in 1532 (Henry VIII.) an act of parliament was passed, requiring that each person occupying land fit for tillage should for each quantity of 60 acres sow at least 1 rood of it with flax each year. This quantity was increased from a rood to an acre in 1562 (Elizabeth), under pain of a heavy penalty. In 1691 (William and Mary), with the view of encouraging the flax cultivation as much as possible, an act was passed fixing the tithe on flax at only 4*s.* per acre. In 1713 a bounty of 1*d.* per ell was allowed on the exportation of home-made sailcloth (12 Anne, cap. 16); and in 1806 (46 Geo. III., cap. 46) a bounty was offered for the importation of flax and hemp from the American colonies. These references—and we could readily add to them—tend to show that the cultivation of flax has always occupied the attention of different civilized countries; and as regards our own, they would lead us to infer that, although probably the proportion grown in former times, when countries had to rely almost entirely upon their own productive resources, was superior to that of late years, still the demand was always, as it now is, greater than the supply.

The *botany* of flax is of a less complex character than that of most of our "Farm Crops." It forms the characteristic genus of its order—LINEÆ—a small order, containing, according to Lindley,[1] three genera, and about ninety species, which are to be met with scattered irregularly over the greater part of the world. Europe, North Africa, and North and South America seem to be its principal

[1] *Vegetable Kingdom*, p. 485.

stations; individual members, however, are found in India, New Zealand, Australia, and other countries. Its native country appears still to be a matter of question among botanists, as it is found growing wild in most countries where the physical conditions of soil and climate are suited to its growth. The general opinion, however, inclines towards ascribing it to the East, where, with the principal cereal plants furnishing food to man, it was known and cultivated from the earliest periods of our history. Be its original country in the East, or where it may, the natural disposition to suit itself to such a vast range of soils and climates as those in which it is now to be met with, is of infinite importance to man, as it enables him to avail himself of the advantages resulting from its cultivation to a far greater extent than he otherwise would be able to do.

The members of this order generally are remarkable for the tenacity of their fibres, the elegance of their shapes, the beauty of their flowers—which are blue, red, or white[1]—and the emollient and demulcent properties of their seeds. All are harmless; some few possess a slight medicinal action; in others even this is absent. Of these we may instance the *Linum catharticum*, a very common weed of our poor soils, whose leaves contain properties of a purgative character, and the *L. selaginoides*, which is accounted in South America of great use both as a mild aperient and as a tonic. Probably these properties pervade the whole order, but have not been remarked in the common flax. Several of its members are plentifully met with in this country as weeds. The *L. catharticum*,

[1] M. Brogniart considers that white varieties often exhibit a marked difference in the colouring of the leaves, and suggests that a modification may also exist in the tissues of the stems. M. Louis Vilmorin (*since dead*) is at present experimenting upon the cultivation of white varieties of flax. So far he considers the fibre to be of inferior and coarser quality.—*Annales de l'Agric. Française*, Fevrier, 1853.

already alluded to, is one of the characteristic weeds of poor soils. The *L. perenne*, or Siberian flax, is usually met with on soils of the chalk formations. The *L. usitatissimum* is less commonly met with, and then generally on cultivated soils; and more rarely still the *L. angustifolium*, which is found growing on sandy and poor pastures, principally on the sea-coasts.

Although there are many species belonging to this order known to botanists as possessing fibres suitable for

COMMON FLAX—Linum usitatissimum.

textile purposes, the only species cultivated is the *Linum usitatissimum*, or Common Flax, which is an annual plant, with delicate branching round stem, from 18 to 24 inches, covered thinly with narrow glaucous three-ribbed leaves, and bearing at the ends pale blue shiny flowers. The flower-heads possess four, or more commonly five sepals; the petals are always equal in number with the sepals; the stamens are also equal in number and alternate with them. The flowers are succeeded by a seed-pod, or ovarium, agriculturally known as the "boll," or "capsule," with ten divisions, or rather five perfect cells, which are again separated by an imperfect partition, extending from its outer wall. In each of these cells is found a single seed, of a flattened oval shape, of a more or less dark brown colour, mucilaginous to the taste, and containing a large proportion of a brownish yellow oil, possessing the peculiar though slight smell characterizing linseed oil. This oil is readily obtained by pressure from the seed; the residuum being the well-known feeding substance termed linseed cake. Dr. Lindley tells us that there are two very different varieties of the *L. usitatissimum* in cultivation, though in the markets the produce—fibre as well as seed—is classed together under the same names, and used for the same purposes. The *L. humile* or *crepitans* (the *Springlein* of the Germans), is a plant somewhat shorter and more inclined to branch than the common flax, and possesses larger capsules, twice as long as the calyx, which burst with considerable elasticity when ripe; its seeds, too, are both larger and of a paler colour. A great deal of the linseed which is imported from India and other eastern countries is the produce of this variety. *The L. usitatissimum* (the *Winterlein* of the Germans), or true Winter flax, has smaller capsules, scarcely longer than the calyx, not bursting with elasticity when ripe, but firmly retaining their contents, which are of a darker brown colour. These distinctions, which are certainly of practical importance in an agricultural point of view, do not seem to have been much remarked in this country. In the selection of foreign seed for sowing, the fine bold samples of pale coloured seed should be avoided, lest they should perchance be the produce of this variety, which would probably occasion some loss in harvesting, were the crop grown for seed purposes.

Some experiments[1] recently made with the *L. perenne* tend to show that its perennial nature and its capability of sustaining itself on soils of the poorest description, entitle it to more consideration than it has hitherto received at our hands. Its hardy nature, and its branching and vigorous habit of growth, when a little care and attention is bestowed upon it, would lead us to believe that on the poor thin soils of the chalk formations, for instance, it might be cultivated with advantage, and would probably on such soils give a far larger return than could be obtained from any of the plants we at present cultivate. The branching habit of the plant would be favourable to the production of seed, but unfavourable, it is true, to the production of fibre. The cost of production, however, would be so small, that this could be sold at a comparatively low rate for inferior purposes of consumption, for which a large and constant demand exists.

PERENNIAL FLAX—*L. perenne.*

[1] *Agri. Gaz.*, 1860, p. 270.

Flax fortunately has a very wide range of soils;[1] sands, sandy loams, light and heavy clays, gravels, chalks, marls, alluvial and warped soils, even reclaimed marsh lands, peats, and moors, are all to be met with under cultivation, and under ordinary circumstances producing a crop. The classes of sandy loams and of alluvial soils, natural as well as artificial (warped), however, appear to be those best suited to its cultivation. In this country we rarely meet with it except on the better description of soils and those in good condition. In Ireland large crops are sometimes obtained on peat-bog lands with a clay substratum. The plant delights in an open soil, through which the rain-water may freely percolate, as its roots are of a fibrous character, and extend laterally and vertically to a considerable distance, frequently from 2 to 3 feet. All the conditions required for its successful cultivation are, that the soil be deeply tilled, in good heart and good tilth, well drained and well cleaned. If all these conditions be secured we may, under ordinary circumstances, calculate upon a good crop; and neither of them can be neglected with impunity, though perhaps the influence they exert respectively upon the crop during its growth may not be of equal importance to it.

Depth of tillage always adds to the feeding-ground of a crop, and places increased supplies of mineral

[1] The following tabulated statement gives the general analysis of the soils of the most noted flax-growing districts in Ireland and in Belgium. In some of the latter, take No. 4, for instance, the soil must have been of the poorest character.

	Irish.			Belgian.			
	Londonderry and Tyrone.			Dussell, near Antwerp.	Pays de Waes.		
					Courtrai.	Lakeren.	Ypres.
	1.	2.	3.	4.	5.	6.	7.
Silica	73·72	69·41	64·93	92·78	87·04	91·8	86·47
Alumina	6·65	5·77	8·97	1·11	1·52	1·22	1·57
Water	7·57	11·58	8·62	2·03	3·8	1·85	2·92
Organic matter	4·86	6·67	9·41	2·74	4·48	3·45	5·78

food at its disposal, and thus aids materially the development of its bulk. Although soils rich in organic matters are not generally so suitable for flax as those of a medium class, still it is always desirable that the soil should be in good heart and condition, as the flax crop occupies the ground only a short time—fourteen to sixteen weeks—and must find its needed supply of food within a limited range, and in an available form. This condition of the soil is materially affected by the state of division of its particles; a fine tilth, by exposing an extended surface to the action of the air and of the rootlets of the plant, assists directly in the preparation of the food, and also in giving the plants better access to it. The percolation of rain-water through the soil, as opposed to its evaporation from the surface, not only materially raises its temperature, but also carries down with it portions of air, which act upon the mass of the soil through which they pass, and greatly advance those decompositions of its constituents which form the food of plants, and which, by the presence of water, are at once reduced to and retained in an assimilable form. So much has been already said in reference to cleaning the land destined for any crop previous to sowing, that we need say nothing here. It must be obvious to every *thinking* farmer, that where two crops are growing in a field, one of which brings him in a return either in money or in meat, and the other he can neither sell nor consume, it is clearly his interest to get rid of the latter by every means in his power, as each weed occupies the place and consumes the food of a more worthy plant, and thus robs him of so much of his proper returns. These points, which are of direct importance to all our "Farm Crops," are especially so to the flax crop, as the plant is in its cultivated state of a delicate and slender habit, but ill fitted to rough it in the field with the stouter and stronger indigenous plants, of a quick habit of growth, and of perhaps less powers of assimilation than those of our other ordinary crops; therefore, if we wish to carry on a successful cultivation, we must assist it by those means which experience and a proper knowledge of the requirements of the plant have shown to be usually followed by satisfactory results.

In England flax is so sparingly and irregularly grown as hardly to assume the character of a regular rotation crop. In Ireland and on the Continent it assumes a different importance, and there always occupies an important position in their farming systems. Its botanical characters are such as to enable it to occupy any position in the rotation that the circumstances of the case—soil, markets, or convenience of the grower—may render most suitable. It may follow or precede a straw crop, or a fallowing, or a forage crop; and indeed it may be met with in cultivation in different countries occupying each of these positions. As a rule, however, it is generally arranged to follow a straw crop; the autumn then affords the opportunity for thoroughly cleaning the land, and for leaving it deeply tilled during the winter, the stubble keeping the land open for the action of the frosts and rains, and thus rendering a fine surface tilth for the seed-bed pretty secure in the succeeding spring.

In Belgium the following rotations are met with on some of the best-managed farms, the soil and the district appearing generally to determine the particular practice: —1, potatoes; 2, wheat; 3, rape; 4, oats; 5, flax with seeds; 6, seeds; 7, barley. On the better sort of light sands, which are not adapted for wheat, we find, 1, rye and turnips; 2, oats; 3, roots (parsnips or carrots); 4, rye and turnips; 5, flax; 6, seeds. Where the sand becomes, by the admixture of a larger proportion of clay, a good staple loam, wheat is taken after the parsnips or carrots; if the soil be better suited for barley, then that takes the place of rye; and where the land approaches a heavy loam, then colza or rape is sown for its seed produce. In Ireland the practice is very similar, as is evidenced by the two rotations now given, which are those of some of the best flax-growing districts:—1, roots (potatoes or turnips); 2, wheat; 3, flax with seeds; 4, seeds cut; 5, seeds grazed; 6, seeds grazed; 7, oats; 8, flax. Or, 1, oats; 2, flax; 3, roots; 4, wheat with seeds; 5, seeds cut; 6, seeds grazed. Of course there are several other rotations practised in both countries. The examples given are those of successful cultivation, and differ only in so far as they are influenced by the difference in climate of the two countries—the one, Belgium, being comparatively dry and suited for grain cultivation; the other, Ireland, being humid, and far better adapted to herbaceous growth. In each, however, we see flax following a straw crop, and this no doubt is its best position; it then comes to maturity, and can be harvested in time either for a forage crop of some kind to succeed; or for the crop sown down, in some rotations, with it either to mature and be harvested, as in the case of carrots; or to make a good growth, as with seeds, before the winter comes on.

In some of the poor districts on the Continent flax is taken after grass, the old pastures being ploughed up, furnishing an amount of fertilizing matter sufficient to enable them to take two or three crops of a better description than the natural character of the soil usually admits of. In Ireland they like, when possible, to break up old pasture land, take a crop of potatoes, followed by wheat, and then (the third year) a crop of flax sown on the stubble. In this case they get both quantity and quality of produce; whereas, if they were to take the flax first, on breaking up the old grass, it would be sure to grow rank, give probably a large bulky crop, of inferior quality, and be very liable to sustain injury should the weather be at all unfavourable at the time approaching its maturity. Although it is desirable to have the soil in good condition, organic matter in large proportion always is prejudicial to the crop; and experience has shown that, under ordinary circumstances, flax does not succeed so well after grass or root crops, even where carried off the ground, as in the case with potatoes, as after a straw crop. On the light sandy soils of Belgium and Holland, containing naturally but very small proportions of organic matter, organic manures are used to flax, as indeed they are to all their crops. From 300 to 500 rape cakes are allowed to each acre; these are dissolved in about ten tons of liquid manure, "purin," containing the liquid and solid excreta of the house and of the stables, and then carted and distributed over the land, immediately previous to sowing. If the land intended for flax has been thoroughly tilled and cleaned in the autumn, and left with a good deep winter furrow, it will require but little preparation in the spring. *It is always better to avoid using the plough if possible at that period of the year.* The finely weathered surface is turned in, and it is well-nigh impossible, by any mechanical treatment of the soil, to reduce a fresh furrow-slice to the same tilth, while every time any implement or animal passes over the surface it becomes compressed and consolidated, and in some soils and seasons materially injured. Therefore, in all cases spring ploughing should be avoided, if possible. If the autumnal cultivation has been well attended to, a deep turn with the "cultivator" across the line of ploughing will thoroughly break up the old furrow-slices, open and dry the soil if necessary, and leave the finely-divided surface soil untouched, and in first-rate condition as a seed-bed for the following crop.

Assuming that all these points have been carefully attended to, and that the land is thoroughly prepared for the crop, it is desirable, previous to getting in the seed, to run a light roller over the surface, in order that it may be perfectly smooth, and the seeds all deposited at an equal depth. It is important for the fibre produce that the seeds should all germinate, and the growth proceed equally throughout the whole crop, which might not be the case were the surface irregular and uneven at the time of depositing the seed. The end of March or the beginning of April is the time generally recommended for sowing. The seed requires no preparation, but merely attention as to its quality. We have already endeavoured to show how much the success of a crop depends upon the quality of the seed used, and have had more than one opportunity of speaking about the adulteration of our farm seeds, especially those which we are accustomed to import from other countries. The selection of flax seed is a matter of great moment to the cultivator, and great care is necessary in obtaining a good sample. Foreign seed is universally preferred, even by the Belgians, who always select Baltic flax for their seed purposes. In Ireland it is also always preferred. For heavy soils the Dutch seed is frequently used, which is the produce of Riga seed once grown in Flanders. The American seed was at one time tried, as being somewhat cheaper; experience, however, has shown, that the plants had a tendency to grow branchy instead of a single erect stem; and although good for seed purposes, a large portion of the fibre was necessarily lost in scutching. In England, where the cultivation is entirely special and limited, home-grown seed is frequently used, and the crops have succeeded equally well; but in the regular flax-growing countries, where they rely greatly upon their flax as the money-producing crop, they always obtain a new supply. The Riga seed is everywhere considered the best for seed purposes. This, however, as is the case indeed with all foreign samples, is too dirty to admit of being used directly for the flax crop, as the amount of weeds mixed up with it would not only materially lessen and lower the value of the produce, but stock the land to the prejudice of after crops. The best plan to pursue is to obtain foreign seed sufficient merely to reproduce the quantity ot seed required for the flax crop, and to sow this separately in wider drills, not less than 12 inches apart, so that it may be kept entirely free from weeds, and thus furnish a clean sample for the crop of the following year. This practice is generally followed in Belgium and in Ireland, where it is commonly known and sold as seed "one year from the barrel." The seed varies of course considerably in price; the Riga is, however, always the dearest; the Dutch and American being offered at a lower price, are consequently preferred by some growers.

The quantity of seed used is from 1 to 2 bushels per acre. In Belgium about 1½ cwt. is usually sown. Where flax is grown principally for its fibre, a larger quantity of seed is used than when the seed produce is the chief object of cultivation. In the former case, by thick sowing the plant is induced to throw up a tall slender stem, with only one or two small branches towards the top, and thus increase its amount of stems and fibre at the expense of its seed; in the latter case, the plants being fewer in number have more space, and a better access to air and light; a more vigorous growth is induced, side shoots are thrown out, surmounted in due course by flowers and seed-pods, while the stems, owing to the branching habit of the plant, are only fit for an inferior sample, and of course fetch a lower price in the market when sold for steeping purposes. In England, where the practice of drilling is well-nigh universal, the seed is deposited by the ordinary drill of the farm. This practice is largely followed in Ireland, though by far the larger portion is still sown broadcast, which is the common mode still pursued in Belgium and other flax-growing countries. For this method an increased proportion of seed must always be allowed as compared with drilling. By either method, however, it is important that care should be taken to deposit the seed at an uniform depth, which should be as shallow as possible; so that it be fairly covered is all that is required. If it be deposited too deep it will remain a long time in the soil without germinating at all; if it be placed at irregular depths its germination and growth will be irregular, and its produce, both as regards seeds and fibre, will be irregular, and of less market value. In drilling, the rows should be from 8 to 12 inches apart, and the lightest seed harrows used to cover in the seed; in broadcasting, it is generally brushed in with the bush-harrow, in the same manner as grass and other small seeds. In both cases the land should have a turn with the light roller, which finishes the operation.

When sown for the fibre alone, or for fibre and seed combined, it is recommended to be sown somewhat earlier than where the seed only is the object of cultivation. Vegetation is so rapid in its processes in the summer, and the crop grows so quickly, that the plants sown late have not time sufficient to mature and consolidate their tissues, which is so necessary for the production of good fibre, and which the slower vegetation of the spring months generally secures to those sown at an earlier period. For fibre purposes, then, the last week in March is probably the best time; when both fibre and seed are desired, the sowing may be delayed for a week or two later; and when the crop is intended for its seed produce alone, any time before the end of April will be equally suitable. At the same time it should not be forgotten, that whether the crop be grown for fibre or for seed, the sooner it is harvested and the field cleared the better opportunity exists for taking a catch or intermediate crop of some quick-growing plant, as buckwheat, mustard, or rape, which not only occupies the ground profitably, but is an excellent preparation if the succeeding crop be a cereal, or for getting in turnips or any other crop that may be intended to follow it.

Both in Ireland and in Belgium clover seeds are frequently sown down with the flax, and in the latter country carrots are also met with sown in the same manner. This practice, though very commonly seen, even in well-managed farms, is only admissible when both the land and the seed are perfectly clean and free from weeds. Even then it cannot be recommended, as the two crops thus sown together have to struggle for the food which ought, under ordinary circumstances, to be devoted to only one; and as flax has to complete its growth long before the other arrives at maturity, it must suffer the most, while the operation of harvesting the flax cannot be effected without injury to the crop left behind it in the soil. The only attention the crop requires after it has been well got in, is to be kept clear of weeds. This, where it has been drilled, is done by hoeing carefully either by hand or the expanding horse-hoe; where broadcasted, however, it must either be left untouched or carried out in a different manner. In this country it is generally left to take its chance. In Belgium, where manual labour is far more largely and commonly employed than with us in farm work, and where the extravagance of our weed-growing farmers is rarely to be seen, the operation of hand weeding is never omitted, and is effected in a manner peculiar to the crop. As soon as the plants have acquired a certain growth, and the weeds begin to show themselves, suitable weather of course being selected for the work, children are sent on to the field for the purpose of clearing it of all surface weeds. The work is done by them on their knees, which are well padded, to prevent them from crushing or injuring the young and tender plants; a small basket or open bag suspended from the neck receives the weeds, which are collected from time to time by the overlooker, and carried off the field. As this operation can only be done once, it is important that it be done effectually, and every weed is by these means removed from the field. Care and consideration are required as to the best time for the work, as if left too late the plant is liable to be injured by the pressure of the weeders; the precaution, too, is always taken of working against the wind, in order to give the young plant the advantage that might arise from the action of the wind in assisting it to recover its erect position as quickly as possible.

In about ten weeks after the plant appears above the ground it has completed its growth, and flowering commences, the whole field then assuming a very beautiful appearance. The flowers, if the crop be evenly grown, come pretty well together, and do not last long, and are followed by the "capsules," or "bolls," containing the seed. At this period of the growth of the crop, the consideration as to the proper time of harvesting it first presents itself. This has an important bearing upon the value of the produce, and must be mainly determined by the purpose for which the crop was grown. If the fibre be the only object, in some places the flax is pulled directly it begins to flower, under the idea that at that period the tissues of the plant are finer, and, although the produce is less, it secures the best qualities of fibre; more generally, however, it is left until the stem begins to change colour at the bottom, when it is at once pulled, and considered to be in the best condition for steeping, no attention being paid at all to the seed.

When both fibre and seed produce are desired, careful observation on the part of the grower is required, as much depends upon his judgment both as to the quantity and quality of his produce. The seed-vessels or capsules are of a globular form, with the top surface slightly drawn up to a point. On opening them, from six to ten (more commonly the latter number) cellular divisions are seen, each occupied by a seed, which at first is a colourless integument, enveloping a watery mucilaginous matter. On examination in a day or two, it will be found to have assumed a more solid consistence, and the seed to have changed to a pale green colour. This is the first point to be noticed, and not a day should now pass without observing the changes that take place, as these changes form the criteria by which the period of harvesting the crop should be regulated. In Belgium—and we instance that country, as the flax cultivation has a higher importance there and receives far more attention than with us—the way they proceed is this:—A full-grown plant is selected, and the best matured and ripest capsule is taken. This is cut across with a sharp knife, and the section of the seeds examined. If they have become firm inside, and the outside has assumed a good deep green colour, the plant is considered fit for immediate pulling. At this time the entire plant will exhibit signs of its approaching maturity—the bottom of the stalk will be seen to have assumed a yellowish tint, and have become much harder to the touch than it was before, good indications of an interruption to the circulation of the juices of the plant. If this altered condition be allowed to go on by the plant remaining in the ground, the change of colour will rapidly make its way up the stem until it reaches the capsules, and then the seeds will be found to be fully matured, quite hard, and to have assumed the dark colour with which we are so familiar in the market samples. The next stage of the plant would be the bursting of the seed-vessels and disjection of their contents, and the decay of the entire plant; but to preserve both seed and fibre, the plant should be harvested at the earlier stage, at which time the fibre is at its best condition. If left until the seeds are quite matured, the stem gets hard and woody, and the fibre is apt to get much broken in the subsequent process of separation. Long experience has proved that this is the most profitable time to pull the flax; for although the seeds are not at that time fully ripe, yet if allowed to remain in the sheaf, they will absorb from their integument a quantity of sap to render them sufficiently mature for the purpose of vegetation, though perhaps for commercial purposes their market value may not be so high as if allowed to stand a little longer in the field. These points should all be duly weighed by the grower before he gives directions for pulling the crop, as sometimes the markets or the requirements of the farm may render one portion of the crop more valuable than the other, and he would of course arrange his time of harvesting it accordingly.

The mode of harvesting flax differs from that of any of our other crops, as for the sake of obtaining the fibre as long as possible, the plants are pulled up by the hand, roots and all, instead of being cut in the ordinary way. This is both a tedious and an expensive process, and is a great obstacle to the introduction of the crop into districts where it has not been grown, as unless the people have had a little practice at the work, they are generally very slow at it at first, do it badly, and if paid by day-work, dissatisfy the grower, and if by piece work, are dissatisfied themselves at the little they have earned. The flax is pulled by the labourer, each hand singly grasping a small handful carefully by the neck, just below the seed-vessels, and drawing it up out of the soil, and laying it in rows across each other. These are allowed to remain lying open on the ground for a certain time, generally one or two days; they are then collected together, and bound into small-sized sheaves or bundles, care being taken that the band shall be placed just under the seed-heads of the plant, and the bottoms or butts left unconfined and open. If the crop has been irregular in its growth, and the stems are of unequal lengths, it is desirable, as far as it can be managed, to pull them in different bundles, according to their lengths, as both in steeping and scutching much fibre is otherwise lost. It is also desirable in binding them, that the butts should be gently pressed on the ground, in order to regulate the lengths of the different stems. After the sheaves, or "bundles," as they are termed, are bound, they are arranged in small stooks, usually of four, five, or six each, placed in a circle, the butts being well spread out, so as to admit the air freely to their centres—the weather, and the condition of the crop when pulled, of course, regulating the period they have to remain on the field.

The trouble and expense of hand-pulling flax are always obstacles in the way of its introduction, or at all events of its being grown a second time in a new district. In the United States, where the consumption of linen is even greater than with us, and where consequently the flax industry is really of more importance to them, and where labour is far less plentiful and more costly than with us, these obstacles have greatly retarded its systematic cultivation, and led to the construction of a machine for effecting the same work in a more expeditious and economical manner. The following description of the machine, taken from the report of her Majesty's Commissioners to the New York Industrial Exhibition,[1] will give a tolerably good idea of its construction, and show our own machine-makers how readily the American mechanic applies his powers to meet the requirements of industry, whether it be in the finer operations of the factory or the mere crude labour of the field:—

[1] Special Report by Professor John Wilson, F.R.S.E., &c., p. 114.

"The machine is propelled by a horse harnessed in the centre of the back part, and the flax operated upon is left lying in two parallel lines on the ground, intermediate between the track of the horse and of the wheels. In the forward movement of the machine in the field, the standing flax is separated and gathered up between long wedge-shaped projections, forming a breast or front near to the ground, and is then pulled by means of vertical rollers, furnished with arms reaching forward underneath the branching top of the plant, which is thus at each revolution bent over at nearly right angles with its growth, bringing up the lower part of the stem into the bite of the vertical rollers, and by them delivered on the ground in regular layers. The rollers are driven by gear-wheels, on a shaft receiving motion from the two large carrying wheels, to which the whole machine is adjusted. This machine, I was informed, would with one horse enable the grower to lay eight acres of flax on the ground in one working day. The cost of hand-pulling is with us from 10*s.* to 20*s.* per acre: by this machine, if the inventor's statement be correct, it could be done for certainly less than 1*s.*, thus effecting a reduction of fully nine-tenths of the cost of labour, an equal saving in the time required, and relieving, in fact, the farmer from all anxiety about the work."

The flax-pulling machine would, if its performance in the field be equal to what was said of it, be a most beneficial introduction in our own flax-growing districts, where hand-pulling is the universal mode by which the flax crop is harvested. At the same time, we may reasonably question whether this mode of harvesting, by hand or by machine, is the most advantageous after all, either for the farmer who produces the straw, or for the manufacturer who has to convert it into fibre. If the tillage operations of the farm have been properly carried out, and the directions given as regards tilth of surface and rolling after the seed is got in been attended to, there is no reason why we should not avail ourselves of the "mowing machine," which is now doing such good work in our grass fields, and cut down our flax as near to the ground as possible in the same manner. The machine would make better work of it than of grass, as it would clog the knife less, and we might readily count upon 10 or 12 acres being cut in a working day, at a cost not exceeding as many shillings; or even a good scythesman would readily cut down from 1 to 2 acres in the day, at about double the above rate. Hitherto we have always fallen in with the idea that it is necessary that flax should be pulled up, root and all, in order that the greatest possible length of fibre may be secured. For all textile uses, the portion of the fibre of any value exists only in the stem above the ground; and to obtain this in a separate state, a *chemical* process of disintegration has to be carried out in the first place, which is then followed by a *mechanical* process of separation, viz., breaking and scutching. At the lower part of the plant the fibrous tissues assume an altered condition, and are strengthened by an increased proportion of woody tissue, and these are finally sealed up by the roots, which terminate the plant. If this lower part were removed, which it would be by the method of harvesting now suggested, the first process of disintegration in the "steep" would be carried on more rapidly, and also more regularly, where large quantities were operated upon, as the dried juices of the plant would be more regularly acted upon and extracted, while, at the same time, it is most probable that we should lose nothing in the length of the dressed fibre, if we take into account the injury it sustains when the ends or butts of the steeped straw are submitted to the action of the scutching frame.

When they have arrived at the desirable state of dryness, they are carted away, and are either stacked for future use, or are at once taken to the place where the subsequent operations for the conversion of the crop into fibre are to be carried on. In this country, the form and mode of stacking is the same as with the straw crops, the only difference is in their smaller size. On the Continent, however, they adopt a different method, and arrange the sheaves in long, narrow stacks, having only a width of two sheaves, placed head to head together (about 4 to 5 feet), their butts forming the two outsides. These stacks frequently extend 20 to 30 feet in length, and are held together by two stout poles firmly driven into the ground at each end; their height rarely exceeds 8 to 10 feet. A row or two of sheaves laid lengthwise along the centre, at the top, gives a slight inclination to the thatch with which they are covered, the eaves being carried out so as to drip clear of the sides. By this method the crop may be carried earlier from the field, and requires less time in the stack, both matters of importance to the Belgian farmer, who never allows his lands nor his hands to remain unoccupied if he can help it.

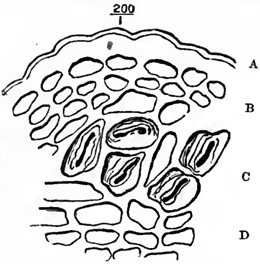
In some cases, especially if the demand be pressing, and the weather suitable, the sheaves are not stacked at all, or at all events only a portion of them, but the seed is separated, and the straw carried to the steeping place at once. Indeed, this is the plan usually followed in districts where the old methods of preparation are still followed, as the process can only be carried on successfully while the natural temperature of the water is sufficiently warm to induce a regular fermentation, and is arrested as soon as the temperature falls with the advancing autumn. The portions of the crop then unsteeped have to wait for the succeeding summer's work. Where, however, the improved processes, to which we shall presently refer, are adopted, time and temperature are of no importance, as they can be carried on during the winter as well as at any other period of the year. These processes vary so materially in the principles involved, and also in their practical details, that we propose to give them a separate consideration, as although the technical treatment of a crop hardly appertains to agriculture proper, still the after treatment of flax, so far as its fibre preparation is concerned, is so generally carried out by the grower, that it practically forms an exception to the rule, and becomes a matter of inquiry and information, as important to him as the mere tillage processes of his crop. The improved processes, however, have given rise to another branch of the flax industry, intermediate between the grower and the consumer—the spinner or manufacturer—that of its conversion from the straw into the prepared fibre. This division of labour confers a great benefit upon the grower, as supplying a regular market for an article which a well-organized establishment can handle and dispose of far more beneficially than he could do at home, with imperfect means, and too often but very imperfect knowledge.

In commencing the technical treatment of flax, the first operation is that of separating the seeds from the stems. The seeds are then used either directly as food, or they are first submitted to pressure, by which a large portion of the oil they contain is extracted, and the residuum is left in the form of a dry, hard substance, used largely for feeding purposes, and known by the name of "oil-cake." The stems or straw thus remain for the preparation of the fibre, which constitutes the chief value of the crop. The ordinary method by which the seed-bolls are separated is that of "rippling," which is effected by drawing the heads of the sheaves through a stout ripple, or comb, firmly fixed on to the centre of a bench, or rather form, from 8 to 10 feet in length, on which the operators sit astride, facing each other on opposite sides of the comb. The comb has a row of tempered iron teeth, about 15 to 18 inches long, set at distances of one-third of an inch apart at the base, and gradually increasing by the tapering form of the teeth to about two-thirds of an inch at the top. It requires to be strongly made, in order to stand against the strain continually against it in the operation, and should be well rivetted into an iron plate, which can be screwed on to the bench or form. Underneath this simple machine a large sheet is placed (if the floor be sound this is unnecessary); the sheaves or bundles are then supplied on the right hand of each of the ripplers, who takes a large handful by the base of the stems, and by an easily acquired motion spreads out the heads into a fan shape, and this he pulls sharply through the teeth of the rippling comb, which, owing to the difference between the diameters of the stems and of the seed-bolls, allows the former to pass through readily, but strips off the latter, which fall down in a heap on the floor. The two ripplers use the comb alternately, the one renewing his handful while the other is drawing his through the comb. Practised hands do this with great rapidity and exactitude, and a large quantity is got through in the day. The rippled straw is then laid down on the left side of the operator, and is carefully tied up again into the same-sized "bundles" by a boy, when it is ready for immediate use. The seed-bolls require to be winnowed, to clear away the small pieces of footstalks and bolls from the seed, which should then be spread out thinly on the floor, and exposed to a current of dry air for a day or two, or, better still, when practicable, exposed on a sheet to the sun and air until they are quite dry, when they will be found to have become darker in colour and more plump in appearance. The rippling process can only be safely followed when the flax is fresh from the field: where it has been stacked any time, and the straw got dry and rigid, it would be broken and greatly injured by the operation. In this case a "bat," or beater, in the shape of a flat piece of hard wood, 8 × 12 inches in size, with a short wooden handle set at a certain angle, is used for the same purpose. The "bundles" are held by the left hand of the operator on a table, and the heads are struck with this "beater," the seed falling from the broken capsules or bolls on to a cloth placed beneath. This beater is often used to break up any bolls that may remain entire in the rippled seed. The sooner the rippled straw goes to the steep the better, as the fermentative process is more readily set up now than when it has become perfectly dry and hard.

Before describing either the ordinary or the improved processes of preparation, let us briefly consider their object, and the nature or composition of the substance they have to treat. The object may be given in a few words—the separation of the fibre from the other portions of the stem. If we take a portion of the stem, break it, and carefully examine it, its composition will be found to consist mainly of three distinct parts. The centre is occupied by a substance composed of cellular tissue, in appearance like wood, which is usually called the "shove" or "boon." Round this centre is a tubular sheath, composed of long tough fibres cohering firmly together, the whole structure being cemented together by a nitrogenized, mucilaginous compound, and enveloped by a thin and delicate skin or bark. The structural arrangement of the stem of the flax plant is admirably described by Schacht,[1] from whose excellent treatise on "Plant Cells" the accompanying *woodcut* is taken. If a piece of the dried stem be rubbed between the fingers, the bark is immediately removed, and the fibrous portions are more or less readily detached

[1] *Physiologische Botanik*, "Die Pflanzenzelle," von Dr. Schacht, Berlin, 1852.

Fig. 1.



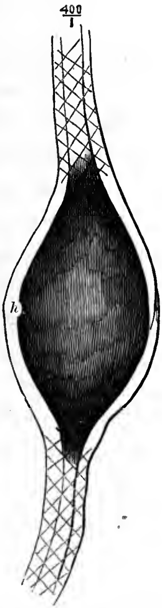
TRANSVERSE SECTION OF FLAX STRAW.

A. Epidermis. C. Fibres.
B. Bark. D. Shove, or woody centre.

Fig. 2.

Fig. 3.

Fig. 4.



Figs. 2, 3, and 4. Longitudinal outlines of fibres. *h, h, h, h.* Cavities.
2 and 3. Ordinary cavities. 4. Rarer shaped do.

from the woody centre. These fibrous portions being composed of bundles of very delicate filaments, may be split up into almost any degree of fineness, according to the efficiency of the process adopted.

Now, these various processes—which, as has been already observed, differ widely both in principles and in their practical details—may be all classed under two heads: the *mechanical*, in which the operations are conducted in a *dry* state, and the *chemical*, in which moisture and temperature are more or less necessary. In the first, the object is obtained by the different parts being mechanically separated from each other without any changes being effected; in the latter, the plant itself is disintegrated, either by the action of fermentation, which destroys, or of some solvent, which merely abstracts the cementing matter by which the several parts of the straw are held together. Of the first but little need be said, as, except for rough goods not requiring to be bleached—as canvas, rick covers, rope yarns, &c.—it cannot be advantageously made use of. However, as it costs as much to steep bad straw as good, and the expenses in some such cases frequently exceed the value of the produce, it would appear that the *mechanical* or *dry* process may be beneficially tried where the raw material is of inferior quality, where there is a difficulty in steeping it properly, or where coarse fibre only is required. Several different modes have from time to time been devised for effecting this mechanical separation, the principal of which are given in the appended note.[1] Even in the event of a successful result in the

[1] In 1812, Lee took out a patent for this purpose, to whom parliament accorded a peculiar privilege—that the time for specification should be extended from six months to seven years. This was speedily taken up by the Irish Linen Board, who expended £6000 in their endeavours to introduce it into the flax-growing districts. One of the machines was, a few years ago, to be seen in the White Linen Hall at Belfast, where, probably, it is still preserved. Before the time for specification arrived, another patent was taken out by Hill & Bundy, in 1817, and more recently, those by Donlan and others have

separation, it must be remembered that goods manufactured from fibre thus obtained are always liable to be injured by moisture, or by any other condition that would act upon the nitrogenized substances, which would still to a great extent remain enveloping and cementing the fibres together.

The second, the *chemical* or *wet* process, is effected in three very different ways, and must be considered under three distinct heads, as in each a different principle is involved. The *first* is that where the separation is effected by simple fermentation, known as "steeping;" the *second*, where it is due to the abstraction of the nitrogenized extractive compound by the agency of chemical solvents; the *third*, where simply water, either heated or in the shape of steam, is made use of for the same purpose.

In the first, a destructive fermentation is carried on, either slowly or rapidly according to the temperature of the water in which it is steeped, at the expense of the extractive matter of the plant, and offensive and noxious gases are generated; in the second, this matter is removed by the aid of chemical ingredients, which are costly, and never altogether efficient in their action; while by the third, the separation may be effected without any chemical changes taking place in the composition of the plant, and all its several parts be left in an available condition.

Of these different processes the first, that of "steeping," is the oldest, and still may be termed the universal method by which flax fibre is prepared in every country in which it is grown, the only improvements that have taken place since our earliest records having been of quite recent date. The method described by Pliny[1] as being

been made known to the public. On the Continent the same attempt has been made, and with like success. Some years ago, M. Christian, Directeur du Conservatoire des Arts et Mitiers, devised a mechanical process for the separation of the fibre, which appeared to answer well enough at first, but was soon afterwards gradually abandoned.

[1] *Plin. Nat. Hist.*, lib. xix. cap. 1.

practised by the Romans is the same in all essentials as that of the best flax district of Belgium at the present day; the only advance modern times have made is in the substitution of an increased and regular temperature, for the lower and irregular temperature of the pools or rivers in which the steeping is commonly carried on. This system, introduced by Schenck in 1846, was a great improvement upon the old, as we are now able to effect the operation at any and all periods of the year, in a one-tenth part of the time formerly required, with far more certainty as to the results, and, in most cases, with increased returns from the straw operated upon.

We must, however, describe the old process before a correct estimate can be formed of the advantages offered by the new. The old process of "steeping" is carried on differently in different countries and in different districts. The oldest is probably that called "dew-retting," in which the straw is spread out thinly on the grass, and carefully and regularly watered, so as to supply sufficient moisture to excite and support a fermentative action in the tissues of the straw. This is a very tedious process, still, however, more or less practised in all flax-growing countries, requiring several weeks for completion, and in dry seasons not practicable at all. The other and more usual method is to immerse the straw either in tanks or pits constructed for the purpose, or in pools or slowly-running streams. In Ireland pools and tanks are more generally made use of; in Belgium the streams and smaller rivers are always preferred for the purpose. There, especially in West Flanders, the "steeping" is carried on as a distinct and separate branch of the flax industry—very few of the growers themselves undertaking that primary act of preparation of the fibre, while many send their produce from a considerable distance to be steeped in some of the more renowned streams. Of these the river

Lys has the highest repute, and we will therefore take the practice followed in the Lys districts as the best standard for comparison or example.

This river, which rises in the north of France, and runs through West Flanders, is celebrated throughout the greater part of its course for its peculiar and excellent properties for the purpose. It possesses a considerable depth of water, with a very slow motion, both favouring a regularity of temperature, upon which probably its high repute is mainly based, as analysis[1] does not give any indications of its constituents possessing any peculiar properties, or indeed being different from those of other slowly-running streams. The commencement of the "steeping" season is determined by the temperature of the water; towards the end of April or beginning of May is the usual period, and it lasts until the end of September, during which time the work is in full operation, giving employment to a great number of people. The whole process may be briefly described as follows:—The flax to be operated upon is placed in "bundles" or sheaves, loosely bound on a sparred frame, or crate, made for the purpose, from 12 to 15 feet long, from 8 to 10 wide, and from 3 to 4 feet deep, the bars being rounded off at the sides, and about 4 inches apart. The bundles are arranged in rows, the butts of one coming next to the heads of the others, the whole are then firmly

[1] Analysis of the water of the river Lys, by Dr. Hodges:—

	Grs.
One gallon contains of organic matter,........	2·86
Inorganic matter,........................	19·67
Solid substances,........................	22·53

The inorganic or mineral matter consisted of—

Chloride of Sodium,........................	1·9
Sulphate of Lime,........................	1·22
Carbonate of Lime,........................	13·58
,, Magnesia,........................	1·27
Oxide of Iron,........................	1·13
Silica,........................	0·8
	19·90

fastened down by cross pieces of stout wood at the top, and the frame is sunk in the river to the depth of about 6 inches, by means of suitable weights attached. In a few hours the straw has become well charged with moisture, and a natural fermentation is immediately set up. In a few days bubbles of gas begin to ascend and convey to the surface a scum of decomposed matter, which, directly it is seen, gives the operator notice that disorganization of the tissues is proceeding, and that constant observation and care are now needed lest it proceed too far and injure or destroy the fibres of the flax, which it is the object to obtain. As the process of fermentation and consequent disorganization goes on, the swelling of the straw and tendency of the mass to float gradually subsides, and the crate or frame begins to sink deeper into the water. This at once indicates that the decomposition has advanced quite far enough, and that it must be arrested or injury will ensue. To test this, the frame is raised and a few straws withdrawn from the mass; these are broken in two places a short distance apart, and if the woody part will then separate so as to be pulled out by the fingers without breaking the fibres of the flax or drawing any of them out with it, then the steeping has proceeded far enough, and the flax should be at once withdrawn from the frame or injury will ensue. If the steeping be allowed to be carried too far, the fibre becomes weak and soft, and if it be not carried on far enough, the fibre is always harder and less pliable, and a greater proportion is lost in the process of scutching. This particular period is therefore one of great anxiety to the operator, as upon his judgment and care the quality and yield of the straw intrusted to him materially depend. He watches the first indications which experience has taught him to rely upon, and then tests the progress of disorganization by drawing a sample of the straw every four hours, until he finds that it has reached the desired condition, and the object of the operation of steeping is effected. The frame is then hauled up to the surface, and a man goes into the water and carefully hands each bundle separately to others on the bank, who set them up in long rows for the water to drain from them. The following day they are usually ready for drying; the bundles are then opened and the straw spread out thinly on the ground, which is kept always in grass for that purpose. They remain on the ground generally about eight or ten days, during which time they should be turned three or four times, especially if rain falls during the interval. When quite dry, on breaking the straw it will be seen that, owing to the absence of the cementing extractive matter, and the difference in the contraction of the ligneous and fibrous portions, these are now completely detached from each other, and may be separated without much difficulty, which is the next operation the straw has to undergo before the process of preparation is complete.

This method of "steeping," though less tedious than the "dew-retting," still requires a considerable time for its operation—in pools or tanks, from ten to fourteen days are required; in streams, where the temperature is generally lower, from fourteen to twenty-one days are consumed. In both cases much depends upon the quality of the water, and upon the average temperature. Any impurities, especially salts of lime and of iron, are very injurious; they retard the fermentation, and affect the fibre. These irregularities, both as regards the time required and effect produced by the cold steeping, led to the consideration of another method, by which a regulated temperature could be obtained, and the time and risk of the old method lessened. The merit of practically employing heated water for this purpose is due to Schenck, who took out a patent for it in 1846, though the principle was not at all new, and had indeed been partially applied for a long time past. The first "rettery" on this principle was established in Mayo in 1848; now there are some twenty to thirty at work in different parts of Ireland, besides several in this country, operating upon from 40,000 to 50,000 tons of straw annually. In this the principle of fermentation is the same as in the old process, but is now totally independent of external temperature, being placed under the control of the operator, who can easily regulate the action of the steep according to the quantity of flax operated upon, or the quality of the article he wishes to produce. An important saving in time is effected, from seventy-two hours for the finer qualities to ninety-six hours for the coarser only being required, instead of from two to three weeks. The work, too, can be carried on all the year round, instead of only during the summer months, and a more regular and certain fibre is obtained. The size and number of the steeping tanks are regulated by the general working arrangements of the "rettery," and these again are mainly determined by the local circumstances of supply and sale. The temperature of the "steep" is kept up between 80° and 90°, and controlled at will by the operator. Here, however, we have the same destructive fermentation at work as in the ordinary steeping, under a certain control, it is true, but generating, as the decomposition proceeds, the same foul and offensive gases. These gaseous exhalations, which far and near stamp the unpleasant proximity of a "rettery," have been examined by various chemists, and have been found to consist chiefly of carbonic acid and hydrogen in nearly equal parts, with combinations of both sulphur and phosphorus with hydrogen. The fermentation appears to be of a peculiar character, merely traces of acetic acid being found, while butyric acid is generated in large quantities. In fact, the fragrant butyric ether, so extensively used now as a flavouring substance, especially in the preparation of "pine-apple rum," might readily be collected in considerable quantities from the stinking water of the foul and offensive steeping tanks or pools.

The great advantages which this hot-water process offered over the ordinary system of steeping were disputed by some of the old steepers, so that in order to bring the question to a fair issue, the Irish "Flax Improvement Society" undertook, in 1850, a series of comparative experiments, in which the following doubts as to the hot-water system were specially investigated and reported upon:—

1. That the yield of fibre would be less than by the ordinary method of steeping.

2. That fibre so prepared would be weakened.

3. That linen made from the fibre would not bleach properly.

In reference to the *first* objection, the committee reported that their experiments[1] showed that the uniformity of temperature had the effect of *increasing* the yield of fibre. As regards the *second* objection, the results were equally favourable. In the first experiment, the flax steeped in

[1] In one experiment, conducted at Lisburn by Mr. Davidson, 112 lbs. of flax straw, after being steeped and dried in the usual way, gave 20 lbs. of scutched fibre; while 112 lbs. of the same straw steeped by the hot-water process gave 24 lbs. In another trial, 112 lbs. of cold-steeped straw gave 14 lbs. 5 oz. of dressed fibre; whereas the same quantity of straw yielded by the hot-water process 17 lbs. 11¼ oz. Other experiments on a larger scale confirm these results. In ten comparative trials, made with nine different sorts of flax, it resulted that the average produce of 1200 lbs. of flax straw gave 144 lbs. of dressed fibre in the hot-water steep, and only 118 lbs. when steeped in the ordinary way.

Dr. Hodges, in a paper read at the meeting of the British Association at Belfast (1852), gave a statement, extracted from the working returns of the Cregagh rettery (Schenck's patent), of the changes which 100 tons undergo when treated by this process:—

100 tons of dry flax on the average yield—

1. By seeding, 33 tons of seed and husk, leaving of flax straw 67 tons.
2. By steeping, the 67 tons of flax straw yield of steeped straw 39·5 tons.
3. By scutching, the 39·5 tons of steeped straw yield 5·9 tons of dressed fibre, and of tow and pluckings, 1·47 ton.

the ordinary way spun to 96 lea yarn, and that by the hot-water system spun to 101 lea yarn. In the second experiment, the cold-steeped fibre gave 60 lea, and the hot-steeped gave 70 lea. The *third* objection was submitted to an extensive bleaching firm, whose evidence in favour of the hot-water process was very decided. The committee concluded their report by stating their belief that all reasonable objections had been fairly and reasonably met.

This process is so simple, and its advantages over the old method so manifest, both in respect to time, quantity, and quality of produce, that it is somewhat remarkable that, notwithstanding the knowledge which existed of the value of temperature in respect to fermentation, even indeed in reference to flax itself, it has only so comparatively recently been employed. In looking back we find that so long since as 1787, great interest was excited in Ireland by a plan to immerse flax in scalding water; a large proportion of the vegetable matter was extracted thereby, and fermentation was more readily set up. In India, the practice of partially steeping flax and other similar fibres in hot water has existed for many centuries past. According to Dr. Campbell, at Bencoolen the general process followed is to steep flax and hemp in warm water, in which it is allowed to remain for two to three days. In the presidency of Bengal, at Rungpoor, and other places, the same practice exists, which indeed appears to have been in general use by the inhabitants of the Malayan peninsula for a long time past.[1]

An old German process, termed "molkenrost," in which the flax is steeped in sour whey, largely diluted with warm water, is well known to generate a quicker fermentation, and to produce the finer qualities of fibre. In this process the action appears to be threefold in the advantages it possesses over the ordinary steep. The raised temperature

[1] See *Jury Reports*, chap. x. p. 96, Great Exhibition, 1851.

of the mixture is of course favourable to fermentation, which is assisted materially by the nitrogenized constituent (caseine) of the milk,[1] while the solvent power of the lactic acid probably aids generally in the disintegration of the straw, and the more perfect separation of the fibre. The relations between temperature and fermentation were very clearly shown and described by Hermbstaedt, whose experiments in reference to the chemical principles involved in steeping flax and hemp, were conducted at the commencement of the present century.

Many methods have been devised for dissolving out the nitrogenized extractive matter of the straw by means of chemical solvents, both acids and alkalies, and thus doing away with the tedious and noxious process of steeping. Both weak acid and alkaline solutions appear to a certain extent to possess this property. Some ten years ago the attention of the public was called to a process patented by M. Claussen, in which an alkaline solution was employed for effecting the preparation of flax fibre in a peculiar manner. The attempt itself, however, to make "flax cotton," though at first attracting some attention, was soon discovered to be really no novelty, inasmuch as in 1775 Lady Moira

[1] In a paper "On the Development of the Fermentation Fungus in the Fluid of Warm-water Flax-steeps" (*British Association Reports* for 1852), Dr. Allman gives the details of his examination of the process of steeping by Schenck's patent. The various phases in the development of the minute organism constituting the fermentation fungus were described, and were considered by him to be analogous with those noticed in the fermenting stage of other albuminous liquids. By taking some of the fully developed, and placing them in flax-tanks, where the fermentation was not commenced, it is very much accelerated; and he suggested the question, whether or not it would be advantageous to apply the principle practically to the process of "steeping," as is, in fact, always done in brewing beer. In new tanks or vats it is always found that the fermentation is not set up so readily as in old ones, which may be accounted for by the fact, that some of these cells (organisms), formed previously, adhere to the wood, and thus act at once upon the fluid directly the tank or vat is charged. Some years ago, a method of accelerating the steeping process was in operation on the Continent, where *common yeast* was employed for the purpose of setting up the fermentative action, the flax being placed in shallow tanks, and kept covered with water.

had prepared both hemp and flax in the same manner, the detailed particulars of which were given in the *Transactions of the Society of Arts* for that year. Previous even to Lady Moira's successful experiments, the action of alkaline solutions on flax fibre had been described by Lilljikreuses and Palmquist, who, in 1745, had made use of a solution of caustic potash for the purpose. In 1777, Baron Meidingen proposed the use of alkalies in the preparation of "flax cotton," and subsequently established a factory for the practical operation of his process, at Berchtoldsdorf, near Vienna; and similar methods were also brought before the notice of the public by Kreutzer in 1801, by Stadler and Haupfner in 1811, by Sokow in 1816, and subsequently by several others in different parts of the Continent.[1]

The action of acid solutions has also been rendered available for the same purpose. In 1842, M. Rouchon, of the Ecole Polytechnique at Paris, devised a method for preparing flax by means of immersion in a weak acid solution for a short period, and then placing it in a mass, kept moist by repeated arrosions. These were carefully repeated every twenty-four hours, until the desired effect was produced. The flax was kept tied up loosely in small bundles, which were turned over every day; and a man and a boy could attend to and work about two tons per day.

The use of chemical solvents has the advantage of effecting a great saving of time as compared with either the cold or hot process of steeping, and of being carried on without its unpleasant accompaniments. From twelve to twenty-four hours are sufficient by this principle of action, instead of the three or four days required by the hot-water steep, or the two to three weeks by the ordinary processes.

[1] *Roy. Agri. Soc. Jour.*, vol. xiv. p. 200—"Flax, its Treatment, Agricultural and Technical."

The practice, however, although frequently commenced, has never retained its hold on public opinion, or kept its ground in practice, as the ingredients used are expensive, a portion of the products rendered useless, and the fibre liable to be injured, unless proper care in the manipulation be taken.

We now come to the third division of the processes or methods adopted for the separation of the fibre from the other portions of the straw. Here we make use of only the solvent power of water at a high temperature, or in state of steam, to effect our purpose. This mode of treating flax was patented by Watts in 1852, and was a very great and important advance upon any of the old methods. The tediousness and irregularity of the steeping process, whether cold or hot, with all its noisome consequences, were avoided; no expensive chemicals, involving considerable and careful manipulation in their application were required; the chance of injury to the fibre was lessened; while, at the same time, the whole of the products of the operation were rendered available by the manufacturer. The operation was simple in the extreme. The whole working arrangements were inexpensive, and required but little space for their organization on a suitable manufacturing scale. The straw, deprived of its seed-bolls by passing it through smooth iron rollers, was placed in bundles in a steaming chamber of suitable dimensions and shape, the upper part or top being formed by an iron tank or vessel containing cold water, and acting as a refrigerator, and the lower end having a perforated false bottom, elevated about 12 inches above the bottom of the steaming chamber. Steam at a low pressure was blown from the boiler into the lower part of this chamber, and passing upwards through the layers of flax straw, came in contact with the iron cold-water tank at the top, by which it was speedily condensed, and trickled down again through the straw in the shape of boiling water, dissolving out and carrying away with it the extractive matter, which was finally withdrawn at the end of the operation, or as often as required, through a tapped waste pipe placed below the false bottom of the chamber. In about ten to twelve hours the operation of steaming was completed, and the flax was then withdrawn for the subsequent operations of drying and scutching. The steep liquor, which by the other processes was entirely useless, save so far as its small manurial value was concerned,[1] by this process became an object of some value for feeding purposes, as it contained the whole of the extractive matter of the straw in a perfectly sweet and unchanged condition, and was indeed very palatable to and relished by the stock—milking cows, and pigs—to which it was given.

An improvement on Watts' process was subsequently made by Buchanan, who, instead of using steam, submitted the flax to be operated upon to the action of heated water merely, arrangements being made to control the temperature within a certain limit—a point of great

[1] Sir R. Kane states (*Industrial Resources of Ireland*) that the steep liquor of the old process contains nine-tenths of the extractive matter of the plant, and gives the following as the composition of its solid constituents:—

Carbon,	30·69
Hydrogen,	4·24
Nitrogen,	2·24
Oxygen,	20·80
Ash,	42·03
	100·00

The ash consists of—

Potash,	9·78
Soda,	9·82
Lime,	12·33
Magnesia,	7·79
Iron and Alumina,	6·08
Phosphoric acid,	10·84
Sulphuric acid,	2·65
Carbonic acid,	16·95
Silica,	21·35
Chlorine,	2·41
	100·00

These substances would be, of course, in a largely diluted condition.

importance to its chemical powers, both as regards its action on the nitrogenized extractive matter of the straw and the quality of the fibre produced. In the first process the solvent power was clearly not due to the steam, but to the heated water resulting from its condensation, and as this was always in contact with fresh steam, it was necessarily kept up to its maximum temperature of 212°. Now it is well known to chemists that albuminous solutions containing even a very small proportion of albumen (1 in 1000 parts for instance), coagulate at a temperature of 180°, and then become insoluble in water; and it is always considered that flax fibre is more or less injured if submitted to a temperature beyond certain fixed limits. These two important points were duly regarded and taken advantage of in Buchanan's process. The temperature of the steep was kept between 150° and 180°, and the operation, both as regards time and produce, more satisfactorily performed. The mechanical arrangements, too, were well worth attention; they were equally simple and inexpensive, besides which they were completely *automatic*, thus saving the labour and risks consequent upon carelessness. An entirely new principle of action was introduced, by which a great saving of time was effected—three to four hours now being quite sufficient for the operation. Instead of the straw remaining all the time in contact with the liquid which becomes speedily charged with the extracted matter, and thus deprived more or less of its solvent power, this latter was, by a very simple but effective contrivance, frequently withdrawn from the steeping vat, and again forced into it at a regulated temperature, by which it was each time brought into contact with fresh surfaces, and more efficiently extracted the soluble matters of the straw. A familiar instance of the effect produced by exposing fresh surfaces to the action of a solvent, is readily seen in the immersion of a lump of sugar in a glass of water. If left there without motion, it will remain a long time before it is entirely dissolved, whereas if it be passed up and down through the water, or the latter have motion given to it, so that in either case changed surfaces be brought in contact with each, the solution is readily effected. By Buchanan's process the steep liquor was equally available as by Watts'. This was examined by Dr. Hodges, who gave the following as the results of his investigation into its composition. One gallon evaporated to dryness, gave—

Of organic matter,	353·97 grains.
Of inorganic matter,	161·49 ,,
Total extractive matter,	515·46 grains.

The organic matter afforded on analysis—

Of nitrogen,	17·79 grains, or equal to
Of nitrogen compounds,	110·82 grains in the gallon.

The inorganic matter possessed the following composition:—

	Per cent.	Grains per gallon.
Potash,	27·17	44·63
Soda,	3·18	5·12
Lime,	5·91	9·49
Magnesia,	4·60	7·40
Peroxide of Iron,	·83	1·33
Phosphoric acid,	5·66	9·01
Sulphuric acid,	15·64	25·11
Carbonic acid,	12·43	19·96
Silica,	3·00	4·83
Chloride of Sodium,	21·58	34·61
	100·00	161·49

The taste and smell of the liquor very much resembled that of hay, and when poured over the crushed "bolls,"[1] or chaff, it was readily consumed by cows and pigs, which appeared to thrive upon it. No purgative effect had been produced, while its nutritive properties were, according to

[1] The seed "bolls" themselves contain, on the average, about 9 to 10 per cent. of nitrogen compounds.

the above analysis, estimated as fully equal to distillers' wash.

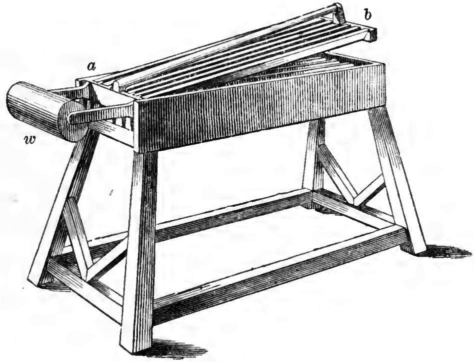
The important advantages resulting from this improved method (Watts') of treating flax were immediately recognized by the Flax Improvement Society, and a committee of investigation appointed to institute "a careful and extensive series of experiments, with a view to compare it, both in a practical and financial point of view, with the modes of hot and cold water steeping generally practised." The experiments were personally superintended by the committee, and flax straw of ordinary market quality operated upon, of which 10 cwts. 1 qr. 21 lbs. was taken and placed in the steaming chamber, where it was submitted to the action of steam for 11 hours. After steeping, wet-rolling, and drying, it weighed 7 cwts. 11 lbs., and on being scutched the yield was 187 lbs. of fine flax, and of scutching tow 12 lbs. 6½ oz. of fine, and 35 lbs. 3 oz. of coarse. The yield of fibre in the state of fine flax was therefore at the rate of 18 lbs. per 112 lbs. of straw, or 26¼ per cent. of steeped and dried straw. The estimated cost of the entire operation was £10 per ton of clean fibre, while the market value of the samples produced was estimated at from £56 to £70 per ton.

Notwithstanding the evident advantages of these improved processes, they appear to have been practically unsuccessful, and not to have produced the beneficial results expected. In Watts' process, the oil contained in the straw was expelled by the high temperature, which was supposed by some to cause the fibre to be less soft and flexible than that prepared in the ordinary way. This quality is considered of such importance to the sample, that a method was devised and patented by Jennings for improving the fibre, by giving it an additional portion of oleaginous matter after it had been separated from the stem. This he effected by boiling it in a weak solution of an alkaline soap, drying it, and then again immersing it in a weak solution of pyroligneous acid at a high temperature, which decomposed the soap, and left the fatty base intimately mixed up with the fibre. It was then washed in soft water, dried, and submitted to the heckles, the fibres splitting up into finer filaments, and becoming soft and silky to the hand, while their strength was not at all reduced. The fibre of flax is very different to that of cotton. Under the microscope flax is seen to consist of bundles of very fine filaments, cemented and adhering closely together, their separation being determined by the greater or less efficiency of the operation to which they are submitted; so that, in reality, coarse and fine fibres are merely relative terms. Jennings, by a chemical process, carried on the action of separation of the fibres, and by depositing a fatty matter on the surface, improved its handling and spinning properties, and generally advanced its market value. When woven into goods, they were found to bleach more readily, and to lose less in weight by the process than those made from ordinary fibre.

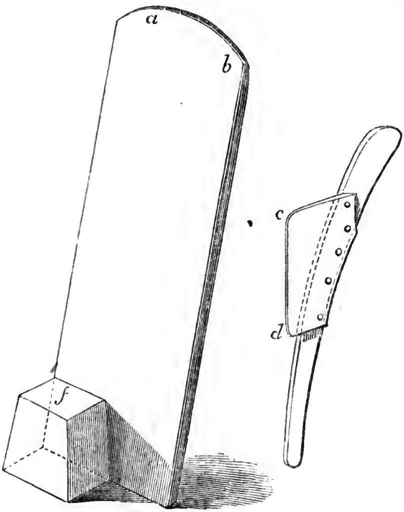
Another improvement in the preparation was introduced about the same time by Pownall, to obviate the defects of Schenck's process, caused by the steep-water getting saturated with the products of decomposition, and charging the fibre more or less with its results in the shape of a yellow powder, offensive to the smell, and causing injury and inconvenience in the subsequent operations of spinning and weaving. He devised a method of passing the flax straw, immediately when taken out of the steep, between a pair of smooth rollers, while, at the same time, a stream of water played upon them. By these means all the foul water was pressed out of the straw, the stem was crushed up and thoroughly broken, without injuring the fibre, while the water flowing continuously over the straw while passing through the rollers backwards and forwards, washed out the extractive matter, and the pressure of the rollers left it comparatively dry.

Having thus given the principal working details of the different processes of steeping flax straw preparatory to the separation of the fibre, which part of the operation is very commonly performed by the grower, we need only briefly allude to the mode by which the separation is effected, and the flax rendered fit for the use of the spinner and weaver, which indeed usually forms a distinct branch of the industry. In the countries or districts where the old system of cold steeping is practised, the "breaking" and "scutching" are generally performed by hand labour; the introduction of the new processes was, as might be expected, accompanied by new mechanical modes of effecting the same object with a rapidity, precision, and economy of price, quite unattainable by hand labour.

The ordinary mode of "breaking" may be readily understood by a glance at the accompanying woodcut of the machine generally used for the purpose. It con-



sists of two principal parts—a moveable sparred frame (*a b*), hinging into a corresponding fixed horizontal framework, the spars of which fit into the intervals of the moveable one. The fixed framework is supported on a pedestal, the other, hinging at *a*, is nearly balanced on that fulcrum by the weight at *w*. In working the machine the operator stands at the side, and taking the upper frame with one hand, he lifts it up, and with the other places the straw to be broken between the two, and then gives it a succession of blows with the upper frame until the desired end is obtained. The woody structure of the straw is thus completely broken, and fitted for separation by the next process, that of scutching, or "swingling," as it is sometimes termed. Here again the manual process has been successfully imitated by machinery; the old method, however, is still practised in the cold-steeping districts. This is effected in the following manner:—The flax straw is taken up in successive handfuls, and laid over the top (*a b*) of an upright wooden stand, as in woodcut. The operator rests one foot on the lower block *f*, which steadies his movement, and gives successive blows with the edge of the swingle *c d*—a flat, thin blade of wood, fixed to another stouter piece of the same material—upon the projecting part of each handful of flax, which is turned about after each blow so as to present every part of it in turn to the blows of the swingle. When every portion of the "shove" or woody portion is separated, the fibre remains fit for market



purposes. In establishments where the improved processes of steeping the straw are in operation, the subsequent processes of preparation are conducted in a more expeditious and efficient manner. Instead of the long and tedious operation of drying by exposure to the air, the steeped flax is at once submitted to pressure, by being passed between smooth steel rollers, which not only effectually crush and break the woody centre, but at the same time squeeze out nearly the whole of the moisture, a few hours' exposure to a current of a dry air in a suitable shed or chamber being all that is necessary to render it perfectly dry. It is then passed through a train of toothed rollers, which break up the woody centre into short lengths, and at once submitted to the action of the scutching frame, by which the separation of the fibre is effected in a very satisfactory manner as regards time, cost, and produce.

In speaking of the treatment of flax by these different methods, we have only referred to it in a dried state, harvested and treated in the usual way. It is not, however, necessary that it should always be so; it is usually more convenient, it is true, where large quantities are to be operated upon, but where the quantity is small and can be worked up at once, it would appear, from the following comparative experiments, that steeping it in a *green state* is the most advantageous. M. Dufermont, cultivateur à Hem (département du Nord), found that, when the flax was used green the steeping only required from six to seven days, and that six days' "grassing" gave the flax a finer colour than could be obtained by any other means. It was dried and ready for scutching in three weeks, whereas the ordinary time in the district averaged from one to one and a half years.[1] He found

[1] It is generally considered desirable that the steeped flax should be kept some time—one, two, and even three years—before being scutched.

also that it yielded 5 per cent. more fibre, and that the fibre was worth fully 10 per cent. more money in the market. The flax was pulled before it was quite ripe, the seed-bolls removed by rippling, and the straw immediately placed in the pits. The seed, however, was reduced about 9*d.* to 1*s.* per bushel in value. The details of the experiments he gives thus:—[1]

FIRST EXPERIMENT.

	Value.	Original weight.	Dried.	Steeped and dried.	Scutched.	Value of Fibre per kilo.	Value of Seed.	Gross Returns.
	francs.	kilos.	kilos.	kilos.	kilos.	francs.	francs.	francs.
Green Flax,..	222	4,030	...	826	191	1·70	27	357·70
Dried ,, ...	222	4,030	1,142	178	178	1·55	31	306·90
Balance in favour of green flax,............								45·80

SECOND EXPERIMENT.

	Value.	Original weight.	Dried.	Steeped and dried.	Scutched.	Value of Fibre per kilo.	Value of Seed.	Gross Returns.
	francs.	kilos.		kilos.	kilos	francs.	francs.	francs.
Green Flax,..	6·05	100	...	26·00	6·35	1·90	...	12·06
			grammes.					
Dried ,, ...	6·05	100	30·250	22·50	5·50	1·65	...	9·07
Balance in favour of green flax, ...								2·99

This practice of steeping the flax in a green state before it is fully matured, which, by the foregoing experiments, appears to be attended with great advantages, is carried on to a considerable extent in the Waes district of Belgium.

We are not in a position to give any very satisfactory account of either the *diseases* or *insect* injuries to which the flax crop is subject. The only injury that has been noticed in this country arises from the presence of the "flax dodder"—*Cuscuta epilinum*—a prominent member of a parasitic family of plants, which have already been described and figured at page 123, in reference to the clover crop, this species being distinguished from the

[1] *Annales de l'Agri. Française, Mars,* 1853.

others by its slender, pale green coloured stems, the stems of the others being either of a reddish or reddish yellow tint. When the crop is attacked by this enemy considerable damage is always done; and where foreign seed has been used, or the subsequent weeding been neglected, the weeds that grow up intermixed with the crop not only deprive it of a large portion of the mineral food materials which would otherwise be available, but also lower the market value of the flax straw, by the increased difficulty they occasion in the steeping and scutching processes. Owing to the size, shape, and general physical characters of the flax seeds, the seeds of other plants may, without any very great difficulty, be separated from them; at all events, the practice, universally recommended, of only sowing foreign seed sufficient to reproduce seed for the *fibre* crop of the succeeding year, and keeping the seed crop scrupulously clean, will materially assist the purpose.

The consideration which the flax cultivation has always received even from the earliest times, and the many and important uses to which its products have of late years been applied, have caused its *chemistry* to have been well worked out, both by our own and continental chemists. There are few plants entering into regular cultivation that yield to industry and applied science such large returns, giving at the same time remunerative occupation to a large amount of skilled labour. The straw or stem, which in itself has a market value of about £3 per ton, is converted by industrial applications into a material—dressed fibre—having a market value ranging from £50 to £100 per ton. The seed, whose average price may be taken at £10 to £12 per ton, is submitted to a process by which one portion of it, linseed oil, is separated and sold at from £25 to £30 per ton, while the residuum, oil-cake, has always a ready market at from £8 to £10 per ton. Even the seed capsules or bolls have a certain feeding value, and should always be given to the cattle; while by the last of the processes of preparation described—that of dissolving out the extractive matter by water, instead of destroying it by fermentation—the whole of the dried juices are rendered directly available and valuable for feeding purposes, the woody centre, or "shove," alone remaining unused, and this also may be utilized as fuel material.

When the crop is grown for both seeds and fibre, and allowed to come to full maturity before being harvested, the straw averages about two-thirds of the entire weight of the crop, and the seed-capsules about one-third. These latter again are separated for use by the winnower, when the seeds generally give about three-fourths, or from 70 to 80 per cent., and the "bolls" one-fourth, or from 20 to 30 per cent., by weight of the produce operated upon.

The proximate composition of various specimens of flax-seed is thus given:—

	1. Riga.	2. Memel.	3. Blk. Sea	4 English	5. English	6. English	7. English
Oil,	34·70	36·00	38·42	36·66	32·77	33·50	38·11
Organic compounds contg. Nitrogen, [1]	50·60	51·70	45·82	48·33	52·93	52·84	49·29
Water,	9·45	8·74	10·12	12·33	11·00	10·58	8·57
Ash,	5·25	3·56	5·64	2·68	3·30	4·08	4·03
	100·00	100.00	100·00	100·00	100·00	100·00	100·00
[1] Percentage of Nitrogen,	3·60	3·33	3·31	4·60	4·28	4·25	4·29

The mean results of the analysis of these samples are—

	Foreign (3).	English (4).
Oil,	36·37	34·76
Organic compounds containing Nitrogen,[2]	49·41	51·10
Water,	9·44	10·62
Ash,	4·78	3·52
	100·00	100·00
[2] Percentage of Nitrogen,	3·41	4·33

The ash or inorganic matter contained in the seed averages between 3 per cent. and 4·5 per cent.; in the straw about 5 per cent. Its composition varies with the country and soils in which the samples examined have been grown. The following is the mean of several analyses by Johnston, Kane, and Way:—

	Seed.	Seed.	Straw.
Potash,	24·45	34·17	11·78
Soda,	3·17	1·69	11·82
Lime,	13·95	8·4	14·85
Magnesia,	9·86	13·11	9·38
Oxide of Iron,	1·87	0·5	7·32 with alumina.
Phosphoric acid,	38·06	38·54	13·05
Sulphuric acid,	1·54	1·56	3·19
Silica,	5·7	1·45	25·71
Chlorine,	0·51	0·36	...
	[1] 99·44	[2] 100·00	[3] 100·00

The evidence which these analyses give us is of less direct value to us in an agricultural, than indirectly in an industrial point of view. They show us, it is true, that the seed possesses a high nutritive value, but that it also contains a large proportion of oil, which, although an important part of its composition, is far more valuable for other purposes than for consumption as an article of food. Both theory and practice lead us to assign a certain value to oily compounds, when given to animals in small quantities. The flax-seed, or linseed, as it is more commonly called, however, contains them in larger proportions than animals can generally assimilate, and consequently a portion passes through the animal in an undigested state, and is at any rate useless as food, even if it does not, by its presence in excess in the stomach, so derange the digestive functions as to act as a direct purgative, and thus reduce the condition of the animal. If linseed be given therefore in its normal state, it ought always to be administered in comparatively small quantities, and mixed with some other alimentary substance deficient in oily compounds, so as to restore the balance between the two great principles of nutrition—the flesh-

[1] and [3] By Kane and Johnston. [2] Way.

forming and the respiratory and heat-giving compounds (see vol. i p. 2)—and thus sustain the animals in good health and condition. For this purpose beans, or any of the other leguminous seeds (peas, lentils, vetches, &c.), are well adapted. These all contain the nitrogenized compounds in excess, and need some compensating fatty or oily compounds to supplement their deficiency, and thus develope their full feeding values. Besides these physiological points, the money view is certainly unfavourable to the consumption for feeding purposes of an article—and that, it must be recollected, in the proportion in which it exists in linseed, of very questionable service—so costly as linseed oil, when by disposing of the linseed itself, for the extraction of this oil, the residuum, linseed-cake, in itself a more valuable substance for general consumption, can be obtained, and a profit made by the transaction.

Having now before us the chemical composition of the crop, it will be well to see how far the character, so generally attached to it, of being an *exhausting crop*, as it is termed, is justified by the evidence which chemistry places at our disposal. Having already discussed the meaning and true agricultural value of an exhausting crop (vol. i. p. 369), we will now, for our present purpose, assume an average crop to yield 20 bushels of seed and 2 tons of straw, and we shall find that, supposing the entire crop were sold off the farm, it will take away with it about 250 lbs. of mineral substances in the proportions already given, or about the same, both in quantity and in fertilizing value, as would be removed by an average crop of wheat, barley, or beans. In flax-growing districts, however, the crop is rarely sold altogether off the farm; the seed, or a great part of it, is kept for feeding purposes, and the straw is very commonly steeped and prepared by the grower, and the scutched fibre only sent to market, and thus lost, in a manurial point of view, to the farm. The fibre thus removed, including the tow and pluckings, never exceeds 10 per cent. on the original weight of straw, and according to some experiments made some six or eight years ago by Dr. Hodges, for the purpose of ascertaining the relative proportions of the produce of flax, and also of the distribution of the inorganic matter in them, carries away with it but a very small portion of the mineral substances abstracted by the growing crop from the land. The flax experimented upon by Dr. Hodges had been steeped in the ordinary way, and was found to contain 1·73 of ash. Of this undried steeped straw 4000 lbs. weight was taken, which produced—

Of dressed fibre..............	500 lbs.
Fine tow	132
Coarse tow..................	192
	824 lbs. of fibre altogether.

These several products were duly examined and found to contain—

In the dressed fibre.........	4·48 lbs. of ash.
Fine tow....................	2·08
Coarse tow	2·56
Or, in the whole 824 lbs. of the fibre,	9·12 lbs. of inorganic matter;

so that of the 69·20 lbs. which were contained in the 4000 lbs. weight of steeped straw operated upon, only 9·12 lbs. were carried off in the market fibre, the rest being left on the ground in the refuse portion of the crop. Now, as the straw generally loses about two-fifths of its original weight by steeping, these data of Dr. Hodges would show that if the fibre only were sold off the farm, the quantity produced from a crop of flax yielding 2 tons of straw to the acre would not take with it more than about 5 lbs. of inorganic or mineral matter, a quantity too small to exert any appreciable effect, for good or for bad, upon the fertility of any soil.

The extraction of the oil, resulting in the manufacture of linseed or oil-cake, and the large and increasing consumption of it in this country, has invested this portion of the subject with an interest and importance which it does not possess in any other country. The treatment the seed undergoes in the manufacture is very simple. It is merely crushed and submitted in that state to a very high pressure, by which the oil, or rather a portion of it, is expelled, and the solid portions remain in the shape of compressed hard cake. The relative proportions of the two, the oil and the cake, depend of course on the quality of the seed, and the efficiency of the process—the crushing and the pressing. In no case, however, is it mechanically possible to extract the whole of the oil; on the average, about two-thirds to three-fourths, or 66 to 75 per cent., are pressed out, and the remaining portion, one-fourth to one-third, or 25 to 33 per cent., left in the cake.

Of the samples of foreign seeds already referred to in the analysis given, the importer and crusher, an intelligent and reliable authority, gives the following as the trade produce of the several samples:—

No. 1. Riga, of average quality, weighing 52½ lbs. per bushel, would produce from 90 to 95 lbs. of oil per quarter, or equal to 22 per cent., whereas it contained by analysis 34·7 per cent.

No. 2. Memel, good quality, weight 56 lbs. per bushel, would produce from 100 to 105 lbs. of oil per quarter, or equal to 22·8 per cent., whereas it contained by analysis 36 per cent.

No. 3. Black Sea, weighing 53¼ lbs. per bushel, would produce about 112 lbs. of oil per quarter, or equal to 26·3 per cent., the analysis showing 38·42 per cent.

Thus in neither case do we find that more than two-thirds of the oil naturally existing in the seed is expressed by the manufacturing process to which it is submitted, the remaining one-third forming a portion of the residual cake, and adding materially to its value for general feeding purposes.

Oil-pressing and the manufacture of oil-cake is carried on to a considerable extent in this country. Foreign seed is mostly operated upon, the small quantity of seed grown in this country being either consumed directly for feeding purposes, or used as seed, for which a good market price is always obtained.

Besides the "cake" made in this country, a large quantity is annually imported from the Continent and from America; France, Holland, Belgium, Italy, Germany, and the Baltic ports furnishing the chief supplies, and giving the particular designation by which the "cake" is known in the markets. All these various oil-cakes are liable to differ both in their commercial and in their real feeding values. The English, though made from foreign-grown seed, is generally preferred by buyers and feeders of stock, and is always quoted at a higher price in the market. The percentage composition of the different samples, as is shown by the following tabulated series of analyses, is subject to considerable variation—the home-made averaging a smaller proportion of nitrogen compounds, and a larger proportion of oil, than either of the others. This difference alone is not, however, sufficient to account for the preference it commands in the market. Independently of its chemical constituents, it possesses other advantages. The flavour, both as regards taste and smell, of home-made cake is generally sweeter and more agreeable to stock, and for this reason is more highly appreciated than cakes possessing a more or less rancid taste or smell. It is not difficult to account for this superiority. On the Continent the linseed is exposed to a greater pressure than in England, and the extraction of the oil is commonly aided by means of an increased temperature. This, though not uncommon in England, is never carried sufficiently high to affect the flavour of the substance. It is always carefully regulated, and both the products—the oil and the cake—testify, by their superior quality, to the policy of the practice. Again, home-made cake is prepared only to a comparatively limited extent, and meets with such a ready sale as to insure its consumption before the large proportion of oil left in the cake has time to become rancid, or any of the changes noticeable in the foreign cakes have time to manifest themselves. The foreign cakes, on the contrary, having to pass through several hands before they reach this market, frequently attain a considerable age before they meet with a sale, and the oil, having been exposed to a considerable temperature at the time of pressing, is certain to become more or less acted upon by the oxygen of the air, and consequently rancid. In addition to this constant cause of the bad flavour or smell met with in foreign samples, they are too often kept badly stored, in damp and ill-ventilated places, before shipment; the long sea voyage frequently causes them to heat, and sets up an incipient fermentation, all of which tell considerably against their general quality and value.

The following tabulated series of analyses by Mr. Way,[1] ot a large number of samples of foreign as well as home-made cakes, shows the difference that exists in their more important constituents—those, in fact, by which the value of the compounds is usually calculated:—

Table I.—Analyses of French Oil-cake.

	Nitrogen.	Calculated Nitrogen compounds	Oil.	Water.	Ash.
1.	4·58	28·62	9·77	6·96	21·62
2.	3·98	24·87	7·45	7·48	22·66
3. Dunkirk,...............	4·63	28·94	10·12	7·20	8·72
4. Tréport,................	4·72	29·50	10·16	7·32	7·61
5. Bordeaux, ...	4·61	28·81	9·99	8·16	8·08
6. Marseilles,............	4·59	28·69	9·67	8·59	7·02
7.	4·96	31·00	8·40	7·85	7·25
8.	5·72	35·75	7·89	8·31	7·66
Mean percentage, ...	4·72	29·50	9·06	7·60	7·89

[1] *Roy. Agri. Soc. Jour.*, vol. x. p. 479.

The composition of the series appears to be pretty uniform, if we except the two first, which, from the percentage of ash left, must have been adulterated purposely with some mineral matters, for the purpose of increasing the weight. This form of adulteration is very rarely met with in oil-cakes, all the samples of foreign flax seed contain, however, a proportion more or less large of other seeds, which no doubt act disadvantageously upon both products—oil and cake. These, however, though they lower the feeding value of the cake, can only be detected by careful microscopic examination, the proportion of ash not being increased by their presence.

TABLE II.—ANALYSES OF GERMAN AND DUTCH OIL-CAKE.

	Nitrogen.	Calculated Nitrogen compounds	Oil.	Water.	Ash.
9. German,	4·84	30·25	10·62	7·54	9·03
10. ,,	4·85	30·31	8·58	8·11	8·54
11. Dutch,	4·26	26·62	10·33	8·29	11·11
Mean percentage,...	4·65	29·06	9·84	7·98	9·56

TABLE III.—ANALYSES OF RUSSIAN OIL-CAKE.

	Nitrogen.	Calculated Nitrogen compounds	Oil.	Water.	Ash.
12. Russian,	5·00	31·25	11·83	8·84	8·67
13. ,,	5·28	33·00	11·89	8·92	8·11
Mean percentage,...	5·14	32·12	11·86	8·88	8·39

TABLE IV.—ANALYSES OF ITALIAN AND SICILIAN OIL-CAKE.

	Nitrogen.	Calculated Nitrogen compounds	Oil.	Water.	Ash.
14. Genoa,	4·82	30·12	12·34	8·77	8·37
15. ,,	5·35	33·44	11·32	9·29	6·39
16. Sicilian,	4·40	27·50	6·60	8·97	8·33
17. ,,	5·04	31·50	7·00	9·96	7·51
Mean percentage,...	4·88	30·47	9·32	9·25	7·78

TABLE V.—ANALYSES OF AMERICAN OIL-CAKE.

	Nitrogen.	Calculated Nitrogen compounds	Oil.	Water.	Ash.
18.	4·58	28·62	13·04	7·63	6·49
19.	4·10	25·62	13·57	9·51	7·56
20.	5·25	32·81	10·71	6·56	5·76
21.	4·63	28·94	11·49	7·53	5·67
22.	4·91	30·69	7·45	8·81	6·04
23.	4·85	30·31	11·51	7·06	7·15
24. New Orleans,.......	4·85	30·31	12·11	6·09	5·78
Mean percentage,...	4·74	29·62	11·41	7·60	6·35

TABLE VI.—ANALYSES OF ENGLISH OIL-CAKE.

	Nitrogen.	Calculated Nitrogen compounds	Oil.	Water.	Ash.
25.	3·92	24·50	16·55	8·23	6·18
26.	4·23	26·44	13·43	8·66	6·92
27.	4·99	31·19	13·88	8·83	6·90
28.	5·08	31·75	13·34	9·38	8·04
29.	4·90	30·62	14·33	8·10	7·54
30.	4·51	28·19	10·05	9·25	6·94
31.	3·93	24·56	16·10	10·26	5·45
32.	4·29	26·62	11·28	7·20	9·63
33.	4·62	28·87	15·32	7·51	6·04
Mean percentage,...	4·57	28·56	13·52	8·60	7·27

TABLE VII.—MEAN COMPOSITION OF THE VARIOUS SAMPLES EXAMINED FROM THE DIFFERENT COUNTRIES SPECIFIED.

	Nitrogen.	Calculated Nitrogen compounds	Oil.	Water.	Ash.
French,...... 8 samples,	4·72	29·50	9·06	7·60	7·86
German and Dutch, ... 3 ,,	4·65	29·06	9·84	7·98	9·56
Russian, ... 2 ,,	5·14	32·12	11·86	8·88	8·39
Italian and Sicilian,.. 4 ,,	4·88	30·47	9·32	9·25	7·78
American,.. 7 ,,	4·74	29·62	11·41	7·60	6·35
English,..... 9 ,,	4·57	28·56	13·52	8·60	7·27

These analyses are valuable and interesting in several respects. They show—

1st. That the percentage of nitrogen compounds, or flesh-forming constituents, in all the varieties of linseed cake, is about the same as that contained in peas and beans; therefore, for the purpose of laying on flesh in feeding or working animals, they may be considered as equally valuable with those grains.

2d. That for the purpose of fattening, linseed-cake is superior to these and to our other grains, and, indeed, to all other kinds of vegetable food, with the exception of oily seeds.

3d. That samples of cake are liable to considerable variation, both in the percentage of nitrogen, or flesh-forming compounds, and of oil, which they contain.

4th. That, as a rule, the English-made cakes contain the largest proportions of oil, and the foreign-made cakes the largest proportions of nitrogen compounds; the one being considered the best as far as the production of fat is concerned, as in feeding animals—the other where the production of flesh is the principal object, as is the case in young or growing stock.

And, lastly, that the English or home-made cake is generally more carefully made, in a better condition, and more palatable to animals, than that met with in our markets as coming from either of the countries named.

In a recent paper[1] by Dr. Anderson, "On the Composition and Qualities of different kinds of Oil-cake," he gives us results of a series of analyses conducted in his laboratory, combined with some valuable statistical details and practical observations, especially in reference to linseed-cake. The importance of the question is at once seen from the returns of "seed" and "cake"[1] annually imported into this country, and consumed for feeding purposes, by which it will be seen that within the last ten years the importation of cake has increased about 35 per cent., while that of the linseed itself has become

[1] *High. Soc. Trans.*, 1860, p. 234.

very nearly double in the same time. In estimating the quantity of linseed "cake" annually consumed in this country, Dr. Anderson says, in reference to the large quantities in seed imported, that "it must be borne in mind that linseed is used for other purposes besides those of the oil-crusher; but the quantity diverted to these uses is not large, and I have ascertained, from the best information at my command, that the flax seed grown in this country, and of which no account is taken in these calculations, will be sufficient to cover all that is used for seed, in medicine, &c., leaving the whole of that imported free for the manufacture of cake. At 53 lbs. per bushel, which is rather a low average, 1,001,552 quarters of linseed (the average imports of the last four years) must weigh 189,568 tons, which, allowing 25 per cent. for loss of weight in the process, must yield 142,156 tons of cake, which, at the average price of £9 per ton, must be worth £1,279,404." According to these figures, then, the following will be a good approximative statement of our annual consumption of linseed-cake, and its cost:—

From 85,952 (average of last four years) tons of imported cake of all kinds, deduct 25 per cent. for rape and other imported cakes, which leaves 64,464 tons, at £8,	£515,712
142,156 tons of home-made cake, at £9,......................	1,279,404
	£1,795,116

[1] Quantity of Oil-cake imported.

1848,.........	73,029 tons.
1849,.........	59,462 ,,
1850,.........	65,055 ,,
1851,.........	55,096 ,,
1852,.........	53,616 ,,
1853,.........	64,475 ,,
1854,.........	76,230 ,,
1855,.........	80,659 ,,
1856,.........	83,256 ,,
1857,.........	99,265 ,,
1858,.........	80,269 ,,

Quantity of Linseed imported.

1848,.........	799,650 quarters.
1849,.........	626,495 ,,
1850,.........	608,984 ,,
1851,.........	630,471 ,,
1852,.........	799,402 ,,
1853,.........	1,035,335 ,,
1854,.........	828,513 ,,
1855,.........	756,951 ,,
1856,.........	1,180,180 ,,
1857,.........	1,051,113 ,,
1858,.........	1,017,844 ,,

The oil-cakes include that made from rape and other oil-seeds. These probably amount to about 25 per cent. of the whole quantity.

It must be recollected that these statistics have reference to linseed-cake alone; besides which the consumption of other oil cakes, as "rape," "cotton-seed," "earth-nut," and others, is increasing in even greater proportion. Each year our farmers have to rely more and more on these important food-substances for the manufacture of the beef and mutton we require for our consumption, and for the supply of manure they require for their crops; for, even in a manurial point of view alone, the fertilizing value of the imported food would follow very closely on that assigned to the purely manuring substances themselves. No facts are better calculated than these to impress upon us the importance of a proper knowledge of the composition and characteristic qualities of the different kinds of oil-cakes we meet with in the markets, without which, indeed, our purchases must always be made at a great disadvantage. Opportunities frequently occur for purchasing oil-cake of different kinds at prices considerably below their real food value; while, on the other hand, cakes and other feeding substances are introduced to the markets at prices far beyond what they are actually worth.

Dr. Anderson's paper gives the results of his investigation of the whole series of oil-cakes known in our markets, and is well worth the careful perusal of all interested in stock-feeding experiments. His observations on the oil-cake, the produce of our present subject, the "Flax Crop," not only form the most recent of our numerous contributions to the same subject, but are so clearly and intelligibly expressed, that we cannot do better than give them in his own words:—"Linseed-cake, which is the staple, and much more extensively consumed than any others, when of good quality, differs but little in composition. The average composition, deduced from a large number of analyses, may be taken as follows:—

Albuminous (*nitrogen*) compounds,	28·53
Oil,	12·47
Mucilage, sugar, &c.,	35·78
Fibre,	6·32
Ash (*mineral matter*),	6·11
Water,	10·79
	100·00

The ash contains—

Earthy phosphates,	2·92
Phosphoric acid combined with the alkalies,	0·38

Particular samples vary to some extent from this standard, but the difference is not very large, and chiefly affects the proportion of oil, which is generally rather lower in British-made cake, owing to the superiority of the machinery used in the oil-mills of this country. When the oil is low, it will generally be found that the albuminous compounds are above the average. In judging of the value of any cake, attention must be directed to the oil and albuminous substances in the first instance, but it is also important to observe that the fibre and ash should not be large. An excess of the former generally indicates the presence of some foreign matter, and of the latter, that the cake has been made from dirty seed, probably containing a quantity of sand, and in that case it is objectionable, from its tendency to produce intestinal irritation in the animals fed on it. In estimating the value of any sample, however, it will not do to rely exclusively on the analysis, for instances occur in which a cake may have a composition but little different from the average, and yet be of inferior quality. A remarkable instance has lately come under my notice, in which a sample, giving the following results, was analyzed:—

Albuminous compounds,	27·75
Oil,	9·30
Mucilage, sugar, &c.,	35·93
Fibre,	5·25
Ash,	12·73
Water,	9·04
	100·00

On examining the sample, it was at once apparent that notwithstanding these results it was extremely impure, and contained a large quantity of grass and other seeds, amongst which I detected some grains of what appeared to be blighted rye. Owing to the general similarity in composition of many kinds of seeds, it is perfectly possible that an oil-cake may be adulterated to a very considerable extent without its being apparent in the analysis, and hence it is necessary to submit the sample to a very careful examination before forming an opinion on this point. The question of the adulteration of linseed-cake is considerably narrowed by an important commercial consideration. It yields an oil distinguished by its tendency to harden into a solid varnish, and hence is called a "drying" oil; and it is impossible to adulterate this oil with any other without producing such a deterioration of its characteristic properties as to be immediately obvious. Hence linseed oil-cake is never adulterated with any other kind of oil-seed; but when an admixture occurs, it is usually with some cheap non-oleaginous seed, and most generally with grass seeds. In the great majority of instances in which this occurs the seeds have not been added as a deliberate adulteration, but are due to the careless cultivation of much of the linseed used abroad. It is difficult, of course, to form an opinion as to where inferiority due to dirty seed ceases and positive adulteration begins, nor is the determination a matter of much importance in a practical point of view. In judging, therefore, of the goodness of a cake, attention must be paid to its general appearance. It should be a hard, well-pressed cake, with no tendency to split into layers. Its colour should be reddish, and when broken across its appearance should be uniform, and the smooth and glistening outer coat of the seed should be apparent. It should then be carefully examined for foreign seeds. Among these are frequently found small black seeds, which are hard, and have not been broken in the mill. These are often considered by the farmers to be injurious to the cattle; but it does not appear that this opinion is well founded, for they belong to various species of *Polygonum*, a genus which is not poisonous. They are objectionable, no doubt, because they are not digestible; and as they are so small that no difficulty would exist in separating them from the linseed, they are an indication of dirty seed; and where they are abundant it is not uncommon to find that the proportion of sand also is large. Grass seeds, fragments of flax straw, and of the capsule in which the seed was contained, may all occasionally be observed, and when they are abundant, should be noticed.

As far as possible some judgment should be formed as to the proportion in which these substances are present; and as grass seeds resist to a considerable extent the crushing process, they may with a little patience be picked out in considerable quantity. Some of the cake should then be reduced to powder, and mixed with cold water, when it ought to form a thick and firm paste; and if they be used in the proportion of 100 grains of cake to 1 oz. of water, the paste should be so stiff as to retain the form into which it is made. This character is of great importance, because almost every other seed which can be used as an adulterating substance diminishes the stiffness of the paste; and the only other substances which possess a sufficiently mucilaginous character are oily seeds, which cannot well be mixed with it. The general appearance of the paste, its peculiar odour and colour, are also characteristic.

Of more strictly chemical tests there are few to be relied upon. One of the best is to mix a small quantity of the paste with a dilute solution of caustic potash. If the fluid acquires a yellow or a green colour something is wrong; but, on the other hand, adulterating substances may be used which fail to give any indications with potass. While attention to these points will enable the observer in many instances to detect the inferiority of an oil-cake, it is no unfrequent occurrence to find specimens in which the eye detects nothing amiss, but which analysis shows to be inferior. Not long since I examined a sample which was particularly well pressed, was in remarkably neat cakes, and showed to the naked eye not the slightest appearance of foreign seeds, but analysis proved its composition to be as follows:—

Albuminous compounds,	21·35
Oil,	9·01
Mucilage, sugar, &c.,	39·96
Fibre,	9·36
Ash (mineral matter),	9·51
Water,	10·81
	100·00

The small proportion both of oil and albuminous compounds in this sample is remarkable, the latter being as much as 7 per cent. below the average. It was afterwards so far explained by information I received, that, at the mill where it was made, it was the practice to mix with the linseed a small quantity of bran or 'thirds,' not as an adulteration, but because it had been found that the seeds pressed better and gave a larger yield of oil. On examination with the microscope, I found that it did contain some granules of starch, apparently of wheat, but the quantity was not large; and I can scarcely imagine that this was the sole cause of the small proportion of albuminous compounds."

In reference to the chemical investigation of linseed-cake, Dr. Voelcker tells us that the ash which remains behind on burning should not create much effervescence when mixed with an acid. If a strong action takes place, it would show the presence of carbonates in greater proportion than good cake should contain, and would indicate the probable adulteration of the cake with substances containing woody fibre. Good cake gives an ash containing a small proportion of carbonic acid, but a large proportion of phosphoric acid, potash, and lime. Thus linseed-cake contains in considerable proportions those elementary bodies necessary to build up the bony structure of the animal body, as well as afterwards to clothe it with the desirable amount of flesh and fat. The manurial value of linseed-cake is better seen in its inorganic constituents, though the organic composition, containing, as it does, such a large percentage of nitrogen, adds greatly, without doubt, to its efficiency. These inorganic constituents have been determined by Mr. Way as follows:—

	20. American Cake.	21. American Cake.	12. Russian Cake.	13. Russian Cake.
Potash,	24·32	23·50	16·01	22·90
Soda,	0·93	0·51	0·43	0·01
Lime,	9·04	7·87	5·60	7·52
Magnesia,	15·33	15·27	9·35	15·43
Peroxide of Iron,	2·62	3·28	1·45	1·60
Phosphoric acid,	33·43	28·02	25·52	34·91
Sulphuric acid,	2·38	5·29	1·23	1·63
Carbonic acid,	6·88	1·64	0·26	0·19
Silica and Sand,	9·08	12·86	39·10	14·41
Chloride of Sodium,	1·06	1·87	0·85	0·42
	100·09	99·11	100·00	100·02

THE HEMP CROP.

Among the plants cultivated for *special purposes* in this country, we have two—the Hemp and the Hop—both belonging to the same order—Urticeæ—but occupying very different positions as regards their importance as farm crops. Although the consumption of hemp has greatly increased during the present century, its cultivation, which was never carried on to any large extent, has gradually diminished, and now is only to be met in a very few districts, and then only to a very limited extent. A supply of hemp for textile and cordage purposes is a matter of necessity to all maritime countries, and must be furnished either by home production or importation from abroad. In former times, though our requirements were less, our sources of supply were far more limited; consequently we were forced to rely more upon our own home powers of production, and hemp was looked upon as one of our regular crops. At the present day our wants are enormously increased, while at the same time our powers of supplying them are augmented; the range from which we can draw what supplies we require is greatly extended, and our modes of communication and of transport are equally facilitated. Another point bearing on the diminished cultivation of hemp is, that it is a native of a warmer climate than our own; and although sufficiently hardy to be grown successfully in this country, its development is comparatively limited, and it never reaches the dimensions which it assumes in Italy and the southern countries of Europe or in the East.

The early history of hemp is not so well recorded as that of flax. Although it was known to the ancients, it does not appear that they were acquainted with its properties as a fibre-producing plant. Columella tells us that it delights to grow in a fat, dunged soil, and in a watery soil, or plain, and moist, and deeply digged. Dioscorides and Galen describe the plant, and detail its various medicinal uses. Herodotus also speaks of the plant as having been seen by him growing wild in Scythia (North Danubian provinces) when he visited that country. Pliny, who speaks of the plant in his *Natural History*, says not a word of this property, but contents himself with extolling the virtues of its stem, leaves, and roots. In fact, what some writers on Roman antiquities remark, that the hemp necessary for the use of war was all stored up in two cities of the western empire, Ravenna and Vienna, under the direction of the two procurators, called *procuratores linificii*, must be understood evidently as referring to flax, and not to hemp.

Hemp is supposed to be originally a native of the warmer parts of Asia, its wild locality extending from Syria to the mountains of India, in all of which districts it is met with at the present day in a natural state. Roxburgh found it growing wild in great abundance among the mountainous districts of North India, and also as a common plant in the gardens of the natives of that part of Asia. It is now to be met with, both in a wild and in a cultivated state, largely distributed over the milder climates of Europe, in most of which countries it is grown both for its fibre and for its seeds. In eastern countries the plant is valued not only for its fibre and for its seed, but a third product is obtained from it in the shape of an intoxicating drink. The leaves are stripped off the stems, and are subjected to a slight fermentative action, as in the preparation of tobacco. They are then dried, powdered, and, mixed with some favourite aromatic, are infused in water, their narcotic qualities exerting a peculiar and powerful action upon the nervous system, the effect produced being said to be similar to that ecstatic feeling produced by the action of opium. The dried leaves are also mixed with tobacco, and used for smoking.

The plant being an annual, and not cultivated for the sake of substances which, like starch or sugar, generally demand a long season for their production, is perfectly adapted to this climate, Lindley tells us, notwithstanding its eastern origin. All that it is required to do here is to grow freely and to form an abundance of stems, from which the natural fibre can be extracted; and the ordinary climate of the summers of Great Britain is quite sufficient to secure this. But we look in vain in English-grown hemp for the narcotic, stimulating, and intoxicating properties which are so marked in the same plant grown in Syria and in India. In those countries, as the plant approaches maturity, a resinous secretion, having a heavy, unpleasant odour, issues from the hairy stomata of the stems and leaves. In this secretion resides a powerful narcotic principle, analogous in its effects to that of "nicotine," the active principle of tobacco. This resin exudes in India from the leaves, flowers, and slender branches of the plant. When collected into masses, it forms the *churras* or *cherris* of Nepal. Its odour is fragrant and narcotic; its taste slightly warm, bitter, and acrid.[1] Linnæus speaks of its "*vis narcotica, phantastica, dementius, anodyna, et repellens.*" The Turks employ it under the names of *hadschy* and *malach.* The Arabs are acquainted with its properties, and name it *hashish.* The Brazilian savages delight in its use. Even the Hottentots use it to

[1] *Pharmac. Jour.*, vol. i. p. 489.

get drunk with, and gave the name of *dacha* to it. To use the elegant language of Endlicher, "*Emollitum exhilarat animum, impotentibus desideriis tristem stultam lætitiam provocat, et jucundissima somniorum conciliat phantasmata.*" With us, as in other similar climates, such secretions, though the results of the natural functions of the plant growing under its natural conditions, rarely are formed; and hemp may be fairly taken as an example of the inutility of attempting to cultivate profitably, except under very special circumstances, the produce of climates materially different from our own. It has been surmised that the hemp of India is a different species from that cultivated in Europe. Such, however, is not the case. The only difference between them is that which results from the effects of climate and soil on their continuous cultivation.

Botanically, the hemp belongs to the natural order URTICEÆ—Nettleworts—from which, however, it has been separated by Endlicher and other botanists, and formed into a sub-order, termed CANNABINEÆ, which consists only of two genera—hemp and hops—both of which enter into cultivation in this country as farm crops. There is only one species of hemp—the *Cannabis sativa*—an erect-growing plant, attaining the height of 5 or 6 feet in this country, but in more favourable climates frequently doubling these dimensions. Indeed, Thaer,[1] on the authority of Crud, states that in favourable soils it is frequently seen growing to the height of 15 and 18 feet. Hairs are scattered somewhat sparingly over its surface, from which the peculiar resinous substance already alluded to exudes. The leaves are completely divided into five narrow, taper-pointed, rough, serrated fingers or lobes. The most marked feature in the plant, in an agricultural point of view, is that it is *diœcious*, some plants being

[1] Von Thaer, *Principes Raisonnécs d'Agri.*, tome x. p. 289.

male and others female. The flowers of the *male* plants are arranged in loose panicles, and consist of five small sepals, including as many stamens. In the *female* plants the small green flowers are scarcely distinguishable from the tufts of leaves amidst which they grow. Each flower consists of a narrow scale rolled round a minute ovary, terminated by a couple of glittering thread-like stigmas. When properly impregnated and matured, this ovary becomes the well-known grain or seed-vessel called hemp-seed, a favourite food of poultry and small birds. The seed itself inclosed with the grain contains a large percentage of a fixed oil, soft and tasteless in itself, which, when expressed, is used for lubricating purposes, or for mixture with other oils—the residuum forming an oil-cake, largely used in some districts for cattle-feeding, and generally quoted in the market-lists at about the same price as the other second-class cakes.

The soils best suited for hemp are those containing large proportions of organic matter, especially if they lie low and are inclined to moisture. The deep, rich, alluvial soils of our marsh lands would probably be better adapted for hemp-growing than for the cultivation of any other of our seed-bearing crops. Loams even of the strongest class, provided organic manner be present naturally, or supplied plentifully in the shape of well-rotted dung, will carry good crops. Old pasture lands, when broken up, give a produce satisfactory both in quantity and quality to the grower; and even peat lands, bogs, and morasses, if the surplus water be carried off by intersecting drains, may be generally cultivated successfully with hemp, provided the climate of the district be suitable to it. In all soils which are too rich for flax, or on which the cereals would be likely to run too much to straw, and be weak and liable to be laid, hemp may be sown with propriety; but upon the drier class of soils—as gravels, sands, the thin soils of the chalk formation, or, indeed, any others deficient in moisture and in organic matter—it is never advisable to attempt its cultivation. In the rich, irrigated districts of Lombardy and Tuscany, the cultivation is carried on under the most advantageous conditions. There it becomes one of their most important crops, and occupies a regular position in their farming system. With us it is now so sparingly cultivated that it excites but little attention anywhere, and is entirely limited to those districts where the particular class of soils in which it delights is met with. These soils, either alluvial or humous in their character, are chiefly met with in Lincolnshire, Notts, and Cambridgeshire, and on these, during the early part of the present century, hemp was grown to a considerable extent, and even now may here and there be seen in cultivation as a field crop at the present day.

Although we can hardly assign any distinct place in the regular rotations of our improved systems to a crop which occupies the ground so short a period, and which is cultivated to so limited an extent as hemp, still, from the habit of growth of the plant and its food requirements from the soil, we should consider that it might properly both follow and precede a straw crop; or, if the land were deficient in organic matter, it might with equal propriety follow a root or forage crop fed off on the land. The preparation of the land is very similar to that recommended for flax. If it succeeds a straw crop, autumnal cultivation should be carefully attended to, and the land left with a good deep-shouldered winter furrow. In the low-lying districts, where hemp is usually grown, the land requires early attention in the spring, in order to get rid of the water with which so often, even in drained districts, it remains charged during the wet season. Although hemp delights in a moist soil, still any stagnant water is as injurious to it as to other cultivated plants. This must be carefully provided against, and the land got into good tilth by cross ploughing, rolling, and harrowing, as may be considered advisable. The manure may be applied before the winter ploughing, or in the spring, as may be most convenient to the farmer, care being taken that, if applied in the spring, it be in a well-fermented state, so as to mix readily with the soil, and furnish a good supply of food to the young plants in an assimilable condition. If the manure be applied before the winter ploughing, it may be used in a fresh state; in that case, a proportionably larger quantity must be used. For this purpose nothing is so good as farmyard dung, of which a liberal dressing should be given—say from 15 to 25 tons of fresh dung in the autumn, with a top-dressing at the time of sowing of from 2 to 5 cwts. of Peruvian guano; or from 10 to 15 tons of well-rotted dung in the spring, with the same proportions of Peruvian guano, mixed and distributed in the manner described at pages 302 and 420, vol. i.

The same care should be taken in cleaning the land intended for hemp as in preparing for the flax crop. Hemp, however, has this advantage, that if the land be clean at the time of sowing, the growth of the young plants is so rapid that they smother the weeds, and leave the land quite free from them; whereas the flax, a more delicate plant in every respect, has a continued struggle with them for existence, and always leaves the land more or less foul. This tendency of the hemp to keep undisturbed possession of the ground, necessitates its being sown by itself. Neither seeds nor any other crop can be sown with it, as is done so commonly with flax. In Russia, where hemp is largely cultivated as a field crop, it is a practice in some districts to grow cabbages with it in alternate rows (see page 388, vol. i.), the hemp being obnoxious to the white cabbage butterfly, and thus acting as a preservative of the cabbage crop.

The last week in April or the first week in May is considered the best time in ordinary seasons for getting the seed in the ground. If sown earlier, it is liable to injury from the late frosts of our springs; and if sown later, the early growth is too rapid, and the plants shoot up spindly and weak. The season and the state of preparation of the land must of course determine this point. With all crops, it is better to delay sowing a few days than to get them in under unfavourable conditions, either of weather or soil. From 2 to 4 pecks of good seed is ample for an acre; where more is used, it is impossible that the plants can have proper access to air and light, and their natural healthy development must be checked. It is, however, a matter of importance to see that the seed be good, as the seed used is always of foreign growth,[1] and being only a produce of secondary importance to the grower, it is too generally harvested and stored in a careless and negligent manner. Unless it had been fully matured in the pod at the time of harvesting, or been carefully exposed to the air and dried after being separated from the stem, it is, like other oily seeds, very liable to heat in the mass, and its germinative powers to be either partially or completely destroyed. The quality of the seed is generally indicated by its appearance. If it be of a bright shiny gray colour, plump and bold in appearance, of good weight, and of a sweetish taste, with a greenish yellow colour when crushed by the teeth, we may receive it as well matured and harvested, and fit for seed. If, on the contrary, these external indications be wanting, and the seed be of a dark colour and bitter taste when broken, it is most probable that it has been

[1] Riga seed is always considered the best for seed purposes.

injured by storing, and is unfitted for reproductive purposes.

The "drill" should always be used for depositing the seed. In a crop grown for fibre purposes, it is of great importance that the plants should be as uniform as possible in their growth, both as to their development and their time of maturity, in order that the resulting produce in fibre should make an even sample, which always is a matter of money importance in the market. This can never be secured so completely by "broadcasting" as by "drilling." By the former, the seeds are irregularly distributed over the surface, and deposited at irregular depths; the first influencing materially the relative growth of the plants—those having most surface area growing stouter and more vigorously than those having less, while the seeds deposited near to the surface germinate and throw up their stems more rapidly than those buried at a greater depth, the plants generally retaining their superiority during the whole growth of the crop. Where the crop is cultivated for fibre purposes only, the quantity of seed per acre should be less, and the drills be drawn at less distances apart, than when grown for the double produce of fibre and seed, which, indeed, is the common practice. The spaces between the rows should not be less than from 15 to 18 inches for either fibre or seed purposes. A plant possessing the vigorous habit and rapidity of growth of the hemp requires good access to light and air, to enable it to digest properly and elaborate into its own structure the food materials it has obtained from the richly manured soil in which it is grown. At less distances than 15 to 18 inches these necessary conditions cannot be secured to it, and the plant must suffer in proportion.

The seed, which germinates very rapidly, should be deposited as near to the surface as possible, especial care having been taken in the preparation of the land that the seed-bed be in fine tilth, and well supplied with food for the early growth of the crop. After the harrows have covered in the seed, a light roller should be run over the surface to complete the operation, and then the field must be carefully protected against the depredations of small birds for some days after the plants have fairly appeared above the ground. When the young plants have attained a height of about 3 or 4 inches above the ground, they should be "bunched" and "hand-pulled" (see page 303, vol. i.) out to distances of about 8 to 12 inches apart in the drill, the stoutest and most vigorous plants being left for the crop. It is always desirable to send in the horse-hoes between the rows before the plants get too forward, so that whatever weeds have sprung up may be destroyed, the future growth of the crop effectually keeping them from again appearing on the surface. Beyond this no other tillage operations are necessary until the period of flowering, which generally takes place in about twelve weeks after the date of sowing, and then is seen the peculiarity of the cultivation of hemp as compared with our other crops. If the crop be intended for its fibre produce only, the harvesting generally takes place as soon as the process of flowering is completed, and both male and female plants are pulled at the same time, and treated in the same manner. When, however, the double produce of fibre and seed are desired, a different method is pursued, by which the full produce of the crop is secured. The male plants are readily recognized by the difference of their inflorescence, which has already been described. When this process is complete, and the female plants have been fecundated by their pollen, the functions of the male plants have been performed, the flowers rapidly fade, the colour of the stem changes, and decay commences, while the female plants are still in full vigour, completing the process of maturing their seed. Before, however, this decay takes place in the male plants, which, if allowed to go on, would materially lessen the yield of the crop, pullers are sent in between the rows, with instructions to pull all the plants with fading flowers, taking care, at the same time, not to injure the female plants left for their seed, which have not yet reached their full maturity. These male plants are thus collected and tied in small sheaves, and either left standing in a convenient place to dry, or at once taken to the steep.

In about four or five weeks from this time the female plants have matured their seed, and are ready for harvesting. This particular period is generally indicated by the decay of the leaves, and the brownish or grayish tint of the seed-vessels. When fully matured, these have a tendency to open and cast out their contents, so that they require to be carefully watched and harvested at the proper time. This is usually determined by examining the four lower seed-pods on the stem, called by growers "elbow-seed." If these be of a dark gray colour and firm inside, and the pods or husks assuming a yellow colour, it is considered ready for pulling. In pulling the seeded hemp, care should be taken not to break the stems, and where any of the plants have been laid by the winds or rain, they should be very carefully handled, or both the seed and the fibre produce are likely to be lessened, if due precautions be not taken in the harvesting. The pulled hemp should be bound into small-sized bundles or sheaves, and left lying on the ground for a few hours with the butts spread out, so that they may become quite dry. The loose soil attached to the roots is then removed, if necessary, by a blow of a fork or stake, and the sheaves are set up in small stooks of four or six each, and left on the ground until the seed-pods are dry and ready for thrashing. They require to be carefully watched while in the field, to save them from the depredations of small birds, all of which are fond of the seed. The seed is usually thrashed out in the field, a large cloth being spread on the ground, in a suitable place for the purpose; if in proper condition, it is very readily separated, and the stems are then ready for steeping at once, or they may be stacked, and steeped in the following spring. If stacked, great care is needed in thatching, as any rain penetrating through the thatch is sure to do great injury to the fibre produce. The hemp seed, when thrashed out, requires winnowing to separate it from the portions of stem and husks, and should then be spread out thinly on the sheet or floor, and exposed to the action of the air until quite dry.

The processes by which the subsequent preparation of the fibre is effected so closely resemble those already detailed in the preceding Part—FLAX—that no lengthened description is here necessary. For the finest qualities of white hemp "dewretting" is commonly practised. The hemp is spread out on the grass, and regularly watered two or three times a day. A slow process of fermentation is set up, and in about six weeks, if the weather be suitable, the decomposition has sufficiently advanced to have effected the desired change in the straw, and the operation so far is complete.

The ordinary method of preparation, however, is by "steeping." This is usually carried on in pits or ponds, and although the same principles are involved, and the same changes take place as in the steeping of flax, the material is coarser and of less value in the market, and consequently receives far less care at the hands of the operator. It generally requires two or three weeks to complete the process, according to the temperature of the water, the exact period being determined by drawing a sample and carefully examining it. If, on drawing the thumb nail up the length of the stem to the top, the fibre slip up the stem, it has advanced far enough, and should be removed from the steep. If, however, the fibre does not part readily from the stem, it should be allowed to remain a day or two longer. When removed from the steep, it is placed in a heap or "couch" for six or eight hours, in order to drain, and is then carried to the drying and bleaching ground, where it is spread out in thin rows on the surface, and left exposed to the action of the air and rain for two or three weeks, during which time it requires to be turned over about every three days, so that it may be equally acted upon by the weather. This requires to be done carefully, in order not to twist or break the stems. It is usually performed in the following manner:—Two women, working together, place a long light pole under the heads, lift up the stems, and then turn them fairly over, the rows following each other, and occupying a different part of the surface of the drying ground at each removal. The subsequent processes of separating the fibre are similar in principle to those described in regard to flax, the only difference being in the strength of the machinery employed.

The produce of the crop appears to be liable to great variations. In the early part of the present century we find frequent mention made of it in the reports to the Board of Agriculture, especially of the eastern counties. In the Agricultural Report of Suffolk, Arthur Young speaks of it as having been grown in succession on suitable land for seventy years. In some old leases it was stipulated that the land should be sown with hemp for the last two years; in others, again, it was prohibited altogether. The seed produce is generally from 16 to 20 bushels, and of stems from 2 to 3 tons to the acre, which, on the average, would produce from 45 to 60 stones of dressed fibre. The following statements have been given of the cost and returns of the hemp crop when it was looked upon as one of our regular farm crops:—

LINCOLNSHIRE.

Produce per acre,	£10 18 6
Expenses ,,	17 11 0
Profit,	£6 12 6

CAMBRIDGESHIRE.

Produce per acre,	£13 10 0
Expenses ,,	9 16 8
Profit,	£3 13 4

SUFFOLK.

Produce per acre,	£36 17 6	£18 8 9
Expenses ,,	23 19 10	11 19 11
Profit,	£12 17 8	£6 8 10

A more recent estimate[1] of the present returns and cost of production gives a less favourable character to the crop. The debtor and creditor account is thus made out:—

DR.	Rent and taxes per acre,	£2 10 0
	20 tons of manure,	5 0 0
	3 bushels of seed,	0 15 0
	Tillages,	1 10 0
	Pulling, steeping, &c.,	1 10 0
	Taking from steep, spreading and breaking, &c.,	2 5 0
	Scutching, @ 1*s*. 6*d*. per stone,	4 10 0
	Cleaning seed, taking to market, &c.,	0 7 6
		£18 7 6
CR.	60 stones of hemp, @ 4*s*. 6*d*.,	£13 10 0
	20 bushels of seed, at @ 4*s*. 6*d*.,	4 10 0
	Value of husks, &c.,	0 15 0
		£18 15 0
	Deduct expenses,	18 7 6
	Balance of profit per acre,	£0 7 6

[1] *Roy. Agri. Soc. Jour.*, vol. x. p. 181.

When we recollect that hemp requires a soil of more than average natural fertility, richly manured, and that its cultivation differs widely from any other of our farm crops, the foregoing returns certainly do not offer any great inducements for its re-admission into our present system of cropping. Still, however, it would appear that there may exist conditions of soil and of general husbandry arrangements—take Ireland, for instance—where it may be profitably grown.[1] There, in some districts, the soils and climate are well suited to its requirements, while, owing to the difference in their harvest arrangements, the field labour would not be so disturbed by the peculiar mode and period of harvesting the hemp as it would be in this country.

We have very little information in reference to the *diseases* or *insect injuries* to which the plant is subject. The only injury to the crop which has been noticed in this country is that inflicted by a peculiar parasitic plant, a member of the family of "broom-rapes"—*Orobanche*—already referred to at page 126. These plants differ greatly in appearance, and also in their mode of attack, from the "dodders," growing parasitically upon the *roots*, and not upon the *stems*, of their victims, but both drawing their supplies of food from the juices of the plant to which they attach themselves. The broom-rapes are herbaceous, leafless plants: the *O. major* (fig. 1), which is met with chiefly

[1] The annual importations of hemp show that the demand is largely in excess of the home-grown supply, and that a ready market would be found for all that could be produced.

FOREIGN HEMP IMPORTED IN 1857:—

		Cwts.
Of dressed hemp,	. . . .	37,288
Undressed ,,	. . . .	739,938
Codilla ,,	. . . .	14,975
In all,	. . . .	792,101

Of hemp-seed also, 4727 quarters, costing £10,636, were imported the same year.

attached to leguminous plants, grows to the height of about 12 to 15 inches, the stem, which swells into a bulbous form towards the base, being of a yellowish

Fig. 1.

OROBANCHE MAJOR.

Fig. 2.

OROBANCHE RAMOSA.

colour, and closely imbricated with scales. The *O. ramosa* —branched broom-rape—(fig. 2), is found in moist rich soils, attaching itself specially to the roots of the hemp plant. It is the most elegant native species of the genus, growing about 8 to 10 inches high, with a slender branched stem, becoming quite bulbous at the base. The flowers are of a pale blue or yellowish tint, and appear in August and September.[1]

The *chemistry* of hemp does not appear to have received much attention, either on the Continent, where, however, it forms an important cultivation, or at home. We are indebted to Dr. Anderson[2] for the only reliable analysis of the organic composition of the seed we have, the old one by Bucholz generally quoted having been made at a period when the methods of conducting such analyses were extremely imperfect. The sample examined by Dr. Anderson was of foreign growth, and of the ordinary market quality. Its composition was as follows:—

Albuminous (nitrogen) compounds,	22·60
Oil,	31·84
Fibre, mucilage, &c.,	32·72
Ash (mineral matter),	6·37
Water,	6·47
	100·00

The ash contained—

Phosphates (earthy)	2·47
Phosphoric acid combined with alkalies,	·76

If these constituents be compared with those of linseed (see page 308), it will be seen that no very material difference exists between them; at all events, not more than would be compensated by a small reduction in the market price. The oil of the hemp-seed, however, is of a sweeter and far more palatable nature than that of the linseed, which would give to it a superiority for feeding purposes where the seeds were used respectively in their

[1] According to the observations of Vaucher, of Geneva, the seeds of *O. ramosa* will lie many years inert in the soil, unless they come in contact with the roots of hemp, the plant upon which that species grows parasitically, when they immediately sprout and commence their work. The manner in which the seeds of *Orobanche* attach themselves to the plants on which they feed has been observed by Schlauter. This writer states that they only seize seedlings, and are unable to attack roots of a stronger growth.—*Vegetable Kingdom*, p. 610.

[2] *High. Soc. Transactions*, 1855, p. 123.

natural state. The percentage of inorganic or mineral matter may be taken at from 5 to 6 per cent. in the seed, and at from 4 to 5 per cent. in the entire plant. The ash of the seed has been examined by Leuchtweiss[1] and by Way, and that of the entire plant by Kane and by Daubeny, the results of whose analyses are now given:—

INORGANIC CONSTITUENTS OF HEMP-SEED.

	Leuchtweiss.	Way.
Potash,	21·67	15·74
Soda,	·66	1·49
Lime,	26·71	3·56
Magnesia,	1·00	15·81
Oxide of Iron,	·77	·57
Phosphoric acid,	34·96	55·84
Sulphuric acid,	·10	1·32
Silica,	14·04	5·11
Chloride of Sodium,	·09	·56
	100·00	100.00
Percentage of ash,	5·60	4·62

Although there is a considerable discrepancy between these two analyses, still they accord in the principal features of the constituents of seeds, viz., the large proportions of phosphoric acid and of potash, and the small proportions of soda and its compounds, compared with the proportions found in other parts of plants.

The following determination of the inorganic constituents of the entire plant is the mean result of four analyses by Kane and Daubeny:—

Potash,	9·93
Soda,	·50
Lime,	42·91
Magnesia,	5·47
Oxide of Iron,	2·71
Phosphoric acid,	5·26
Sulphuric acid,	1·28
Silica,	8·20
Chloride of Sodium,	1·41
	100·00
Percentage of ash in plant dried at 212°,	4·54

[1] *Revue Scien. et Ind.*, tome iii. p. 22.

The use of hemp-seed in this country is confined chiefly to the food of cage birds, all of which are remarkably fond of it. For poultry it forms a very nutritive food, and may always be given with advantage in the spring and autumn, at moulting time. The early writers—Matthiolus and others—recommended its use for poultry, as causing them to lay eggs more plentifully. It has been used occasionally in this country for general feeding purposes, for which sometimes its comparatively low market price offers great inducements. Mr. Telfer tried it at Cunning Park, and formed a favourable opinion of its nutritive properties. At all events, now that we know its general composition, it is our own faults if we do not render the knowledge available whenever the market prices are favourable for the purpose.

THE HOP CROP.

THE HOP is a far more important member of our "Farm Crops" than the preceding plant—the hemp—which was described first, on account of its cultivation and economic application so greatly resembling that of the flax crop, which it immediately follows in the series. In this country, the hop is grown solely for its economic use in the preparation of beer, and in this form enters largely into general consumption, though it cannot claim any consideration as an article of direct food, either for ourselves or for our cattle. Although the hop plant has been known for many centuries past, its early history is somewhat obscure. No mention is anywhere made of it in the Scriptures; and notwithstanding much discussion has taken place, and many references been made to the plant by early writers, it does not appear to be very satisfactorily proved that the Greeks or the Romans were acquainted with the plant which we now call the hop.

Dioscorides[1] speaks of a plant to which he gives the name of *Smilax aspera,* the same no doubt as that described by Theophrastus[2] under the name of *Smilax,* without any epithet, and which by many writers has been considered as indicating the hop. That the description given agrees for the most part with our hops cannot be denied; but it is, at the same time, equally true that it might be applied with no less propriety to many other creeping plants, and certainly with the greatest probability to that which in the Linnean system has retained the name of *Smilax*

[1] *Dioscor.*, lib. iv. p. 244.

[2] *Hist. Plantar.*, c. iii. p. 18.

aspera. What the Greek author says of the fruit is particularly applicable to this plant; but, on the other hand, it differs widely from the fruit of the hop.

Again, in Pliny[1] we find a plant described under the name of *Lupus salictarius,* which, with more probability, has by many been considered as our hop. But after all, the evidence is very slight, as the only points of resemblance between the plant described and our hop are, that the plant grew in willow plantations, and that it was esculent, and we know well that the young shoots of the hop are in some countries eaten in spring as a salad—the commentators being probably led in their conjectures more by the name *lupus* than by any of the physical analogies between them. In Cato[2] there is mention made of a wild plant which was used as fodder for cattle, and which has also been suggested as referring to the hop. Although we have no evidence that the Greeks or Romans were acquainted with the hop, or at all events with its use in the preparation of beer, it is quite possible that it might have been known to and used at that period by the more northern nations, for the Romans were acquainted only with beer from the accounts given of the Germans and of their manners, and they considered that beverage merely as the unsuccessful imitation of their wine by a people whose climate did not admit of the cultivation of the grape.[3] From the opinions given by the various authors referred to in the footnote, it would appear that hops were not made use of for beer purposes until a much later period.

About the ninth and tenth centuries, however, we have good evidence that the plant was not only known, but

[1] Plin. *Nat. Hist.*, lib. xxi. c. 15.

[2] Cato, *De Re Rusticâ,* xxxvii. p. 55.

[3] Most of the passages which relate to beer in ancient authors have been collected by Dithmar in his edition of Tacitus, *De Moribus Germanor.*, cap. xxiii.; and by Meibomm, *De Cereviciis Veterum in Gronovii Thesaur. Antiq. Græc.*, ix. p. 548.

under a certain cultivation. In the time of the Carolingian dynasty, an old document, in the shape of a letter of donation by King Pepin, speaks of *humulariæ,* which, without doubt, must have been hop gardens. In like manner, in the year 822, Adilard, abbot of Corby, freed the millers belonging to his district from all labour relating to hops, and on this occasion used the words *humulo* and *brace,* by which is to be understood corn and malt used for beer. In the chronicles of the next, and up to the thirteenth and fourteenth centuries, mention becomes more frequent of the existence of hops in a cultivated state, and of their use in the preparation of beer, for which we are undoubtedly indebted to the Germans, who were acquainted with its use for this purpose long before it was introduced into our own or the other countries of the Continent. In the breweries of the Low Countries, hops seem to have been first generally known in the beginning of the sixteenth century; for about this time we find many complaints that the new method of brewing with hops lessened the consumption of *gruit,* and also the income arising from it, termed *gruitgeld.* To this word *gruit* several different meanings have been attached by different commentators. By some it has been considered as signifying malt; by others a peculiar ferment, representing the yeast of our present system of brewing; others again look upon it as a term for a certain mixture of herbs from which the beer was brewed, and that the *gruitgeld* arose from a certain tax, imposed either upon the herbs themselves or to be paid at each time of brewing. From one of the historians of the period, we learn that John, Bishop of Liege and Utrecht, complained to the Emperor Charles X., that for thirty or forty years, a new method of brewing, that is to say, with the addition of a certain plant called *humulus* or *hoppa,* had been introduced, and that his income arising from *gruitgeld* had been thereby much lessened. The emperor, therefore, in the year 1364, permitted him, for the purpose of making good his loss, to demand a groschen for each cask of hops; and this right of revenue was confirmed to Bishop Arnold by Pope Gregory.[1] According to all accounts, the beer of the ancients could not be kept for any length of time, and required to be frequently brewed and consumed fresh.

The old botanical writers, who treat of the good and bad qualities of the different plants, considered among the bad qualities of hops, that they dried up the body and increased melancholy; but among their good qualities that they possessed the property of preserving liquors from corruption;[2] and it is only after the introduction of hops as an ingredient of beer, that we hear of its being capable of being kept for any time without deterioration. It was soon remarked, also, that the keeping of beer depended a great deal upon the season in which it was brewed. In the Ilm statutes (1350) a law prohibited the people under certain penalties from brewing at any other period of the year except from Michaelmas to St. Walpurgis' day.[3] At that period various kinds of beer, flavoured with different substances, seem to have been in use. Amongst others we find named *cerevisia mellita* and *non mellita*. Even at the present time this practice exists to a limited extent, as honey is used in the preparation of beer brewed at Nimeguen and other places, which, under the name of *moll*, is consumed to a considerable extent; while our own brewers at home are charged with the use of liquorice, and other more objectionable ingredients, for the purpose of

[1] The document referring to this is given in *Matthai Analecta* iii. p. 260. See also *Du Cange*, under the word "Grutt" and its derivatives.

[2] St. Hildegard, in *Physicæ*, lib. ii. cap. 74.

[3] A celebrated female saint of the 8th century, said to have been a native of England, but canonized in Germany, where she was abbess of a nunnery at Heidensheim in Thuringia.

giving a peculiar flavour or other property to the article they prepare.

In this country we have no evidence of the use of hops until a much later period. Although some German authorities state that they were in use about the middle of the fifteenth century, and that a statute of Henry VI. forbade their growth as a dangerous introduction;[1] still the balance of evidence is that they were not known in England until the reign of Henry VIII., or about the year 1524, when they were first introduced by some cultivators from Artois. It is nevertheless true that this sovereign, in an ordinance respecting the servants of the royal household, issued in the twenty-second year of his reign (1530), forbade brewers to put either hops or sulphur into the ale. This, however, may be reconciled with the use of hops for brewing at that period by the difference in the ingredients used between ale and beer. At the present time, the proportion of hops used is different, and at that period probably the newly introduced plant was only used when a keeping beverage was required, and not in brewing for ordinary everyday consumption.

In several of our old writers upon the early customs and practices of the people, we find reference made to the popular beverage of the particular period. The fermented liquor, says one,[2] anciently in use in this country is usually termed ale, but we have in fact no certain account of its composition, and all that is now known with anything like certainty is, that it was a pleasant but intoxicating liquor. Our Saxon ancestors were so far addicted to its use, that so far back as the time of King Edgar it was

[1] This is asserted in the *Gottingen Gel. Anzeigen*, 1778, p. 323, but is not confirmed by any documentary evidence; whereas in the "Statutes at Large," vol. i. p. 591, referring to the period, directions are given as to the use of "malt" in brewing, without mention being made of hops at all.

[2] *Husbandry and Trade Improved.* By J. Houghton. London, 1727. Book i. p. 457.

found necessary to order marks to be made in their cups at a certain height, beyond which they were forbidden to fill, under a severe penalty. This probably gave rise to the *peg tankard*, of which specimens are to be met with still remaining at the present day. This *peg tankard* held two quarts, and had on the inside a row of eight pegs, one above another, from top to bottom, so that the space between each contained half a pint. The law of compotation was, that every one who drank was to empty the exact space between peg and peg, and if he either exceeded or fell short of his measure, he was bound to drink down to the next. In Archbishop Anselm's canons, made in the council of London, A.D. 1102, we find an order by which priests were enjoined not to go to drinking bouts, nor to drink to pegs. And again, indeed, at a much later period, we find the city of London petitioning the parliament against the use of hops, "in regard that they would spoyl the taste of drinkes and endanger the people."[1] In the English laws hops are directly mentioned for the first time in the fifth year of the reign of Edward VI. (1552), at which period we find encouragement was given to their cultivation in the shape of certain privileges granted to *hop grounds*. The cultivation of hops, however, which, like the art of brewing, has been carried to perhaps greater perfection in this than in any other country, was very limited even in the beginning of the seventeenth century; for James I., in the fifth year of his reign (A.D. 1603), found it necessary to forbid, under very severe penalties, the introduction and use of spoiled and adulterated hops. At that time, therefore, it would appear that this country did not produce a quantity sufficient for its own consumption. They were then placed under the supervision of the excise, and several statutes and regulations were made for their harvesting and treatment.

[1] Walter Blithe's *Improver Improved*. London, 1649.

Gerarde, in his *Herbal*, published about this period, both figures and describes the hop, which, he says, "joyeth in a fat and fruitfull ground; it prospereth the better by manuring;" and also that it was much esteemed for its use in the brewing of beer. It appears that hops continued to be imported from the Continent in considerable quantities until towards the end of the century, when their cultivation had sufficiently increased in the districts of Kent, Surrey, Essex, and Suffolk, where they were first grown, as to be equal to the requirements of the home consumption, and the importations fell off. In 1710 (Ann. Reg.) a duty of 3*d.* per lb. was levied on all hops *imported* into England; and in 1734 (George II.) a duty of 1*d.* per lb. was imposed on all hops *grown* in England, and afterwards three 5 per cents., or $\frac{12}{20}$ths of a farthing, were added, with the allowance of a deduction of 10 per cent. on the whole for the tare of the cloth. This is what is now termed the "old duty," and is also that upon which the "betting," about which we hear so much in the hop market at a certain period of the year, is made, the calculations of the yield per acre being made from it. In 1802 an additional duty of $1\frac{1}{4}\frac{8}{20}$*d.* per lb. was levied, which, in 1805, was reduced to $\frac{3}{4}\,\frac{8}{20}$*d.* per lb., making thus a gross charge upon the grower of 2*d.* per lb.; upon this also an allowance of 10 per cent. deduction for the cloth is made. This is denominated the "new duty." In 1840 an additional duty of 5 per cent. (3 Vic. cap. 17) was imposed (in common with all other articles of excise) upon the whole previous charge. The actual amount of duty now fixed for hops grown in England is 17*s.* 7½*d.* per cwt., and upon those of foreign growth imported into this country, the duty is £2, 5*s.* At the time of the alteration of the tariff in 1846, it was £4, 5*s.*, having a few years only before been reduced from £8, 8*s.*, which had effectually stopped all foreign importation.

The cultivation of hops is, like that of all our other vegetable produce, influenced mainly by the relations between demand and supply; a few favourable and productive seasons, by lowering the market price, reduce for the time the number of acres under cultivation, which are again increased as soon as any circumstances restore the market value to a remunerative amount. The government return for the last year (1859) shows that the total number of acres of land under hop cultivation was 45,665, of which 9476 were in the Canterbury collection, 1975$\frac{1}{4}$ acres in the Hampshire collection, 3719$\frac{1}{4}$ acres in the Hereford, 1300 acres in the Isle of Wight, 17,530 acres in the Rochester, 1224$\frac{1}{4}$ acres in the Stourbridge, and 8942$\frac{1}{2}$ acres in the Sussex collection. The gross revenue returns of duty on the hops, the produce of this area, were as follows:—

Districts.	£	s.	d.	Districts.	£	s.	d.
Barnstaple,...........	44	11	0$\frac{3}{4}$	Oxford, ...	23	19	3$\frac{1}{2}$
Cornwall,............	1	0	9$\frac{3}{4}$	Reading,.......... . .	197	7	3$\frac{1}{2}$
Canterbury,..........	124,528	14	6$\frac{3}{4}$	Rochester,........ ...	253,211	4	2$\frac{1}{2}$
Essex, ...	1,032	0	10$\frac{1}{2}$	Sheffield, ...	747	6	1$\frac{3}{4}$
Gloucester,......... ..	23	2	10$\frac{1}{2}$	Stourbridge, ...	7,486	0	9$\frac{1}{4}$
Grantham, ...	24	6	1$\frac{3}{4}$	Suffolk,.........	1,268	6	0
Hampshire, ...	22,014	16	2$\frac{3}{4}$	Surrey,................	571	1	2$\frac{1}{4}$
Hereford,............	35,019	2	6$\frac{1}{2}$	Sussex,................	126,940	13	2$\frac{1}{2}$
Isle of Wight,.......	15,816	0	8	Wales, ...	71	2	2$\frac{3}{4}$
Lincoln, ...	137	0	8	Ware, ...	82	13	2$\frac{1}{2}$
Lynn, ...	20	10	2$\frac{1}{4}$	Worcester, ...	9,709	3	0
Northampton, ...	40	12	0				
Nottingham, ...	72	11	5$\frac{1}{4}$	Total,.........	£599,083	6	8

This large amount was made up by the

		£	s.	d.
Old duty at 1$\frac{12}{20}$*d.* per lb.	=	£328,070	2	10$\frac{3}{4}\frac{16}{20}$
New duty at $\frac{3}{4}\frac{8}{20}$*d.* per lb.	=	242,486	12	7$\frac{0}{4}\frac{4}{20}$
Additional duty of 5 per cent.	=	28,526	11	2
		£599,083	6	8

At the present time, the principal hop-growing districts are in the counties of Kent, Surrey, Sussex, Hampshire, Worcestershire, and Herefordshire, and to a more limited extent in Essex, Suffolk, Nottinghamshire, and Staffordshire. The produce of each district has peculiar characteristic properties, dependent mainly upon the geological conditions of the soil in which they are grown, and upon the varieties of the plant cultivated, such properties determining their market values, and also to a great extent the uses to which they are applied in the brewery—the finer qualities, the produce of a rich soil and a congenial climate, being greatly sought after for the manufacture of the higher class of ales, especially those intended for exportation; the others, of an inferior quality, being used for brewing the coloured beers and ales intended for home consumption.

The HOP, as has been already observed, belongs to the natural order URTICEÆ, forming the genus HUMULUS, of which it is the only member, and being known by its specific name, *Humulus lupulus*.[1] It is a coarse-growing, twining plant, indigenous to this country, in common with the north of Europe, in most countries of which it is now met with also in a cultivated state, somewhat altered perhaps in its general appearance and growth. It also grows equally well in North America and the Australian colonies, in which it has lately been introduced, and bids fair, in the course of a few years, to form an important article of colonial exportation. The same peculiarity exists with the hop as with the hemp, the plants being *diœcious*, the *male* and *female* flowers being on *separate plants*, thereby necessitating a peculiar cultivation, differing materially from that of our ordinary plants. The plants, under favourable conditions, grow to

[1] The name *Humulus*, according to Hooker and Loudon, is derived from *humus*, fresh earth, the hop growing only in rich soils. The specific name *Lupulus*, Loudon observes in his *Encyclopedia*, is a contraction of *Lupus salictarius*, the name by which it was, according to Pliny, formerly called, because it grew among the willows, to which, by twining round them and choking them up, it proved as destructive as the wolf to the flock. Lindley considers that *lupulus*, or little wolf, is indicative of its power of exhausting the soil in which it grows.

a considerable height. The stems are angular, hollow, and rough; the leaves are opposite, covered with hairs, heart-shaped, lobed, or undivided, serrated, each with a pair of

Fig. 1.

Fig. 2.

COMMON HOP—*Humulus lupulus.*

conspicuous membranous stipules, which curve backwards. The flowers are distinct, of two kinds, male and female, each produced by its peculiar plant. The *male* flowers (fig. 1) grow in loose, branching axillary panicles, and consist of five oblong sepals, surrounding five stamens, with weak filaments. The *female* flowers (fig. 2) are collected into green scaly cones, growing on axillary single stalks, or in the variety called grape hops, growing in clusters. The scales are oblong, broad, concave, ribbed, and each bears a flower at its base; the flower consists of a green, short, blunt sepal, clasping a roundish ovary, terminated by a pair of spreading downy stigmas. In forming fruit, the scales grow larger and are covered with resinous aromatic particles, called *lupuline;* the ovary at the same time changing into a small nut, invested by the enlarged sepal, and containing a single seed, whose embryo is coiled up without albumen. These female flowers constitute what are known in the market by the name of hops.

The male flowers are of no further use than to impregnate the female flowers with their pollen, which is carried to them by the action of the wind; and when this function is performed, they begin to wither and decay, and are generally removed from the ground. If the female flower or catkin, or *cone*, as it is frequently termed, be carefully examined, it will be found to consist of a number of imbricated scales, greatly resembling the arrangement of the fruit of the Coniferæ, with the fruit at the base, and that the surface of both fruit and scales is studded with minute glands, containing an aromatic resinous substance, constituting the flavouring matter of the hop. This flavouring matter is secreted on the surfaces in a form similar to that of pollen, and has been found, on examination, to consist of a peculiar principle, *lupuline*—a volatile oil—a resin—a bitter principle, tannin—and also some nitrogenous compounds, probably salts of ammonia. Now, it is the possession of *all* these principles which constitutes the value and suitability of hops for the peculiar economic purpose for which they are so largely cultivated. Besides their application in brewing, they are used also for medicinal purposes, their sedative properties rendering them a very serviceable agent in the hands of the physician.

There are several varieties of the hop grown in this country, which, differing in their habit of growth and soil requirements, render their cultivation practicable in many districts where otherwise they could not profitably be grown. Of these the principal are the Canterbury and Farnham *Whitebines*, so much alike in every respect, that they are no doubt the same variety, and which, with the *Goldings*, are held in the highest estimation in the markets, and always command the highest price. Their quality, of course, depends greatly upon the soils in which they are grown; those best adapted for them are the deep rich soils on calcareous subsoils, or those of the greensand formation, in which their roots may often be traced running down to the depth of 12 to 15 feet. They are looked upon as the most enduring variety upon the same lands, some plantations being still in full bearing though planted upwards of fifty years ago. They possess a vigorous growth, and require poles from 15 to 18 feet high The bines of these three sorts are speckled with reddish-brown spots—the *Goldings* being distinguished from the others by the bine being somewhat stouter, and the hops hanging more singly on the branches. The *Grape* variety are so called from their habit of growing in clusters like grapes. Of these there are several sub-varieties—the Yellow, the Green, and Cox's *Grape*, all of which are of a hardier nature, and are less particular as to soil than the preceding. The smaller varieties of the *Grape*, when grown in the better class of soils, rival the *Goldings* in quality; on the stronger soils, with retentive subsoils, however, they become coarse and strong, and are of inferior quality. These are usually cultivated in the

Weald districts of Kent and Sussex. The bines, which are of a lightish green colour, have not the vigorous growth of the *Goldings*, though they are generally more productive in hops, and require poles from 12 to 15 feet high.

The *Jones's* is a very useful variety, as it may be grown on the lighter class and inferior soils, where cultivation of the other varieties could not be attempted. They are not generally so productive as the *Grape*, but are fully as much esteemed for their quality; while, owing to their habit of the bines, which are of a reddish colour, tending rather to their lateral than upright growth, they require poles only 9 or 10 feet high, so that the refuse poles—those unsuited for the other sorts—may be profitably used for this, which greatly reduces the expenses of cultivation. It is generally considered advantageous to have a small portion at all events of the hop ground planted with these hops, so as to employ the refuse poles, which otherwise would only be fit for young plants, or for fuel purposes.

The *Colegates* is a very hardy variety, suitable for growing on the strongest soils, of very vigorous growth, but very backward in ripening. The hop is of small size, and hangs from the branches in thick clusters. The produce is generally large, and when quite ripe they have a good appearance, and handle well; their flavour, however, is strong and coarse, which renders them unsuitable for brewing the finer class of ales, and lowers their market value. The bine is of a pale green colour, fully as stout and vigorous, and requiring the same sized poles as the *Goldings*, but considered to be more liable to mildew than any of the other sorts; however, owing to their lateness at harvest, it is recommended to grow a certain proportion of them, so as to lessen the labour pressure at picking time, and also the chances of injury to the general crop, from climatal and other causes. There are several other varieties, such as the Flemish, Wildings, Rufflers, Golden Tops, &c., met with occasionally in cultivation, which possess, or are supposed to possess, certain advantages for cultivation in certain soils or districts. The varieties now described, however, furnish the great bulk of our hop produce, and to these we must confine our attention.

The range of soils in which the hop, in its different varieties, may be cultivated is considerable, comprising well-nigh every gradation from the light gravels and detrital soils to the strong clays of the Weald. Beside the soil, however, climate and exposure exert considerable influence upon their successful cultivation, as although the hop is indigenous to this country, it is a tender plant, and very liable to injury, from external as well as internal causes, at different stages of its growth. If we run over the soils of the different districts of the hop cultivation, we shall find the finest qualities of Goldings, known in the market as East Kents, growing upon a deep rich loam on a rubbly or porous subsoil, or where a loam of sufficient depth rests upon the broken beds of the upper chalk. On these latter soils the produce is generally less in quantity, but of a superior quality, than where the soil is deeper and naturally richer. The soils of the Farnham hop district are chiefly formed from the upper greensand formation, or from a deep diluvial loam lying in the valleys beneath, the physical characters of the soils, combined with the large proportions of phosphoric acid which they contain, rendering them admirably adapted for the growth of the plant. This district has been the subject of a scientific investigation, the details of which are given in the *Journal of the Royal Agricultural Society*, and will amply repay perusal.[1] Even where the greensand thins out, and the gault clay appears, this latter, which in its natural state is only suited for the growth of oak timber, has, by a judi-

[1] *Roy. Agri. Soc. Journal*, vol. ix. p. 56.

cious outlay in drainage and deep cultivation, been rendered as productive as the greensand soils. Instances are recorded of land thus brought into hop cultivation, which but a few years before would let for only a few shillings per acre, becoming, after an expenditure of about £20 per acre, worth as many pounds to rent as it had been formerly worth shillings. When, however, either the upper or the lower greensand comes in contact with the gault, the soils are naturally of the best description.

The following analyses indicate the characters of the soils referred to in the investigation. The first is the gray marl, which lies directly upon the green stratum, from which the soil proceeds—a soil long noted for its capability of growing famous crops of wheat and beans alternately, without any additional manure:—

Insoluble silicious matter (sand),	19·64
Soluble Silica,	6·45
Phosphoric acid (equal to 3·75 bone earth),	1·82
Carbonic acid,	28·98
Lime,	37·71
Magnesia,	·68
Oxide of Iron and Alumina,	3·04
	98·32

The soil proceeding from this green stratum, with which many fossils are intermixed, gave, on analysis, after these fossils had been carefully separated, the following results:—

Insoluble silicious matter (sand),	32·81
Soluble Silica,	29·14
Organic matter,	3·02
Phosphoric acid (equal to 13·63 bone earth),	6·61
Carbonic acid,	2·30
Lime,	9·53
Magnesia,	1·97
Oxide of Iron and Alumina,	11·46
Potash,	3·10
	99·94

The soils proceeding from the gault formation were found to be even still richer in potash and phosphoric acid, and also to contain a proportion of ammonia, whose presence was no doubt due to the absorbing properties of the clay, of which the soil was so largely composed.

The best soils of the Mid Kent district, where Goldings are grown, are met with in the vicinity of Maidstone, on either side of the river Medway. This district is bounded by the range of chalk hills on the north, and by the Weald clay formation on the south, its characteristic geological feature being the abundance of the well-known Kentish ragstone rock. This rock, which belongs to the cretaceous system, is frequently interspersed with green grains. On analysis, a mass of the rock broken down was found to contain of—

	Per cent.
Insoluble silicious matter,	30·60
Phosphoric acid,	7·23
Potash,	3·31
Soda,	1·02

thus being capable of forming soils of the richest description, which would show that this district, like that of Farnham, was particularly suited, by its natural qualities, for the cultivation of hops.

Below the ragstone range of hills there are very few fine Goldings or Whitebine hops grown, as the strong soils of the Weald of Kent and Sussex are better adapted for the coarser varieties, as the Grape, Colegate, and Jones. In the Weald districts the cultivation is mostly carried on in the valleys, which are, to a certain extent, drained by the rivers which pass through them, or where a large accumulation of surface soil has given them a capacity for artificial drainage greater than the Weald clay generally possesses. Much has been done in this direction of late years, and in all cases drainage has been followed by the best results; the plant is rendered less liable to disease, and its endurance greatly increased. Where the Weald clays thin out on the subjacent beds of the Hastings sand formation, excellent hop soils are produced. These may be seen in the lower part of Kent and the adjoining county of Sussex, situated on the sides of some of the low hills which rise out of the Weald, and offer great capabilities for the cultivation. In Eastern Sussex some most fertile grounds of this character are to be met with lying in the valleys, and producing, on the average, a larger return than perhaps any other district in the country.

In Worcester and Herefordshire we find hops cultivated principally in the valleys of the old red sandstone formation. These soils have long been known for their general agricultural fertility, and although the hop produce seems to be more subject to fluctuation[1] than that of the south-eastern counties, it is probably due to other causes besides that of mere soil. In Nottingham and Stafford shires the hop grounds are met with on the alluvial soils of the new red sandstone formations. The cultivation is very limited, and the quality of the hops rarely commands very satisfactory prices in the market.

The area under hop cultivation, though subject to certain variations, exhibits but a very small increase when compared with the increase of population and the advance of agriculture since the commencement of the present century. At that period we find it ranging between 35,000 and 40,000 acres, and the returns for the past five years tend very much to show that it is gradually declining towards the same level:—

Year.	Acres in cultivation.	Gross amount of produce in lbs.	Average amount of duty paid per acre.	Weight of produce per acre. cwts. qrs. lbs.
1855	57,757¼	83,221,304	12 12 1	12 3 12
1856	54,527	55,868,927	8 19 3	9 0 16
1857	50,974¾	47,717,561	8 3 9	8 1 7
1858	47,601½	53,125,100	9 15 3	10 1 10
1859	45,665	49,089,875	13 2 4¼	9 2 11

[1] In 1823, the whole amount of the old duty paid by the Worcester district was only £4, 3*s.* out of £26,057, the duty for that year, while in 1825, another

This decrease is due, probably, to the abundant crops of the last few years, and also to the increasing importation of foreign hops, to the cultivation of which more attention has latterly been paid, so that they now competé in quality with our own, and can be sold cheaper.

No reference need be made to the proper place in the ordinary farm rotation of a crop of such long duration as the hop; we will therefore proceed at once to the selection of the site for the intended plantation, and of the varieties to the cultivation of which the particular locality selected is best adapted. As protection from the winds, especially those prevailing at the flowering season, is one of the principal points for consideration, a gentle slope is usually taken advantage of, inclining towards the north, rather than towards the south or south-west, which are the winds most prevailing during the later growth of the plant. This aspect, although less exposed to the direct rays of the noon-day sun, secures to the plants a longer continuance of its rays, and thus gives them a better distribution of its light and heat. The flat low-lying lands, although generally of better quality, and more productive and less exposed to the wind, are more subject to blight and mildew than the higher and more exposed situations. On the tops of hills, however, as on the ridge of the chalk range in Kent, the climate is generally too cold, and the produce is comparatively small; but the quality is good, and the crop rarely suffers from blight. The variety of the hop to be grown is also a matter for consideration, inasmuch as some of the coarser sorts may be cultivated pro-

season of blight, it paid £11,911 out of £24,317, the aggregate duty of the whole kingdom. In the former year the average yield per acre was 1 cwt. 1 qr. 5¾ lbs.; in the latter year it was only 1 cwt. 8¾ lbs., while that of the intervening year (1824), the average for the kingdom gave 7 cwts. 11 lbs. In 1837, an extraordinary good year for the district, it paid £38,731 duty; while in 1847 it only paid £1471 out of £216,268, the duty of the whole kingdom for that year.

fitably where the finer varieties would not succeed at all. The Goldings and the Farnham and Canterbury Whitebines are the deepest rooted, and require good loamy soils, resting on pervious rubbly subsoils of the greensand and ragstone beds, and where the gault clay comes near the surface that the soil be well drained, either naturally or artificially; while the other varieties are less particular as to soils, and may be grown on those of an inferior class, even where the drainage has not been so carefully attended to.

The site having been arranged and the variety to be cultivated been selected, the preparation of the ground is the next thing to be attended to, and as this forms a large portion of the outlay required for the formation of a new plantation, it is desirable to see how far we may, by availing ourselves of improved new tools or methods, economize the expenditure without impairing the efficiency of the work. The object to be attained is, that the soil should be deeply tilled—that it should be in high condition—in a finely divided state—and free from any stagnant or surplus water. The last condition is that which demands our first attention—deep and thorough drainage must be secured, or all the other conditions named would be rendered nugatory.

The class of soils usually selected, on account of their depth and porous substrata, for hop grounds, possess a natural drainage, and rarely need any artificial aid; those lying low on alluvial bottoms, in valleys, or along the course of rivers, generally admit of the drainage being carried sufficiently below the surface to allow of a good deep soil for the roots to feed in above the water level. After the drainage is secured, the deep tillage with which the formation of a hop ground is always commenced, has to be effected. This is usually done either by *trenching* or by *ploughing* and *subsoiling*. The *first* is admitted by all to be most beneficial to the land and to the crops, while the *latter* is the cheapest and the most expeditious in performance. Trenching is done by moving the soil two or more spits deep, and either burying the surface soil and bringing the subsoil to the top, or by loosening, and breaking up, and turning over the under soil, and replacing the surface soil over it in its original position. The nature of the soil usually determines which is the best method. When the surface and subsoils are pretty homogeneous in their physical characters, it is generally thought best not to bring up the subsoil, but merely to break up and invert it without bringing it up to the top. Where, however, the subsoil is very compact and different from the surface, it is better to break it up thoroughly and remove it to the top, as otherwise it is apt to cohere again, and in a few years become perhaps as indurated and impervious to the roots of the plants as it was previously to being trenched. The cost of the work (trenching) depends upon the nature of the soil and the depth it is to be moved—from 6*d.* to 1*s.* 6*d.* per square rod may be taken as the average rate of payment for the work. By ploughing and subsoiling the soil may be moved equally deep, and at a much cheaper rate. Six horses with the Kent plough will turn a furrow from 10 to 12 inches deep, and the subsoil plough with four horses will follow it, taking a depth of some 6 inches more. These would get over about two-thirds of an acre a day, at a cost of 40*s.*, or at the rate of 60*s.* per acre.

Here it is that our new auxiliary, the *steam-plough*, shows the great and economical powers it possesses. This is the sort of work, especially on the strong cohesive soils, in which it can be applied to great advantage. In the report[1] of the trials of the Chester meeting, we find that the soil (a strong clay loam) was turned over to the depth of 14 inches by the steam-plough, at a cost, including all expenses, of 18*s.* 4*d.* per acre, and that it

[1] *Roy. Agri. Soc. Jour.*, vol. xix. p. 326.

was the opinion of competent judges "that the same work could not have been done in the same manner by horse labour at all; and that by manual labour, with the usual trenching tools, it could not have been done for less than 10*d.* per rod, or £6, 13*s.* 4*d.* per acre, and then only in a very inferior manner."

Where old meadow or pasture land is broken up for hops, if done by hand, the top spit is always buried, and if done by the plough, the sward is generally taken off about 3 or 4 inches, and a second furrow run to a depth of 9 or 10 more, and turned over on the top of the other, so as to bury the sward deep enough to insure its decay and prevent its vegetating again on the surface. The subsoil plough then follows, and completes the work of preparation by stirring the soil to the desired depth. This operation also costs about £3 per acre, and could be equally well performed by the steam-plough, at less than half the price already stated. This mode of preparing the land is always carried out in the autumn, so that the soil may have the full advantage of the winter's frosts and rains. If the surface be buried, and the subsoil brought to the top, the ordinary weeds will give no further trouble. If, however, the surface be merely inverted, and the land stirred with the subsoil plough, it is important that full advantage should be taken of the opportunity, and the land be thoroughly cleaned. When these operations have been efficiently carried out, and the general condition of the soil been secured, either by feeding off green crops on it, or the liberal application of farmyard or other manures, nothing more is to be done until the time for planting, which is generally in the spring, when it is always a good plan to run a narrow-tined grubber pretty deep across the ground, in order to break up the surface crust formed by the winter's rains, and to give access for the air to the subsoil.

For *planting*, the practice universally followed is to take cuttings or shoots from old plants, and either carry them direct to the new ground or to a nursery bed already prepared for their reception, where they are struck, commence their individual growth, and are removed at the end of the season as early as the new ground is prepared for their reception.

Plants may also be obtained from the matured seed of the hop, yet the process is a tedious, and at the same time an expensive one, as they could not be planted out in the ground until they had *been proved*, as, like the seed of the potato, already referred to (page 37), the young stock always varies greatly from the parent, and although a valuable new variety might occasionally be produced, no reliance could be placed upon the seedlings following the stock which it was desired to grow. In the prize essay[1] "On the Management of Hops," the author says, "I once grew a great many plants from seeds of the Golding hop: there was nearly an equal number of male and female plants, but there was not one female plant that produced a hop at all like a Golding, nor was there a single plant amongst them all that produced a hop that I would have raised a plantation of, or was not very inferior to any hop I ever saw growing in a plantation. I am aware that from seed a new variety of hop is produced, and from which a small number of plants may be taken and propagated, but it must be by the usual method of cutting from the parent stock that the variety can be extended, so that by cuttings only can a plantation be raised to any extent." He also gives it as his opinion, that if it be wished to raise a plantation quickly, *bedded plants* may be used, as they will generally give a yield of 3 to 4 cwts. the first season after they are planted, whereas no produce can be expected the first season from a ground planted with *cuttings*. These will generally about their third year have caught

[1] *Roy. Agri. Soc. Journal,* vol. ix. p. 532.

up the bedded plants, whose development is always more or less checked by being transplanted from the nursery to the field, and will give a better return than bedded sets from cuttings of the same year. "Bedded sets" offer the great advantages of an earlier return, and of a better plant—the expense of the nursery and of transplanting being the only extra outlay incurred, as a set-off against the rent, interest on capital, and labour of the twelvemonth saved.

When "bedded sets" are used, it is recommended to plant them out early in November, or, indeed, as soon as the land is prepared for them; if it be left till the spring, March is the best time for the purpose. "Cuttings" should be got in immediately they are taken from the old plants. In dry soils and forward seasons this may sometimes be done towards the end of February; March, however, is the usual period: if left later, and dry weather should set in, the young plants do not strike freely, and many blanks appear. Great care is required that the cuttings, whether for bedding or for planting out at once, and whether raised at home or purchased from others, be from a good healthy stock, and true to the variety intended to be grown. Care should also be taken that the cuttings from the male plants should be kept distinct from those from the female plants, otherwise they are likely to be irregularly distributed, instead of having them dispersed at given regular distances over the ground.

Respecting these distances, and indeed the functions and value of the *male* plants altogether, a difference of opinion appears to exist with practical men. Some growers plant and retain every tenth or up to every fifteenth "hill" with male plants; others distribute them with less regard to regularity throughout the ground. Again, another plan recommended is to keep the male plants on the outside, so that the pollen may be carried over the ground by whichever wind may blow, while there are some growers who search for the unproductive male plants at the time of flowering, and with a short-sighted economy, unchecked by that knowledge of the functions of vegetable life which every farmer *ought to* possess, at once extirpate them as useless incumbrances of the soil.

The ordinary functions of the male organs of a plant are to *prepare* the pollen or fertilizing substance, which, alighting on the stigma of the female organs, effects their due impregnation. In *diœcious* plants, as the hop, where the flowers containing the reproductive organs are on different plants, the functions are the same, though, being separated, they are carried out in a somewhat different manner. Although there are some instances known to botanists which tend to show that plants may be impregnated even though the pollen has not access to the stigma, we have no good reason to believe that hops come under this exceptional condition, but rather that the presence of the male plant is necessary to the full reproductive powers of the female, the female cones having the power of increasing after the ovule has been fertilized by the small portion of pollen falling over it.

As experiment is generally more valued than precept, especially by merely practical men, the result of one undertaken specially to this end, with hops raised from seed, and in their fourth year, may be adduced in support of the opinions expressed. In a small plantation where the male and female plants were growing intermingled on the ground, a bushel was collected at the proper time, weighed, and found to be 36 lbs.; a like quantity picked at the same time from cuttings, with the male plants left in certain proportions, gave a weight of 35 lbs.; whereas the same measure obtained from plants from which all the males had been carefully extirpated, weighed only 22 lbs. Strong confirmatory evidence is given also on this point by the author of the essay referred to. Besides the great increase in quantity in the above experiment, the quality was much superior, the "lupuline" being supposed by Planchat and other vegetable physiologists to be merely the unappropriated pollen which has alighted on the scales of the female. After the pollen is all shed the males are of no further use that season, and may be removed. Where any quantity is obtained the bines may be made use of to form the coarse bags, in which the inferior varieties of hops are sometimes packed.

Planting is the next part of the cultivation which has to be considered. The mode of doing this is the same in every district. The sets or cuttings are planted on small raised hills at certain distances apart, the only variations being in the number of the plants, and the shape in which they are arranged, and the distances between each hill. The only forms are squares and triangles, and the distances apart vary between 6 and 7 feet. The triangular form is generally adopted, as it possesses one advantage over the square, in that when three poles to a hill are employed, it allows the "nidget," as the implement used for this purpose is locally termed, to move the ground on the outside of the poles more completely than when set up in the square form, and thus renders the tillage cultivation more effective. Although some little space too is gained, it is not advisable, on that account, to increase the number of hills to the acre, but rather to let them have the full benefit of the additional space. The following table gives the number of hills, by each method, to the acre, at the distances specified:—

	Square.	Triangle.	Difference.
			Hills.
6 feet distance between the hills, ...	1210	1406	196
6 ft. 3 in. ,, ,, ,, ...	1117	1296	179
6 ft. 6 in. ,, ,, ,, ...	1031	1194	163
6 ft. 9 in. ,, ,, ,, ...	957	1103	146
7 feet ,, ,, ,, ...	889	1025	136

Where the soil is of a very fertile character, these distances are frequently exceeded; instances exist of very productive grounds set at 9 feet distances apart: this point should always be determined by the conditions—soil, climate, and variety—of each particular case.

In setting out the ground, the ordinary form of marker, fixed at the given breadth, may be used, or in the absence of this the plough is a good substitute; the ground, previously of course properly prepared, and in good tilth, is then passed over by the marker the second time, at right angles to the first, the points where the lines cross each other being the sites for the "hills." When the plough is used, a light furrow drawn at the same distances gives the same indications, and the formation of the "hills" should be at once proceeded with. This is always done by manual labour; a hole from 18 to 24 inches square, and about 12 to 15 inches deep, is dug, and some good, well-rotted dung, mixed up with some of the soil into a sort of compost, is laid in and covered up with the remaining portion of the soil, which, by the additional material given to it, rises above the surface in the form of a small hillock. On this raised spot the "sets" or "cuttings" are planted; five are generally allotted to each, the "sets" requiring more careful handling and arranging in the soil than the "cuttings," and both being placed so that they shall incline towards the centre rather than outwards. After they are planted they require constant watching, especially if the soil be not in good tilth, or the weather be dry and cold; the surface, too, requires to be kept perfectly clean and frequently stirred. Where "cuttings" have been used, it is very customary to take an intercalary crop of potatoes, mangold, carrots, or cabbages, in order to occupy profitably the wide intervals between the hops, and thus help to meet the charges of rent, &c., of the first—always an unproductive—year. This practice, however, should not be attempted if "bedded sets" have been planted, neither is it good policy thus to occupy the vacant spaces at any other time of the plantation, as, although a certain amount of secondary produce may, in most instances, be had, it is in all probability obtained at the expense of the regular crop.

Towards the latter end of May or beginning of June, a stick should be placed in the centre of each "hill," to which all the young bines, as they shoot up during the summer, should be tied; for the "bedded sets," the sticks should be from 6 to 8 feet high; for the "cuttings," about 4 to 5 feet will be sufficient. A top-dressing of Peruvian guano is often applied about this period with great benefit; it is simply spread over the hills, and covered in with the hand-hoe or rake. In the autumn, when the sap has quite gone down, and the young bines have changed colour, they are cut off and covered up by a small quantity of the soil, which protects them sufficiently during their first winter in the soil. Where "sets" have been planted, a small produce is generally obtained the first year, which must be carefully collected by hand-picking from the bine *as it stands*, and not in the ordinary mode of harvesting. The cost of digging and planting "sets" is from 1*s.* to 1*s.* 6*d.* per 100 hills. The sets themselves are usually sold at 2*s.* 6*d.* per 100; and as it takes three to each hill (triangular), and there are 1406 hills, at 6 feet distances to the acre, the cost for plants would be from £5, 5*s.* to £5, 10*s.* Where "cuttings" are used, the expenses are less; they may be purchased at 6*d.* per 100; and as five are allotted to each hill, the whole number required for the acre would amount to about £1, 15*s.* to £1, 16*s.* only—allowing, in both cases, a few extra for failures.

In the following spring, the first operation is to open the hills and examine the plants, which have to be cut or dressed before they are ready for *poling*. This is done by a boy or woman opening round the stock of the hill with a narrow hoe or pecker, so as to expose down to the crown of the hill the bines of the preceding year, and any suckers that may have sprung from them. These are removed by an experienced man intrusted with the work, care being taken that they are cut off at the right place, as much of the future vigour of the bine depends upon this being judiciously done. These suckers or shoots are the "cuttings" which are used for the formation of new grounds. This work is usually paid for by the day, as everything depends upon the care and attention bestowed upon it; if done by piece-work, it is liable to be carelessly done, for the sake of getting over the work quickly

The time for cutting and dressing is as soon as the ground is sufficiently dry in the spring; and it is usually considered advantageous to leave the hills open for a day or two after they are cut, in order to dry up, and then they should be covered up again with a thin layer of fine mould, care being taken to mark those containing weak and sickly plants, in order that at poling they may have the shortest and slightest poles allotted to them. It is recommended to set up the poles in the new hills before any digging or outrooting is commenced on the ground; they mark out the hills where the young plants are, and prevent them from being disturbed and injured. Every planter knows what poles are suited to the ground, and provides those considered best; these should be set up in a triangular form, and forced into the ground as many inches at least as they are feet in length, a hole being previously made for them by an iron bar, called a "hop-pitcher," in the same way as fixing stakes for ordinary hurdles, the pole being driven home forcibly, in order to give it a good bite in the ground, and enable it, when covered with the bine, to resist the force of the winds. If the poles are at all irregular in shape, they are placed so that any curve at the lower part should bend inwards, and at the upper part outwards, thus keeping the heads of the bines as separate and open as possible. The judgment of the planter is called into play in the selection of proper poles. *Under and over poling are alike to be avoided.* If the poles be too long, the bines have a tendency to run and become weak and unproductive; if too short, the bines fall over, get crowded on the pole, and the fruit only forms in an imperfect manner.

As soon as the "poling" is completed, the ground should be well stirred between the hills. This is done either by digging, by the plough, or by the peculiar form of cultivator—the "nidget," as it is locally termed—and great care is taken during the whole season to keep the ground clear of weeds. About the beginning of May, or a little earlier in a new ground, the bines are ready for tying to the poles, which should not be delayed after they are long enough to admit of it, as they are sure to suffer injury by twisting and intertwining if left lying on the ground, especially if the season be moist. The *tying* should be commenced as soon as one bine is ready, the ground being gone over until it is finished and every bine properly secured. This is done usually by women, care being taken that the bines be tied just below the second joint; if it be nearer to the head, the hop frequently bends over, instead of running round the pole. Not more than three bines should be allowed to each pole; all above that number should be pulled up at once, and removed from the stock. The purchase of the poles forms a separate and large item. The annual expense for sharpening and setting them is from 1*s.* to 1*s.* 6*d.* per 100 hills of three each, according to the length of the poles and the nature of the ground, a small extra sum (from 1*d.* to 3*d.* per 100) being paid in some cases for carrying the poles to the ground. As careful work is of far more importance than quickness in tying, it is usually paid for by the day, one woman being employed for each two or three acres under crop. Rushes or Russian matting is the material used for the purpose, the women taking charge of the bines until they are beyond their reach, when boys with a light rough ladder, made in the form of the letter Λ, are sent through the ground, to tie up those which, from the effects of wind or other causes, have got their heads away from the pole, and cannot regain it without such assistance.

Some time during the month of June, as the season is early or late, the hills are "earthed in," by taking a shovelful of fine soil and placing it round the root of the bines, which not only gives support to the plants, but causes them to enlarge and form cuttings for the next spring, and indeed to be generally more productive. The price paid for this work is from 3*d.* to 4*d.* per 100 hills. Previously, however, to "earthing in," the ground should be very carefully looked over, when all unoccupied poles, or every pole upon which the bines look weak and sickly, and not likely to run up, should be taken down, and smaller ones substituted. Any large poles thus removed should be set up again on some of the hills where the bines are growing most vigorously—one bine being taken from two of the poles and attached to this extra one, thus leaving on the particular hill three poles with two bines, and one pole with the original number tied to it. The results always amply justify this small additional attention.

During the following month of July the more vigorous growing varieties, as the Goldings and the Whitebines, require *trimming* or *pruning*, the lower portions frequently branching out considerably, and obstructing the access of air and light. In such case they require to be pruned pretty close, and up as high as 3 or 4 feet from the ground, so that cultivation may be carried on between the hills without injury to the bines, and that free ventilation secured to them so necessary for their general health, and one of the best preservatives against mould or mildew. It always happens, too, that during the summer some poles, especially old ones, are blown down. These should be noticed at once, re-pointed with the hand-bill, and firmly set up again as soon as possible, as, if the plants remain lying on the ground only a few days, they are seriously injured, if not entirely destroyed.

The growth of the hop from the time of flowering up to that of harvesting is a matter of great anxiety, as, though subject to serious injuries from various causes during the whole period of its existence, its risks and vicissitudes seem to increase as it approaches maturity. The operation of harvesting, too, is attended with some anxiety, and even then much of the value of the crop depends upon the judgment and arrangements of the grower for the purpose. It is important that all hops, of whatever sort they may be, should be gathered at a particular period of their maturity. If they be gathered before they are quite ripe, they are deficient in quantity and even inferior in quality; whereas if they are allowed to hang on too long, they become discoloured, dry, have a tendency to break off from the bine, and are lost. The middle period of maturity is that when the hops possess their maximum value, both as regards quantity and quality, and all the strength of the grower should be brought to bear upon them at that particular time. This is determined readily by the handling and appearance of the flowers or cones. They become hardish and crisp to the touch; the extreme petal projects in a prominent manner at the apex; the colour has become changed from a silvery green to a deep primrose or yellow; and on opening the cone or flower, the cuticle of the seeds is of a purple colour, and the kernel or seed itself hard like a nut. As the process of harvesting is by handpicking, additional labour is always required in hop districts at this period, and this should be previously secured by those who wish to do full justice to their special cultivation.

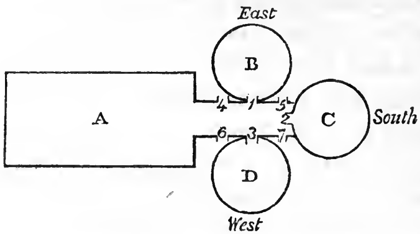
The usual method of picking adopted in the Kent hop-growing districts is thus given in the prize essay before quoted:—"Hops are either picked in large baskets or in bins, the latter being the most general, the bin-frames being sufficiently large to take a cloth for two persons, or a family of a woman with two or three children, to pick into; a man to pull poles to every four or five of these bins, to what is called a bin's company, consisting of eight or ten adult pickers, or of such a number of children as may be equal thereto. The pole-puller or bin-man, as he is called, in addition to his labour of pulling poles, has to hold up the bag or poke for the man who measures to put the green hops in, to carry them to the waggon or cart that takes them away to the "oast," and to strip the bines off the poles after the hops are all picked; for the sooner the bines are taken off the poles the better, since when lying in heaps in wet weather they are very liable to be injured, as the bines hold the wet. The bin-man with his pickers is placed to a certain number of hills, which is called a "set," and remains with them there until it is all picked, and then they move altogether to another set: 100 hills are generally put to a set, which afterwards form a stack of poles. These arrangements, though perhaps of small importance, tend to prevent confusion and promote regularity among the pickers, particularly when there are a great number employed. Hops are picked by the bushel, and are measured in a basket containing about 10 gallons imperial measure; the basket should be lightly filled level with the rim. The price paid per bushel varies with the crop, from 3 to 4 bushels for 1*s*., up to 9 or 10 bushels in good crops; they should be picked free from leaves, except a few smaller ones, and not in bunches. Hops are now much cleaner picked than they used to be fifty years back. At that period 1*d.* a bushel was a common price for a good crop."

In the Farnham district hops are picked in a superior manner to any other district: no leaves are allowed to be touched, and the inferior and discoloured cones are sorted out and put by themselves; the samples are accordingly more even, and fetch ordinarily the highest price in the markets. Mr. Paine thus describes the mode of harvesting as practised in the Farnham district:[1]—"On the larger hop-farms the pickers, consisting chiefly of cottagers from the neighbouring districts where hops are not cultivated, are divided into "companies," which occupy fifty or sixty baskets or bins, two women, or a woman and her children, picking into each, so that there are usually about 150 persons in each company. Baskets or bins are used indifferently, according to the predilection of the planter. They hold 7 to 8 bushels each, of 9 imperial gallons to the bushel, and are gauged and marked on the inside with black lines, thereby saving the trouble and hinderance of measuring. Each company is under the superintendence of a hop-bailiff, who keeps a daily Dr. and Cr. account of the earnings and money advanced to each bin's company. Under him are six or seven men, termed pole-pullers, whose duty it is to keep the pickers supplied with poles of hops as they require them, and to assist in carrying the hops, when picked, to the carts. The hops are carefully picked, one by one, into the bins; and it is the duty of the bailiff to take care that no bunches, or leaves, or mouldy hops, be suffered to remain in the bins or baskets when they are emptied into the surpliers or pokes, in which they are conveyed to the oast-house. The price paid for picking commonly ranges

[1] *Cyclop. of Agric.*, article "Hop."

from $1\frac{1}{2}d.$ to $3d.$ per bushel, although, in blighted seasons, as much as $6d.$ is given. The pole-pullers use a lever with iron teeth, called a 'hop-dog,' in order to assist in pulling up the poles. One company of the above strength will pick down about one acre at a sitting; and when they have cleared it they pass on to another, and are followed by men, who strip the haulm from the poles, and 'hile' or stack them at once."

The hops, when picked, are carted away as speedily as possible to the *drying or oast house,* where they are prepared for packing and sending to market. In the fresh state the hop contains an amount of moisture which would rapidly induce heating and fermentation were they packed, or indeed left in any quantities, in their natural condition. To get rid of this surplus moisture, or *reek,* as it is termed, they are submitted, in thin layers, to the action of a current of heated dry air passed through them, which carries off with it a portion of the moisture, and leaves them in a sufficiently dry state to be put together and thus be kept without injury for any reasonable time. The construction of the "oast or drying house," where this process is carried out, resembles in principle that of the ordinary malt-house, though the arrangement is slightly different. The heat is generated in the lower part of the building, and the hot air ascends through the floors or hairs, as they are termed, on which the hops are spread out, carrying with it the surplus moisture of the hops, which it is the object to get rid of, and passing out at the top of the building through the cowl, an aperture arranged for that purpose. In the general construction of these houses, and their internal arrangements for effecting their object in an efficient and economical manner, much skill and ingenuity have been from time to time exhibited, details of which may be found in the authorities alluded to. The most approved form of construction is shown in the accompanying *woodcut,* which is drawn to scale of 1 inch to 40 feet, and shows how the kilns may be situated with regard to each other, so as to



assist, and not impede, a regular circulation of air to either. A represents a building 40 feet by 20 wide, containing two floors of the same dimensions. The lower one is used for weighing and stowing the hops in harvest time, and is sufficiently open on one side to admit of the waggons or carts bringing in the hops, additional light being given by means of regular windows. The upper floor is used for receiving the hops from the kiln, spreading and cooling them, and packing them for market, B, C, and D are ground plans of three circular kilns, in which the fires are made and the hops dried. The figs. 1, 2, 3 are openings for the admission of persons and of air to the kilns, and figs. 4, 5, 6, 7 are outer doors opening into the passage from the outside, so placed as while giving admission to air, they cause it to circulate in the interior passage before passing into the kiln, and thus prevent irregular currents acting upon the fires, which always are detrimental to the hops on the drying floors above. These doors may be closed or open, according to the force of the wind and direction from which it comes. An oast-house of the plan and dimensions here given will dry about 1200 bushels per day—200 bushels being got off of each kiln twice daily; and as the kilns are independent of each other, either or all of them may be worked, as may be required.

Great care and judgment are required in the drying; damaged hops may be improved and the best hops be spoiled by the manner, judicious or otherwise, in which they are treated. When the floors are first charged, the heat should be applied very gradually, and increased only towards the end of the operation, which generally occupies from six to eight hours, when they should be removed to the cooling room, as much injury is sustained by leaving them in the kiln after they are ready for moving. This is ascertained by the feel far more than the appearance, and can only be acquired by careful observation and experience. They should feel perfectly dry to the hand, and yet should retain a soft silky feeling to the touch. Sulphur is very generally made use of in this part of the preparing process. It certainly does not add anything to the intrinsic value of the hops, but its peculiar bleaching properties are made use of for the purpose of improving the colour of hops, which, either from their natural process of maturing, or from other causes, have become too brown or dark coloured to satisfy the market eye. It thus gives them a fictitious value in the market, and the grower is well remunerated for his outlay in sulphur. Great care, however, is requisite in its administration; it should be applied in small quantities at a time, commencing as soon as the vapour begins to arise from the floor, and continued only as long as the escape of moisture is visible.

From the kiln the hops are removed to the cooling room, where they are spread thinly on the floor, preparatory to packing or bagging. This should be done as soon as they are sufficiently cool to press well under the feet without breaking to pieces, or "mudging," as it is generally termed. If, however, they get too cool, and particularly if they have not been thoroughly dried, they are apt to become clammy, and although they press close and well, they stick together too much, and have no rise or spring in them, which spoils the sample for the market. It is generally considered good management to get the first "oasting" packed before the third comes off the kiln, and so to continue at that rate through the whole produce. When dried, cooled, and packed in quick succession, the sample is sure to handle better than where any delay occurs between the operations. The ordinary method of *packing*, which is still largely followed, notwithstanding the improved mechanical arrangements that have from time to time been devised for the purpose, is to tread them down into the pockets or bags with the feet. A hole of suitable diameter is made at one end of the cooling floor, with a frame or curb raised about a foot above the level of the floor; a round hoop being first fastened in the mouth of the bag, it is let down through the hole, the hoop resting on the curb, on which, owing to its diameter being a little larger, it rests. In some houses a stout framing is fixed to keep the bags in a proper shape. Into this bag or "pocket" the hops are poured by a boy from a basket or scupper, and as they fall in they are trodden down by a man who remains in the bag until it is filled with pressed hops up to the floor line, when it is removed, and the top stitched down with strong twine, or "coped up," as it is technically termed. *Pockets* and *bags* are used indiscriminately by some planters; the finest samples and best qualities are, however, more commonly packed in pockets, and the coloured and coarser varieties in bags. It is admitted that hops keep better in bags than in pockets. The excise regulations in regard to the *net* weight, however, which affects both the grower in regard to the duty, and the consumer in regard to the *real* weight, are more favourable to the pockets than the bags.

There is a great difference of opinion as to the relative advantages of packing by the old method, and by the use of the different machines which have been introduced, and no doubt time will be required to overcome the prejudices in favour of old practices, which a peculiar and limited cultivation is so apt to engender in the minds of those who follow it. Without going into the merits of the different apparatus introduced, which is beyond our present purpose, it is admitted that the hops may be packed by them in a more regular manner and quicker from the kiln than by the old method, while the chances of injury by exposure during cooling are lessened, and the comparatively slow operation of treading, in itself a dusty and unhealthy occupation for the men, and one which is liable to injure the hops, unless they be in exactly the right condition of dryness, is entirely avoided. The cost of this part of the preparation is about 4*s*. per pocket, the pocket itself costing about 3*s*., and the labour from 10*d*. to 1*s*.; where bags are used, the cost of materials and of labour is just one-half more.

Hop-growing labours under one very serious disadvantage, being placed under excise regulations. The number of acres under cultivation, the oasts, and the storehouses have to be registered, and notice has to be given before the hops are packed and weighed. When this has been all duly supervised, the pockets are marked with the gross weight—the name, parish, and county of the grower, together with the date of the year, having been previously marked in large letters on the bag.

As soon as the hops are picked the poles should be stripped of the bine, preparatory to *stacking*, which should not be delayed a day longer than necessary, as the sooner they are cleared of the bines the better. They are then stacked or "hiled" through the ground: in the former mode they are laid horizontally, the tops being brought together in the middle of the stack, the butt ends only being exposed; in the latter, which is that most commonly practised, they are placed upright, in four lots or quarters, containing 100 poles each, the lot being bound together with hop bines stripped of their leaves, the four meeting together at the top, and forming a large conical stack, the apex or crown, in some cases, being capped by a small thatch to turn the rain off on to the outsides. At the time of stacking, all faulty poles should be drawn out, and separated into lengths, either suitable for young plants or for grounds requiring shorter poles than those from which they were rejected. The poles form a large and important item both in the first cost and in the sustentation of a hop plantation, as each year they require to be trimmed and fresh pointed, and a certain number of new ones to replace those which are rendered unfit for further use. For large poles chestnut is considered the best and most durable wood, next to which come ash, willow, and maple. Larch grown close on the ground has been tried with very satisfactory results. The soil of the hop districts, however, rarely is favourable to the growth of larch plantations, and thus they have to be obtained from a distance, which increases their cost. For the smaller sizes, oak, birch, beech, hazel, white birch, and alder are used—the two last being generally looked upon as inferior to the others. In all cases the age of the wood affects its value for hop purposes: poles of fifteen to sixteen years' growth last considerably longer than those of only eight or ten years'. The market value is also affected by the size, quality, and relative demand and supply.[1]

[1] The tabular statement given shows the market prices for the different sorts and sizes of poles:—

	18 feet poles. per 100.	16 feet poles. per 100.	14 feet poles. per 100.	12 feet poles. per 100.	10 feet poles. per 100.
Chestnut, ...	£2 8 0	£2 0 0	£1 10 0	£1 0 0	£0 8 0
Larch, ...	2 5 0	2 0 0	1 14 0	1 2 0	0 10 0
Ash, willow, maple,	2 0 0	1 14 0	1 8 0	...	...
Oak, birch, beech,..	1 10 0	1 6 0	1 0 0	...	...
Mixed—Ash, &c., with oak, &c.,	1 16 0	1 10 0	1 4 0	0 16 0	0 7 0

The average annual expenditure for trimming and replacing the poles, in addition to the first cost, amounts to from £6 to £7 per acre under crop. Where new poles are purchased, they require but little to be expended for the first year or two. To keep the stock up in good condition, however, will take the sum named, as may be seen in the following statement:—

18 feet poles, 3000 to 4000 to the acre, will require, on the average, 400 new poles at 40*s.* every year, ...	£8	0	0
Value of 400 old poles drawn out, at 12*s*....................	2	8	0
Net cost, ...	£5	12	0
16 feet poles, 3000 to 4000 to the acre, will require 500 new poles, at 34*s*...	£8	10	0
500 poles (old ones) drawn out, worth 10*s*.................	2	10	0
Net cost,..	£6	0	0
14 feet poles, 3000 to 4000 to the acre, will require 600 new poles, at 28*s*.	£8	8	0
600 poles drawn out, worth 8*s*............................	2	8	0
Net cost, ...	£6	0	0
12 feet poles, 3000 to 4000 to the acre, will require 1000 new poles, at 16*s*...	£8	0	0
1000 drawn out, worth 4*s*.	2	0	0
Net cost,..	£6	0	0

To this expenditure for new poles must be added the cost of their carriage and the labour of going over and sharpening the whole stock, cutting down the faulty ones to shorter lengths, &c.; the smallest being fit only for young plants.

A hop ground which has been planted with "cuttings" gives no return at all the first year; if "bedded sets" have been used, a small produce—3 to 5 cwts. per acre—may, under ordinary circumstances, be obtained. In about three years the bines arrive at their full bearing; and if the ground be kept well cleaned and tilled, and its condition kept up by regular and liberal manuring, its productiveness may be sustained for a long period of years.[1]

[1] In the prize essay alluded to, Mr. Rutley mentions plantations from 100 to

If the ground has been thoroughly well prepared for planting, and got into good heart, either by feeding off a root crop on the ground with cake, or by the direct application of manure, it will not require any attention to this point until the second or third year, after which a certain amount of manurial substances should be applied every year or every second year, equivalent at least to the amount, abstracted from the soil, and carried off by the crop. Lime is also a necessary ingredient in all hop soils, and should be supplied freely at first, and afterwards at certain intervals; recollecting always that it is better that the interval should be short and the dose smaller, than that larger quantities should be given at greater intervening periods—that lime must never be applied in combination with any ammoniacal manures—as Peruvian guano for instance—and that lime is always used more beneficially with farmyard dung than by itself in such soils. Therefore, if in the preparation of the ground farmyard manure be used, the lime may be advantageously applied at the same period. Practice has long since pointed out the necessity for nitrogenous manures to our hop grounds, and chemistry has more recently explained to us and confirmed the good policy of this practice. *Woollen* rags, horn shavings, shoddy, seal-skins, and various refuse substances rich in nitrogen, were specially used for this cultivation.[1] Now, however, Peruvian guano is found to be a cheaper

150 years old "noted for growing large crops of good quality, and still continuing to do so." At the recent meeting (1860) of the Royal Agricultural Society, at Canterbury, among the samples of hops exhibited for competition were some the growth of a plantation *one year old*—bedded sets—yield 8½ to 9 cwts. per acre; of a plantation *three years old*, yield 15½ cwts. per acre; and others of various ages up to *eighty* and *ninety years old*, the rate of produce at that age appearing to be fully as large as at any of the intermediate periods. The largest quantity grown to the acre of the samples exhibited was 23½ cwts.

[1] Of woollen rags from 12 to 20 cwts. are given to the acre; shoddy is applied at the rate of 20 to 30 cwts.; seal-skins at the rate of 150 bushels. These are applied either in the winter or the spring, and covered in with the fork.

and more efficient application, as it is not only richer in nitrogen, but its composition is more definite and its action more certain and speedy—the rags, &c., requiring a long period for their decomposition in the soil. Where farmyard dung is used it should be in a well-rotted condition, and applied early in the spring, advantage having been taken of the dry and frosty weather in the winter to carry it out on the ground. From 15 to 20 tons per acre should be given, and should be forked in and covered before the hills are opened for cutting. Where Peruvian guano is used it should be reduced to a finely divided condition, and mixed with at least its own bulk of some neutral inert substance, as coal ashes, sand, soil, &c.

From the foregoing statements it is seen that the formation of a hop ground is attended with not only a very large outlay at the commencement, but its cultivation incurs a considerable expenditure every year to keep it in a proper and productive state. The following extracts from the prize essay give the aggregate cost per acre per annum of a plantation at its commencement and during its cultivation. When old meadow or pasture land has been broken up, no manures are needed, and the expenses of preparation for the first year, exclusive of the rent, &c., which is supposed to be covered by the root or other crop grown in the spaces between the hills, amount to £10, 2*s.* 6*d.* The second year's expenses, including rent, &c., are set down at £16, 4*s.*, to which must be added the cost of new poles, &c., for the succeeding year's growth, amounting to £41, 8*s.*, making, with the expenses already incurred, a total of £67, 14*s.* 6*d.* From this sum we have to deduct the net return of the small crop obtained from the second year's growth, and of the old poles, which require to be changed for longer ones, amounting together to £12, 14*s.* This reduces the balance of outlay for the first two years of the plantation to £55 per acre.

The subsequent expenditure each year in the cultivation of an acre containing 1200 hills, including interest upon outlay in the formation of the ground, manures, repairs, &c., and cultivation, is given at £28, 1*s.* 6*d.*;[1] on high-rented hop grounds, it will of course be more, according to the rent paid. When the larger and better sorts of poles are employed, the interest on the capital invested will be increased; and in small plantations, where hand labour is alone engaged in the cultivation, the annual expenditure will be greater. The figures given are based upon the lowest calculations that can be made consistent with good management; where this is neglected for the sake of a small saving in expenses, the grower is not likely to be so well remunerated.

A detailed estimate is given of the expenses incurred in picking, and every subsequent part of the preparation of hops for the market, assuming 10 cwts. to be a fair average produce per acre, and that 1300 bushels of green hops will yield 1 ton when dried, 1½*d.* per bushel being the price allowed for picking. This, including the duty of £17, 12*s.* 9½*d.*, amounts in the whole to no less than £38, 18*s.* 9*d.*, or in round numbers to £40 per ton, so that each ton of hops sent into the market (requiring for its production 2 acres of cultivated soil) represents a minimum expenditure by the grower of £96, 3*s.*, or £48, 1*s.* 6*d.* per acre, the balance of the selling price per ton over this amount constituting the *profit returns* of the cultivation. These are subject to very great variations, not only as regards season, but also as regards different localities or districts. In unfavourable seasons, when blight has prevailed, the produce on some grounds has not paid the expenses of picking, while on others again, where the plant has not been so much affected, the increase

[1] For details of this and the preceding estimates, see *Roy. Agri. Soc. Journal*, vol. ix. p. 581.

in the price has so raised the value of the produce per acre, as to equal in many cases the value of the fee simple of the ground; and instances have already been given (page 360) where the produce of a district, relative to the aggregate growth of the country, exhibited equal fluctuations.[1]

Both the *diseases* and the *insect injuries* to which hops are subject, have, as might have been expected from the importance of the interests at stake, received considerable attention at the hands of scientific as well as of practical men. The "mould" or "mildew" is that which has excited most attention. This is a disease of a parasitical fungoid character, greatly resembling those other forms already described as affecting, under certain conditions, most of our regular crops. Mildew is always more prevalent in wet seasons, of low mean temperature, and in damp grounds, than under different physical conditions of climate and soil. Some varieties are considered to be more subject to it than others—the Goldings, for instance, than the Grapes. Of all the risks the hops have to encounter in their growth, this is always looked upon as the greatest, for it steadily progresses in its attack with more or less vigour, as the season continues favourable to it or otherwise, until harvest time.[2] When it shows itself to any considerable

[1] In 1801 the duty paid amounted to £241,227, and in 1802 it was only £15,463. The years 1812, 1816, 1823, 1825, 1829, and 1840, were also extremely bad years, the average produce per acre having been only—

	cwt.	qrs.	lbs.			cwt.	qrs.	lbs.	
1812......	1	2	15	per acre.	1825......	1	0	8¾	per acre.
1816......	2	0	19¼	,,	1829......	1	1	25	,,
1823......	1	1	5¾	,,	1840......	1	2	8	,,

[2] In a paper on this subject, read at the Meteorological Society (1854), the author traces a direct connection between the temperature and moisture of the season and the hop produce. In comparing the temperature of the twenty-two years of *smallest* produce with that of the twenty-two years of *largest* yield, the author found that in the former series the average amount of duty was £55,728, and the mean temperature of the summer quarter 0·9° *below* the average; whereas in the latter, with an *excess* of temperature of 1·5°, the average amount of duty each year was £211,909.

extent towards the end of June or beginning of July, the chances of anything like a crop rapidly diminish, no matter how vigorous the bine may appear to have been. This loss frequently falls heavier on the grower than an equal lessening of produce from the effects of insects would do, as the effects of the latter are general, and are felt all over the country, a higher price compensating in some degree for a diminished produce, while the effects of the mildew are of a more local character, and rarely extend so far as to affect to any great degree the general market price The disease first shows itself on the upper part of the leaf as a minute white patch; this rapidly increases in size, and shortly causes a corresponding appearance on the under side of the leaf. The disease rapidly spreads all over the ground; the leaves and stems being thus injured, the health and functions of the plant speedily become affected; and if the season, or the individual circumstances of the ground remain unfavourable, acre after acre falls a victim to a disease which, it appears, may be in many cases entirely prevented, and in most cases greatly alleviated, by a little attention to the causes and conditions influencing it.

Many of these forms of disease are communicated to our cultivated crops from the weeds and decaying vegetable matter we leave undisturbed in our hedgerows and waste places, and even too often in our fields. This particular form has been long noticed on the wild hops, so often seen growing in the hedgerows of the hop districts, on which it is preserved, ready to pass over to the cultivated grounds at any time that ungenial weather should render the plants susceptible to disease. It is well known that many fields which were periodically subject to mildew, were permanently freed from its visitations after the hedgerows had been removed, and all the wild hops and other weeds extirpated. This disease was very prevalent in the Kent districts in 1854;[1] the Goldings were the most affected, and the Jones's the least—the Colegates and Grapes being intermediate. The application of sulphur, either simply or in some form of combination, is the only remedy that can be recommended; its action on the hop is the same as on the vine, and when it is properly and plentifully administered, it is generally successful. The expense of applying any remedy to a disease that requires each individual plant, and even separate parts of that plant, to be separately treated, is no doubt extremely heavy where large numbers have to be considered. In a hop ground, as in a vineyard, the question is between no crop at all or a small probable crop, the result of the remedial treatment; and as in such seasons of disease and diminished produce the prices always rule high, the extra outlay, great though it be—frequently from £15 to £20 per acre—if judiciously made, is repaid amply by the resulting increase in the crop. Another form of disease, the "fire-blast," is met with occurring in dry seasons, and generally on thin and inferior soils. The leaves become blotchy, yellow and dark coloured patches show themselves, when they begin to wither and to fall off. This is generally indicative of a poor cultivation; liberal manuring and good and regular tillage is the best remedy that can be applied to it. This is by some confounded with the "red rust," from which, however, although the appearance is somewhat similar, it is entirely different; the one being the result of disease, the other of the attack of an insect, which we shall presently allude to.

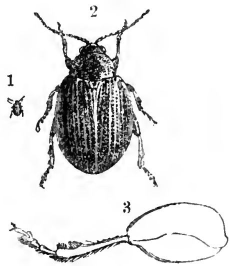
The hop grower appears to be wholly at the mercy of the *insect* tribe. They form the barometer that indicates the rise or fall of his prosperity, as well as of a very important branch of revenue, the difference in the amount of the duty paid by hops, due principally to their attacks,

[1] See a paper by Mr. Berkeley, in *Agri. Gaz.*, 1854, p. 597.

frequently exceeding a quarter of a million sterling. "It would not be difficult (Kirby and Spence's *Entomology*) to show that nearly the whole of this large sum, and their own still greater, are losses thrown away by the hop growers from their ignorance of entomology. Led by their old prejudices of the 'fly' being produced by the cold winds, &c., they do nothing towards its destruction. If aware of the way in which it is generated, and by killing each female in the beginning of the spring, they might prevent the birth not of thousands, but of millions of aphides. Were they to take measures for thus lessening the numbers of their destructive enemy, they would, to a great extent, secure themselves from its attacks. The 'aphides' being so soft, are killed by the slightest pressure, so that it is merely necessary to rub an infested leaf between the thumb and fingers, with a force quite insufficient to injure its texture, to destroy every aphis upon it. From experiments made in the Worcestershire district, in 1838, I am persuaded that every leaf on each plant might be thus cleared of the female aphides first infesting it in early spring, by women or children, at an expense of 1s. per sixty hills, and this might easily be repeated if found necessary; while the *Haltica concinna*, or 'flea,' which attacks the bines earlier in the spring, might be destroyed by shaking them from the plants into a sieve or bag of convenient shape, and removing them from the ground."

Among the first enemies the young hop plants have to encounter are the wireworms, which are more frequently met with where old meadows and pastures have been broken up for the plantation, and commence their attacks as soon as the "cuttings" or "sets" are planted. Rape-cake coarsely ground, and spread round the hills, has been recommended as a remedy; it has the advantage of being a good manurial application, even should it not produce the effect desired. The best and safest plan, however, is to open the soil on the hills for an inch or two deep, and handpick them; a few slices of raw potato placed in each hill will draw them together, and render their collection less difficult and tedious, the potatoes being left in the hills until no more are to be met with. If these insects be not destroyed by some means or other, they will destroy, or, at all events, seriously injure the plants.

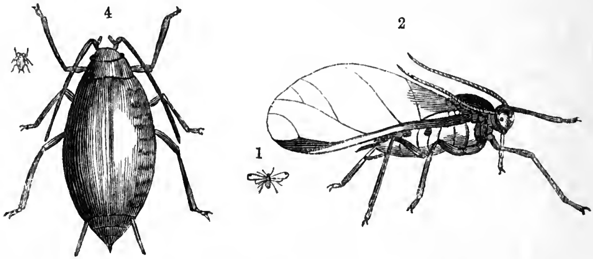
Early in the spring the "hop flea or beetle" makes its appearance on the young leaves and shoots, frequently, if the weather be suitable, appearing in such numbers as to destroy all the vegetation as it appears above ground, and arresting for the time all appearance of growth. This is the *Haltica concinna*, a species closely allied to the common turnip-fly, but broader and more convex in shape. They are of a copper or brassy tint, the wing-cases having about twenty lines of strong dots, and cover a pair of ample wings. They are met with abundantly from March up to August, in woody fields and hedgerows, living on nettles, grasses, &c., and attacking any cultivated plant, as hops, that suits their palate. Several remedies have been recommended for catching and destroying them; but, like the turnip-fly, they are very difficult to catch. Probably the best defence against them is to cover up the young shoots with 4 to 5 inches of fine mould, which gives them security against injury for several days, whe the bines have acquired more strength, and get away faster out of their reach. If much injury has been done to them, the application of a little rich manure, as Peru-



1, 2. Hop flea or beetle—*Haltica concinna*—nat. size and magnified. 3. Hind leg of do.

vian guano, will assist them much when they begin to grow again.

The great destroyer of the hop grounds, however, is the *Aphis humuli*, or "hop-fly," which makes its



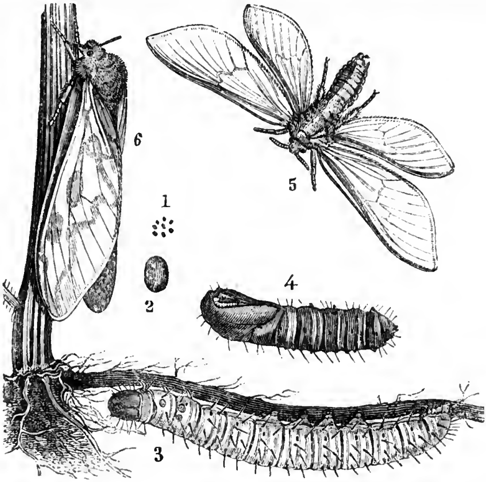
1 and 2. Female Aphis, natural size and magnified. 3 and 4. "Nits" of do., natural size and magnified.

appearance about the middle or end of May, when the bine has made a growth of 4 to 5 feet up the poles. Like other aphides, it is first seen at the top of the plant, fixing itself on the *under* side of the leaves next to the head, and there propagating itself after the rate already described at p. 234, vol. i. The visits of these insects to our crops are still invested with a sort of mystery. We know but little of the conditions, whether of the plant or of the season, that cause them to come, or that relieve us from their presence; their increase is irregular, sometimes very rapid, at others far less so, and in some seasons a change in the wind will cause them to disappear even more rapidly than they appeared. They appear to be particularly susceptible of atmospheric influences, a favourable change in the weather often saving the crop from impending destruction. In June, 1846, Mr. Paine tells us the hops in the Farnham district were seriously infested by this insect, from which they were suddenly freed, and afterwards produced the *largest crop* ever known in that quarter. The condition of the plant, therefore, is never entirely hopeless, however severe the attack may be, provided the lateral fruit-bearing branches be not already formed and destroyed by it; then there is no chance of recovery. Several similar instances occurred the same year in the East Kent district, where the planters sold their crops on the poles as they stood for a few shillings per acre; and yet these same grounds so far recovered that many of them produced a crop worth from £30 to £50 per acre. In such cases, as soon as the bines are free from the lice, whether by a change in the weather, or the exterminating action of the lady-bird or other insects that feed upon them, it is desirable to excite their growth by the application of some readily soluble manure rich in nitrogenous matter; Peruvian guano, salts of ammonia, combined with "superphosphate," are those found to be most efficacious.

One mode of preventing their attack has already been described, and *prevention is always better than cure.* The remedy recommended to be used when they have appeared and commenced their ravages is the application of *tobacco*, administered either in the shape of an infusion, and syringed over the infested parts, or burned in a suitable apparatus, and the plants submitted to the fumes. The good effects on the infested plants of burning weeds have been noticed, and the poisonous influence of tobacco on insect life has been rendered available for this useful purpose in the hop ground. In years when the aphis makes its appearance in large numbers it is usually followed by the "lady-bird" (see p. 62), whose mission appears to be to seek out and destroy these enemies to so many of our cultivated crops. A multitude of other insects also feed upon their bodies, and thus tend to check their undue increase. It has been noticed that a hop ground which has been severely injured by aphides one year is never visited by them the next; and on looking back over the returns of the hop duty, it will be remarked how very rarely two bad years, the results of injury from insects or blight, follow in succession. When they make their appearance late in the season—in August and September, for example—the growth of that year is not necessarily lessened in quantity, but frequently greatly deteriorated in quality, owing to the lice themselves occupying the cones, and depositing excrementitious matter within the scales, thus spoiling both the appearance and the handling of the hops. The aphides that appear at this period of the season are smaller in size than those which attack the bines in the spring, and it has been generally remarked that when they are found in any numbers in the autumn, the bines are sure to be greatly injured by them the following year. In 1848 the quantity was large, but the quality inferior, from this cause, and in 1849 the duty fell from £212,416 to £79,785, owing to the deficiency in the crop.

The "frog-fly"—*Eupteryx picta*—which has already been described (p. 63), inflicts great injuries upon the bines, which they puncture with their strong mandibles, the sap exuding through the wounds, instead of circulating through the tissues of the plants. These are more prevalent in old than in new hop grounds, and require to be sought for and destroyed, otherwise their numbers and their power of injuring the bines increase every year. For this it is recommended to procure a light, shallow, sheet-iron pan, made of a convenient size and shape, to be carried by two women, the bottom of which should be covered with gas tar, so that when it is placed on the ground, at the bottom of a pole, a smart blow on the pole with a stout stick will induce the frog-flies to jump off the bine, and thus be caught by the tar on the bottom of the pan. It should be placed on the leeward side of the bine, and the operation repeated at intervals of a day or two, until they are all destroyed.

Besides these more common enemies, the hop has others which, in their way, commit great and serious ravages. The caterpillars of the "otter-moth"—*Hepialus humuli*

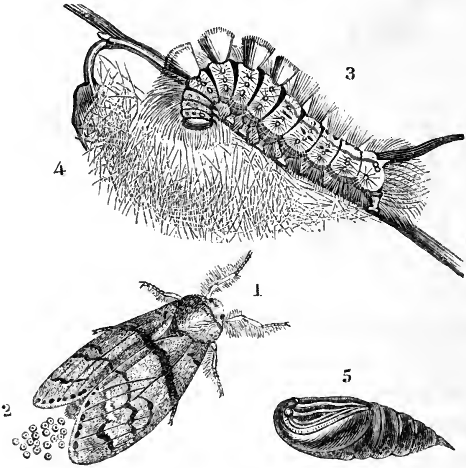


1 and 2. Eggs, natural size and magnified. 3. Larva or caterpillar. 4. Chrysalis of do.
5 and 6. Moth—*Hepialus humuli*—male and female, natural size.

—infest the undisturbed roots, which they penetrate with their strong jaws, consuming the inside as well as the bark. The female moth deposits her eggs in June, and the larvæ—yellowish white in colour, with scattered hairs—bury themselves and feed below the surface until they are from 1 inch to nearly 2 inches in length. The sexes differ in colour and in size, the males being the smallest, and of a satiny white appearance on the outside, and a dusky brown on the inside of the wings, which, while they are flitting about in churchyards and other quiet places at twilight, causes them to appear and disappear as their white or dusky sides fall upon the sight, startling the superstitious, and obtaining for them the common name of "ghost-moths."

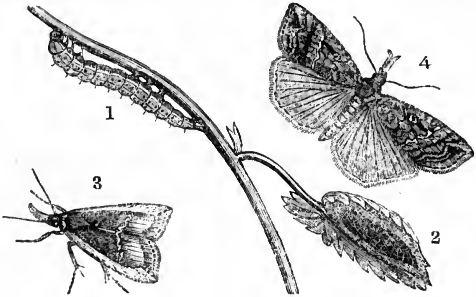
A peculiar centipede, to which the specific name of *Geophilus humuli* has been given, is frequently met with in hop grounds, and is suspected also of injuring the roots of the bines.

The bines receive considerable injuries from the caterpillars of the "pale tussock-moth"—*Laria pudibunda*—



1. Female Moth—*Laria pudibunda*. 2. Eggs of do. 3. Caterpillar. 4. Web spun by do. 5. Pupa.

and of the "hop-vine snout-moth"—*Pyralis rostralis;* to these may be added also the caterpillars of the "comma" and the "peacock" butterflies—*Vanessa C-album* and *V. Io* —though these are not so commonly met, or their attacks so marked, as those of the moths named. The "pale tussock-moth" is a large species, of a grayish white colour, the upper wings freckled, with four irregular transverse darker lines, and an oval spot on the disc, with a row of black spots along the hinder margin. The female lays a number of eggs in June; from these the destructive larvæ commonly called "hop-dogs" are hatched. These are of a greenish yellow colour, with four dense hairy tufts on the back, black stripes dividing the segments, and a long, hairy, rosy tail. When full grown in September they spin a slight yellowish web, within which they change to pupæ. The "hop-vine snout-moth" is of much smaller dimensions, with upper wings of a brownish colour, variegated



1. Caterpillar. 2. Chrysalis of do. 3 and 4. Moth—*Pyralis rostralis*—at rest and flying.

with a dark line across the middle, and a curved one nearer the base. The larva or caterpillar is green, with a very fine brown dorsal line, and a white one down each side, with scattered black protuberances, surmounted by short stiff hairs. There are two broods of the moth in the season —one as early as the middle of April, the other in July. Syringing the bines where the caterpillars have been noticed is recommended by Curtis as a good remedy.

The "red rust" with which the bines are sometimes infested, and which is by many confounded with the "fire-blast," is occasioned by the existence of minute red spiders—the *Acarius telarius*—which take up their quarters in large numbers on the leaves, where they spin their fibrous webs. They are generally met with in dry seasons; if their attack be severe the leaves change colour, and eventually fall off from the bines, and as this generally takes place towards the end of August, the flowers as well as the leaves are more or less affected by them, and are proportionately injured.

Not only are the hops themselves injured by these, and many other insects, no doubt, which have hitherto escaped our notice, but the *hop-poles* also suffer from their attacks, from which considerable losses are annually occurring. The principal culprits in this form of injury are a species of wild bee, small in size and black in colour, with a tuft of ochreous hairs on the face, known as the *Chelostoma florisomne*, the larvæ of which destroy the poles by burrowing into them; and a little beetle, called, from its propensities, the "hop-pole beetle," *Lyctus fuscus* or *oblongus*, the larvæ of which, small in size, thin in shape, and of a chestnut brown colour, bore into the wood, and thus greatly injure it. It would be probably worth while to try the effects of some of the different preparations for preserving timber on the hop-poles liable to be attacked by them; and Curtis tells us that stripping off the bark at first would help to secure the poles from the attacks of the Lyctus, and probably of other wood-boring insects.

The *chemistry* of hops has received considerable attention, both at home and abroad. On the Continent it has been the subject of investigation by Payen and Chevalier,[1] by Ives,[2] by Leroy,[3] and by Hawkhurst;[4] in this country by Way,[5] Johnston,[6] and Nesbitt;[7] whose analyses make us acquainted with its general composition, and indicate the nature and quantity of manurial applications we must apply to our plantations to sustain them in full productiveness.

The average proportions of the three parts of the plant—flowers, leaves, and stem—appear to be nearly equal. The separated produce of two hills was found to consist of—

Hops—Flowers,	3·50 lbs.
,, Leaves,	3·75 ,,
,, Bine or stems,	3·25 ,,

The percentage of ash or inorganic matter differs in the different parts of the plant, and is also subject to considerable variation in the different varieties cultivated. In the flowers it amounts to from 6 to 10 per cent., in the

[1] *Jour. Phar.*, viii. 226. [2] Ibid., xciii. 155. [3] *Jour. Chim. Med*, 1840, p. 2.
[4] *Ann. de Mil. et Reis.*, 1849, p. 507. [5] *Jour. Roy. Agri. Soc.*, ix. 145.
[6] *High. Soc. Trans.*, 1848, p. 69. [7] *Jour. Roy. Agri. Soc.*, vii. 212.

leaves from 15 to 20 per cent., and in the bines or stems from 4 to 6 per cent. The amount of water in the hop is, at the time of picking, about 12 to 20 per cent.

The composition of this ash or inorganic matter is:—

	Hops.	Leaves.	Bine.
Potash,	31·70	13·13	17·16
Soda,	...	...	...
Lime,	9·59	30·78	23·91
Magnesia,	4·80	4·84	3·77
Phosphoric acid,	17·33	9·33	11·69
Sulphuric acid,	5·10	1·89	2·33
Peroxide of Iron,	0·68	0·19	0·80
Silica,	19·16	22·35	9·99
Chloride of Potassium,	8·96	2·29	15·35
,, Sodium,	0·74	3·12	2·63
Carbonic acid,	1·92	12·04	11·92
	99·98	99·96	99·99

The crop of hops—Farnham White-bines—from which the samples analyzed were taken, was a large one, yielding about a ton to the acre, or double the weight of what we have assumed to be a fair average crop. Basing our calculations, therefore, upon the foregoing data as to the percentage and composition of the inorganic matter in the hop plant, we find that the crop would have assimilated and abstracted from the soil in which it was grown the following quantities of mineral matter:—

	In the Flowers.	In the Leaves.	In the Bine.	Gross amt. per acre.
	Lbs.	Lbs.	Lbs.	Lbs.
Potash,	54·01	57·15	22·81	133·97
Soda,	...	...	...	...
Lime,	16·33	133·98	30·99	181·30
Magnesia,	8·17	21·06	4·88	34·11
Peroxide of Iron,	1·14	·82	1·03	2·99
Phosphoric acid,	29·53	40·61	15·15	85·29
Sulphuric acid,	8·69	8·22	3·02	19·93
Carbonic acid,	3·39	52·40	15·41	71·20
Silica	32·65	97·28	12·95	142·88
Chloride of Potassium,	15·26	9·96	19·90	45·12
,, Sodium,	1·26	13·58	3·40	18·24
	170·43	435·06	129·54	735·03

A sample was also submitted to organic analysis, in order to determine the percentage of *nitrogen* the different parts contained, and thus see what quantities the crop had assimilated during its growth. The results are thus given:—

	In the Flowers.	In the Leaves.	In the Bine.
First experiment gave a percentage of.......	2·96	2·51	1·33
Second ,, ,, ,, ...	3·00	2·43	1·35
Third ,, ,, ,, ...	2·98	2·47	1·34

These results show that the crop, the subject of the experiment, removed from the soil 56·44 lbs. of *nitrogen* in the flowers (hops), 49 lbs. in the leaves, and 23·86 lbs. in the stem or bine, or an aggregate quantity of no less than 129·3 lbs. to the acre.

Assuming that good Peruvian guano averages 14 per cent. of nitrogen in its composition, it would require rather more than 9 cwts. to replace this important constituent alone, the *hops* taking about 4 cwts., the *leaves* about 3½ cwts., and the *bines* more than 1½ cwt. If we look to the inorganic analyses, we find also that of the two most important substances, potash and phosphoric acid, the proportion appropriated by the *flowers* is 69·27 lbs. of potash and 29·53 lbs. of phosphoric acid, while the *leaves and bine* carry off 109·82 lbs. of potash and 55·76 lbs. of phosphoric acid. Now, as only one of these three portions of the plant, the flowers or hops, has any market value, it is clearly the interest of the grower to take care that the other portions be carefully preserved and duly returned to the soil, as by so doing he will greatly economize his means, and be able to sustain the normal fertility of his ground at a less expenditure for artificial manures.

THE TEAZLE CROP.

Crops grown for *special* purposes rarely excite much attention, save in the immediate districts of their cultivation, and though some one or two of them—as, for instance, hops and flax—are in this country invested with a general interest, the others are uncared for by most, and indeed totally unknown to many of those occupied in the ordinary farming pursuits.

There are a few of this class, however, which retain a position among our "Farm Crops," and are still to be met with forming a limited cultivation in the different parts of the country, where either the soil, climate, or local circumstances render the districts suitable for them. Among these we find the Teazle, a plant indigenous to this country, and seen frequently growing wild in the hedgerows and waste places where the soils contain a certain proportion of argillaceous matter. The wild teazle has no economic value whatsoever. The cultivated plant is supposed, however, to be merely a *variety* of the wild teazle, the changed form of its *bracts*, which constitute its peculiar value for the purposes to which it is technically applied, being due to and sustained by continuous cultivation.[1] We have no very definite records of the early history of the teazle; we can only trace it back in connection with the manufacture in which it plays so important a part; so that, indeed, although many are disposed, from its frequent occurrence in this country, to look

[1] It is a somewhat remarkable circumstance, that although in harvesting and disposing of the crop many seeds must be left on the ground and dispersed, the cultivated variety is very rarely met with wild, even in the neighbourhood of the growing crops.

upon it as a native plant, others are inclined to suggest the probability of its introduction by some of those artizans whom the troubles of their own country forced over to our shores, and to whom we are indebted for the development of so many of our different arts and manufactures. We have no evidence that the use of the teazle was known to the ancients, though Pliny[1] makes mention of a somewhat similar plant, and Dioscorides[2] has left a drawing and description of the common wild teazle. At the same time there is reason to believe that the manufacture of woollen cloths had attained considerable perfection at the hands of the Romans. In some of their writers we find several passages drawing the distinction between *piled* or *napped* fabrics, which they called "pixæ," as distinguished from those called "tritæ," which were simply woven, the threads being left exposed. These passages, if properly understood, would infer that both *fine cloths* and common stuffs were known to them, and if so, we are in ignorance as to the method they adopted for raising the nap, for which we make use of teazles at the present day.

In former times certain valuable properties were assigned to the water collected in the stalk-sheath of the plant, where the leaves, uniting at their base, form round the stem a hollow cup. This water had the reputation, which is retained to the present day in the minds of the ignorant and superstitious, of being a sovereign remedy for diseases of the eyes. *Labrum Veneris* is one of the names given to the plant by the old writers, and indeed it is not uncommonly called "Venus's Eyebath" at the present day. It was evidently well known in this country in Gerarde's time, as he has described and figured it in his *Herbal*. He speaks of the virtues commonly as-

[1] *Nat. Hist.*, lib. xxvii. c. 10.

[2] In the manuscripts of the Vienna Museum.

signed to it, and tells us "that it is sowne in this countrie in gardens, to serve the use of fullers and cloth-workers."

The woollen industry in which the teazle must have been used, was established, however, long before this date, as we have good evidence of its existence towards the close of the twelfth century, either in the reign of Henry II. or his son Richard I. Indeed, we find it stated by William of Malmesbury, that some Flemish weavers established themselves in the vicinity of Carlisle in the reign of William the Conqueror; but on some disagreement with the inhabitants, they were afterwards removed, in the time of Henry I., to Pembrokeshire. In the same reign cloth-weavers are mentioned in the exchequer accounts; and in the two following reigns they are represented as paying fines to the crown for the privilege of carrying on their trade.[1] The greatest advance in the woollen manufacture seems to have been made in the time of Edward III., in the fourth year of whose reign John Kemp, a celebrated Flanders cloth-worker, received a license to settle himself in this country, which he did, with a number of dyers and fullers, at Kendal, in Westmoreland, where the name exists probably at the present day. The place soon became celebrated, as it still remains, for its coloured goods.

It is about this period that teazles appear to have been regularly cultivated for the uses of the new industry, which was supported by the encouragement and protection given to Flemish artisans to come over and settle in the country, the exportation of English wool being prohibited, and the weaving of foreign cloth being opposed by the government. In a few years regular markets were established, and the "tuckers" or woollen weavers became an incorporated body. Particular towns began to furnish parti-

[1] Madox's *History of the Exchequer.*

cular colours. "Kendal green" is mentioned by Shakspeare in his play of "Henry IV.;" Coventry was famed for its blues, Bristol for its reds, and many other places were equally celebrated for other tints and hues. The industry flourished in every district where it was introduced, and teazles were, as a consequence, cultivated in its neighbourhood.

The sole use to which teazles are applied is in the manufacture of woollen cloths, their curved, tough, yet elastic bracts catching hold of the filaments of the woollen yarns, and giving the surface a rough appearance. This "nap," as it is termed, by a subsequent operation is cut down perfectly smooth, and gives the fabric a soft feel and beautifully finished appearance. The quantity of teazles required for this branch of industry is very large, as each piece of fine cloth requires from one-eighth to one-sixth of a "pack" of "middlings" to bring up the desired face. Many mechanical substitutes, chiefly in the form of steel cards, have been devised, and from time to time introduced, but none have succeeded in supplanting the teazle, whose superiority consists in its elasticity and strength being just sufficient to raise the "nap," without injuring the texture of the fabric, should any knot or other obstacle present itself to their action.

The teazle belongs to the order Dipsaceæ, of which it constitutes the only genus which forms an object of cultivation. The order itself is a very small one, and consists chiefly of herbaceous plants or small shrubs. Its members appear to be natives of Southern Europe—Barbary, the Levant, and the Cape of Good Hope—not being particular as to locality, save that they generally do not like cold, and consequently do not grow so well in elevated and exposed as in low and sheltered situations. Some species possess medicinal properties; some contain an astringent principle, which gives them a certain value for tanning purposes; while others again possess a colouring matter, which might, under fitting conditions, be rendered

DIPSACUS FULLONUM—Fuller's Teazle.

available to the dyer. The only member, however, whose properties are sufficiently important to render it an object of direct cultivation, is the *Dipsacus fullonum*,[1] "Fuller's

[1] διψακος, thirsty; from διψαῶ, I thirst.

Teazle," which stands alone as the only instance of a vegetable substance being used for mechanical purposes in the state in which it is naturally produced.[1] This, which appears to be a domesticated variety of the common wild teazle—*Dipsacus sylvestris*—of our waste places, is a biennial plant, with a fleshy, tapering root, and a coarse, angular, prickly, leafy stem, growing to the height of from 4 to 6 feet. The leaves are oblong, serrated, prickly at the back, and joined at the base with a kind of cup, in which the moisture arising from the dews or the rain is collected and retained. The flowers, which are of a whitish colour, with pale purple anthers, are arranged in a long blunt head, bristling on all sides with stiff, hard, *hooked* bracts.

The teazle requires for its healthy development a soil containing a large proportion of clay; its cultivation therefore is confined to the strong loams and clays, and is, moreover, limited in its range to the very few districts in the country which furnish a market for the produce of the crop. These exist in Essex, Wilts, Somerset, Gloucestershire, and the West Riding of Yorkshire, and to these counties the cultivation is principally confined. As it is a crop widely different in its mode of cultivation from our ordinary farm crops, it is usually met with being carried on by small farmers or speculators, the trouble and labour required and the risks to be encountered being too great for ordinary farmers to be willing to incur. The soil selected should be strong, deep, and free from stagnant water; land newly broken up from grass generally gives the largest returns, although, at the same time, it is not desirable that the soil should be in too high condition, as the plants have a tendency to become too herba-

[1] Perhaps another instance may exist in the Dutch rush or shave-grass (*Equisetum hyemale*), which is used in its natural state for finishing off fine carvings in wood, or plaster casts.

ceous in their growth, and the produce is diminished both in quantity and in quality.

Being a crop so exceptional in its tillage characters, it follows no particular order in the *rotation*. It may succeed any of our ordinary crops; and owing to the careful and constant tillage it receives during the period of cultivation, it leaves the land in a very free and clean condition, suitable for any crop that it may be desirable to take after it. Generally speaking, teazles are seen growing in small patches upon any outlying or irregular-shaped pieces of strong land; these are troublesome and difficult to work, and are frequently let by the farmer to the "teazle grower," who pays a rental for the use of the soil for the two years which the crop requires to come to maturity, and who undertakes the labour and general expenses of cultivation. The soils suitable for the teazle cultivation being of an argillaceous character, require to have the work of preparation completed before the winter sets in. If a straw crop has preceded it, advantage should be taken of the autumn to get the land well cleaned before ploughing the winter furrow, and if the teazles are taken after either a root crop or forage crop, it is equally desirable to get the land ploughed as early as possible with a good deep furrow, so that the winter's rains and frosts may exert their full action upon it. In the spring the work of preparation is continued until a good deep tilth be produced, and a proper seed-bed secured.

The beginning of April is generally the best seed-time, and although the common practice is to sow the seed broadcast, "drilling" is strongly recommended. Half a bushel of seed is usually sown to the acre, and the drills should be set at 24 inches apart. The seed requires no previous preparation, and if the season be warm and moist, the young plants soon show their heads above the surface. In about a fortnight or three weeks' time, the plants will be ready for "singling." This should be done as soon as they have made their second pair of leaves, and the best plants left at about 18 inches apart in the rows. The land now requires to be kept clear of weeds, and constantly stirred between the rows; and as a great deal of the labour is commonly done by the grower himself, a peculiar narrow spade, with a blade 18 inches long by 6 wide, known as the "teazle spade," is used for the purpose, the handle of which is curved, so as to allow of it being used as a paring tool, thus effecting its work as a sort of hand cultivator. This operation is repeated at intervals, as may be necessary, during the summer, at a cost of about 12*s.* to 15*s.* per acre for each "spading;" and as the general custom is to go over the land three times the first season, each time working a little deeper than the previous one, this item of labour alone will amount to from 40*s.* to 50*s.* per acre. Any sickly plants should be removed, and blanks filled up from the nursery bed, which it is always good policy to have in a spare place on the ground or elsewhere, as where the expenses of cultivation are so large, it is important to secure, as far as possible, a good return. Where teazles are cultivated to any extent as a regular crop, it is sometimes the practice to sow only one half of the ground intended for the crop with teazles, and the other half with some other crop (either for seed or forage purposes, as may be most suitable), that will leave the land clear early in the autumn. In such case the young plants are left much closer in the drills, say at 6 to 9 inches apart, so that when the crop has been got off the other portion of the land, and it has been ploughed up and properly prepared, it may be stocked with the surplus plants, carefully drawn from the drills and transplanted at the proper distances apart. By this practice the rent of half the teazle ground is saved, while the profit obtained from its produce is more than sufficient to pay for the extra labour of preparation, transplanting, &c. Before leaving it for the winter, it is desirable to see that "grips" or surface drains are opened to take off any excess of rain that may fall and not pass through the soil, as if the water lies any time on the plants they are sure to die off, and thus reduce the produce of the crop.

In the early spring the same operation of hoeing and spading takes place, and as the season advances, the young plants commence to throw up their seed stems, when they should receive their last spading, and be carefully earthed up, the mould being drawn round the roots and stems, so as to give them greater firmness in the soil, and enable them to carry large branching heads. The flowering generally takes place early in July, and as soon as that process is completed, the crop is ready for harvesting, which should be commenced as soon as *any* of the heads are ready for cutting. The operation is a somewhat tedious one, as the heads mature very irregularly, and the plants have to be gone over singly many times until all their produce is matured. When this is accomplished, the stems should be pulled up, and burned in small heaps on the ground, the ashes being distributed carefully over the surface. The heads are cut off with a sharp knife used for the purpose, with the stalk about 9 inches long; great care is needed, so as not to injure them, and thick gloves are worn by the men as a protection to their hands. When cut, as a rule, they should be always carried home, and placed under cover at night, as even the dews, frequently very heavy at that season of the year, are liable to injure them. If, however, the season be early, and the weather be very dry, they are sometimes tied together in small bunches, and left hanging on the standing plants for a day or two to harden and dry. Every advantage should be taken of sunshine and dry weather to expose them as much as possible, and great care must be taken not to attempt to pack them before they are quite dry. Where the crop is continuously grown, drying sheds and long poles, suitable for carrying them, form part of the "plant" of the farm; where the land is sublet, they are provided by the "teazle grower."

In harvesting teazles the terminating heads are generally first ready for cutting. They are larger and stronger than the others, and only fitted for coarse and inferior cloths. These are known by the name of "*kings.*" The lateral heads are ready the next; these produce the prime teazles, which have received the name of "*middlings;*" and all the heads which, from being either undersized, or in any way defective, so as not to be classed with the others, are tied up by themselves, and termed "*scrubs.*" These various qualities are either separated at the time of "cutting," or are arranged in their different classes after they are dried and when they are being made up for the market. In preparing them for market, it is customary to make them up into "handsful" of from twenty to twenty-five heads each, which are spread out like a fan, and tied together by their stalks, one being left longer in each lot than the others for this purpose. From twenty to twenty-five handsful are strung on to a light hazel rod (like a string of onions), and constitute a "staff," and forty staves constitute a "pack." The "pack," as it is sold in the markets, thus contains about 20,000 heads or teazles. In making up the "kings," however, smaller numbers are used—ten heads go to the "handful," thirty handsful to the "staff," and thirty staves or 9000 heads only, to the "pack." This preparation for the market is usually performed by the persons engaged to harvest the teazles, who are accustomed to the work, and are paid for it at about the average rate of 5*s.* per pack. Teazles are usually purchased of the growers by dealers, who travel through the teazle-growing districts with a light-framed two-wheeled vehicle, on which the "packs" are built up, and taken away to the centres of consumption in the clothing districts.

As the cultivation of teazles involves a large amount of careful and constant labour, it seems to be a crop well suited for cottagers or small farmers, who can give their personal attention to it, or even the labour may be let out at so much the acre from the time of sowing to the harvesting of the crop In some cases the field is let for the crop at a certain price per acre; in others, the farmer finds the land, manure, and horse labour, and takes the risks of the produce, merely contracting for the manual labour during the growth, harvesting, and making up of the produce. The cost of cultivation, including rent for the two seasons the crop requires for its production, amounts to about £15 or £16 per acre; while the returns are subject to great fluctuations, as if the weather should continue wet and unfavourable at the time of flowering, the yield is greatly diminished. The average produce may be taken at from five to eight packs to the acre; from twelve to fifteen packs, however, have been obtained in favourable seasons. This variation we can readily understand, when we recollect that each plant carries from ten to thirty heads, and that at the distances recommended—24 by 18 inches apart—there would be 14,520 plants to the acre. The money return is subject also to considerable fluctuation, though the range of prices has not been so great since the importation of foreign teazles as it was before. An instance is given[1] "of a field of poor clay land which grew an enormous crop more than forty years ago, worth at the time in the market more than twice the value of the land upon which it was grown. That land was laid down to grass after this crop, and remained for thirty years capable of feeding not a sheep, hardly half a

[1] *Cyclo. of Agri.*, vol. ii. p. 955.

dozen rabbits per acre all that time. It was then broken up again, sown with teazles, and bore all the appearance in the month of June of a crop equal in quantity, though not, of course, in market value, to the one it had before. A wet July, however, supervened, and the whole crop was worthless.

Teazles are usually looked upon as a very exhausting crop, for what reason it is somewhat difficult to conjecture, as, although we are without any reliable data upon which to base anything more than an opinion, we may fairly assume that a crop which takes two years to complete its growth, and which receives during that period incessant and careful tillage cultivation, and of which only a small proportion is sold off the farm, instead of exhausting the land on which it is grown, should rather improve it, and render it fit for the reception of other more important crops. And this is practically the case, as, owing to the thorough manner in which the land is worked and cleaned during the cultivation of teazles, the straw crop, which is usually taken after it, invariably shows the benefit it receives from the previous preparation the land has undergone. We must recollect, however, that, generally speaking, the field selected for the teazle crop is of an inferior clayey character, which, from its natural poverty, and difficulty of working, has been more or less neglected by the occupier of the land. Although, therefore, the working it has to undergo during the period of the teazle cultivation fits it for the reception of other crops which could not otherwise be profitably attempted in it, still the cultivation of the teazle does not add to the fertility of the soil in its manurial or chemical sense, and it continues to be comparatively unproductive.

Teazles are a very hardy crop. If land has been properly prepared, and the plants get a good start, the only risk they have to encounter is at the time of flowering, which, with all plants grown for their seed heads, is a period of considerable importance. In their early growth they are liable to the attacks of slugs, and the grubs of other insects, which sometimes occasion great injury to them. A top-dressing of lime, soot, or the other substances already referred to in our forage and root crops, applied along the rows early in the morning, when the dew is on the young plants, will generally effectually stop their ravages. The only other insect that has been noticed infesting the teazle is the *Pyrgus malvæ* or "grizzled skipper," a butterfly about an inch broad in the expanse of the wings, the upper sides of which are of a dark brown colour, marked with numerous cream-coloured spots. The caterpillar is green, with pale longitudinal stripes, a black head, and a yellow ring round the neck, and is met with feeding on the leaves of the teazle, which it rolls up and greatly injures. The species is a common one, appearing about the end of May, and to be found in most part of the country.

Of the *chemistry* of the crop we can say nothing, as we can find no records of analyses in the journals of our own or of foreign countries. Although the cultivation of the teazle itself offers but few inducements to the agriculture of the present day, the investigation of its composition, especially as regards its inorganic constituents, is recommended to those chemists who are willing to take up even an unimportant subject, when by so doing they can contribute to the general stock of useful knowledge.

THE WOAD AND WELD CROPS.

AMONG the crops cultivated for special uses are the plants used for *dyeing*. These are generally natives of warmer climates than our own; and therefore, with the exception of one or two, have never entered into cultivation here, and those that have formerly been grown here, are now only to be met with in cultivation to a very limited extent. The two which we have to describe in this section of our subject are WOAD and WELD—the one furnishing a blue and the other a yellow dye material, much valued in certain branches of textile manufacture. They are both hardy plants, indigenous to this country, and therefore, so far as their natural habits are concerned, perfectly suitable for cultivation.

Woad, which we will take first, has been long known and cultivated for the colouring matter it yields. Although we have no distinct mention made of it by the Roman agricultural writers, still we find it among the plants known to the Greeks, and figured by Dioscorides in the MSS. of the Vienna Museum. In this country its early history is also somewhat obscure. It is supposed, however, to have been the plant with which the ancient Britons were accustomed to stain their bodies.[1] It was grown far more generally in this country in the earlier than in the later periods of our history. It is mentioned by more than one of our earlier authors, and indeed it is

[1] "Omnes se Britanni *luteo* inficiunt, quod et cœruleum efficit colorem."—Cæsar, *De Bello Gallico*, v. 14. This is confirmed by Pliny, who says (lib. xxii. c. 1) that it was used for colouring the bodies of the women and girls during certain religious ceremonies.

said to have given its name to one of the oldest cities in the west of England—Glastonbury, originally called "Glastum," from the Celtic *glas*, blue—the city being so named from the large cultivation of the dye-producing plant woad in its immediate vicinity. Notwithstanding these records of its existence and use in this country from the most remote periods, we have no very distinct records of its regular cultivation as a crop anterior to about 1582, when it was introduced from the Continent, where, especially in France and the Low Countries, it had been cultivated successfully for many years before. In Gerarde we find it figured and described under the name of *Glastrum sativum*. He says of it, "that it serveth to dye and color cloath: profitable to some few and hurtefull to many." Previous to the introduction of indigo, the dye obtained by fermentation from the leaves of this plant formed the staple blue of all European dyers, and prejudice long upheld in this country the interest of its growers against the substitution of its more brilliant and economical foreign rival. Of late years, the cultivation of woad has almost entirely ceased to be carried on in this country. It is now rarely to be met with anywhere but in Lincolnshire, and there only to a very limited extent. Formerly the great clothing districts of the west of England and Yorkshire, by furnishing markets for the produce, offered inducements for its cultivation in their neighbourhood; the increased facilities of transport of the present day have, however, quite neutralized the advantages of proximity in an article so comparatively small and unimportant as regards its bulk to the general cost of production of the articles in whose manufacture it is used, and the cultivation of woad is now limited to those districts where, from the nature and character of the soils, it can be grown most profitably, irrespective of their connection with the centres of consumption. Although indigo has virtually superseded the use of woad in the dyeing of vegetable blues, still a certain demand exists for woad, which is used frequently in combination with indigo for certain tints, and also as a basis for blacks and other colours.[1]

Woad belongs to the order CRUCIFERÆ, which furnishes so many important and valuable plants to the agriculture of this country. It constitutes the distinct genus ISATIS, the species cultivated in this country being the I. TINCTORIA, or DYER'S WOAD. In China, another species, the *I. indigotica*, is largely grown for the same purposes in the northern provinces, where the true indigo[2] cannot be cultivated.

The plant is a biennial, growing to the height of 3 to 4 feet, with succulent, smooth, glaucous leaves, the uppermost being heart-shaped at the base. The flowers, which are small and of a golden-yellow colour, are arranged in panicles, branching, and are succeeded by dark-coloured short pods, opening into two valves, each of which contains a single seed. It is frequently met with growing wild about fields and cultivated places, and is supposed to be a native plant, although no really wild habitation could now be pointed out for it.

The range of soils in which woad can be successfully cultivated is limited to those of the richest description. Deep friable loams containing large quantities of organic matter, as the fen lands of Lincolnshire and Huntingdonshire, the rich alluvial bottoms of valleys, or along the course of the slowly running rivers, which are met with in the western and in the east midland counties, are those alone in which its cultivation is now attempted to be car-

[1] Much curious and interesting information in regard to the introduction of indigo, and the circumstances attending it, is given in Beckmann's *History of Inventions*. See also Schrebers, *Beschreibung des Waidtes*, Halle, 1752.

[2] Indigo is produced by the *Indigofera tinctoria* and *I. cærulea*, both plants belonging to the papilionaceous sub-tribe of the order *Leguminosæ*.

ried on. And even on soils of such natural fertility as these, great care is taken that their condition be not reduced by tillage cultivation previous to the woad crop, for which it is generally the custom to hire rich pieces of

ISATIS TINCTORIA—Dyer's Woad.

old pasture land for the intended period of the crop. On the richest class of soils the crop may be profitably continued under cultivation for four years; three years, however, is the ordinary period, and even two successive crops are considered enough to be taken from soils of an inferior quality. It is clear, therefore, that the richest soils are the most advantageous to occupy in this cultivation, as the expenses of preparation, &c., which are very heavy, are thus spread over four instead of over two years' crops. The crop being, in every respect, of a special character, does not interfere with the regular rotation of the farm, and indeed the manner in which its cultivation is usually carried on, removes it from any direct connection with the farm at all, save where the occupier of the land grows the crop himself. By far the more common practice is for the "woad-grower" to hire the piece of land suitable for his purpose at an agreed price for the term —either two, three, or four years—of his cropping, for which a high price is always paid—from five to fifteen guineas per acre—the grower undertaking the whole of the subsequent tillage, harvesting, and preparation of the produce for market.

In the preparation some growers prefer breaking up the land late in the autumn, by giving it a good deep furrow, and leaving it exposed to the action of the winter's rains and frosts. Others, again, consider that the sooner the seed is sown after the land is broken up the better, and consequently defer the ploughing until the early spring. Probably the difference in the mechanical texture of the soil may affect this question. The alluvial soils on the banks of rivers, containing certain proportions of argillaceous matter and having at the best but a sluggish drainage, would be far less likely to be reduced to the fine tilth necessary for the seed-bed if the breaking up were left until the spring, than if it had been done in the previous autumn; whereas the deep, friable organic loams of Lincolnshire, and those met with in the valleys of older geological formations, would probably be better adapted for sowing directly after being ploughed than if they had been left in furrow during the winter months

The weathering action of the winter upon the two extremes of soils—clays and sands—is very different; upon the one the tendency is to disintegrate and separate its particles, and thus produce a tilth or finely-divided mass of soil; upon the other the frosts have little or no action, and the rains merely tend to wash out the finest portions, and to bring the coarser portions closer together, and thus form a more compact and consolidated mass. And the more our soils approach either to the one or to the other extreme—whether clay loams or sandy loams, for instance—the more they are influenced in the manner described by the action of the weather, if exposed to it during the winter months.

In either case the land has to be broken up, and the surface sward buried sufficiently deep to insure its decomposition and to prevent its appearance above the surface, which, during the entire existence of the crop, requires to be perfectly clean and free from weeds. The surface must then be harrowed and rolled, if necessary, until a proper tilth be obtained for the seed-bed. This is always a matter of great importance with all the cruciferous plants we cultivate. The seed-time commences in March and is continued at intervals until the end of May, as, owing to the constant hand labour required in the cultivation, it is always considered advisable to divide the crop, so that the different portions may come on in succession and render the application of the labour more economical. The seed should always be deposited by the drill, it being very important to regulate both the depth and the distances of the rows, in order that the growth may be equal and the weeds be kept down. It is equally important that the seed used should be *quite fresh;* about one bushel is ample for the purpose—a light roller being run over the surface to insure its evenness. The seeds should be deposited in drills, 12 inches at least apart, and about half an inch in depth, and covered in either by a bush-harrow or a very light pair of seed-harrows, the operation being finished by a second turn of the light roller over the field.

Although woad likes a moist soil, stagnant water immediately tells its tale upon the crop—the plants turn yellow and are soon destroyed. On the low-lying soils generally selected for the cultivation, the drainage is frequently sluggish, and after a heavy rainfall the water has a difficulty in getting away. To meet this state of things, which, if allowed to remain, would probably materially injure the crop, it is always recommended to cut "grips" or water-courses over the field as soon as it is sown, to take off any surplus moisture and keep the young plants dry. The seed, which is even of less size than turnip seed, vegetates in from seven to fourteen days, according to the time of sowing—the earlier sowings growing more slowly than the later, which, however, are far more liable to injury from the "fly," which is as destructive to this as to the turnip crop. When the plants are well up in the drills, and have made a growth of 2 to 3 inches, they require to be "thinned," in the same manner as our root crops, though they are allowed to remain closer on the ground, as their growth is kept down by the continual cropping they undergo during the whole of the growing season. This "thinning" is usually performed by the workers—men, women, and children being indiscriminately employed—on their knees, short spuds or knives being used for cutting out the plants, and for extirpating the weeds at the same time.

Towards the middle or end of July the first sowing will be generally ready for "cropping." This should always be commenced as soon as a change is noticed in the colour of the leaves: this indicates full maturity, and if it be delayed any longer, both the quantity and the quality of the produce suffer. At this time the plants, under favourable conditions of cultivation, should average 8 to 9 inches in height; the leaves should be succulent, and of a good green colour. The mode of cropping or harvesting is both tedious and costly; the leaves are pulled off separately, by a peculiar twist of the hand, from the stem of each plant, which is left uninjured to produce a second crop of leaves. The plucked leaves are placed in small baskets or "skips," carried by the workers; these are from time to time emptied into larger ones, in which the produce is removed from the field to the building, where the subsequent preparation they undergo to fit them for market is carried out. The whole operation of cropping is performed by the workers on their knees. The greatest care is required that no weeds should be mixed with the leaves, and that they should be sound and quite free from grit or dirt, as the mixture of any foreign matter deteriorates the sample. After the crop has been all pulled the ground is well stirred between the rows, the weeds destroyed, and the workers moved on to the next-sown portion of the field, which by this time should also be ready for harvesting, where the same operations are carried out, and the stripped plants left to continue their growth, and replace the leaves of which they have been deprived. In about six weeks from the time of stripping, the plants are again ready for cropping; and this is in some cases performed a third time—the produce decreasing at each repetition, the third rarely yielding more than half the produce of the first. Indeed, some prefer merely to take the finest portions at the last cropping, leaving the remainder to be fed off by sheep, which eat it readily enough, especially as the frosty mornings prevalent at that season of the year deprive the stems and leaves of the bitterness they otherwise possess.

The cultivation of the crop the *second year* is exactly the same as that of the first; the same care is required to keep the land well stirred and cleaned, and the same attention in keeping the produce free from the leaves of other plants and from any extraneous matter. In no case, however, is the produce of the second year equal in *quality* to that of the first. Where the crop is regularly grown every year the produce of the first and the second year's plants is frequently mixed and manufactured together, or they are kept separate, and sold according to their respective qualities. A portion of the crop of the last year is usually set apart for seed; the plants are then left untouched, or the leaves merely taken from the lower part of the stems. A flower-stem is thrown up in the spring, and large bunches of darkish yellow flowers appear; and about July the seed-pods are matured, when they are harvested precisely in the same manner as that described for turnip seed (vol. i. p. 311), the seed being generally thrashed out by the flail on the field.

The cultivation of woad is kept as much as possible in the hands of a few growers, whose object appears to be to restrict the competition, and thus keep up the market price for the article they manufacture. The quantity of seed grown, therefore, though the yield is very abundant, is confined to their own requirements, and great difficulty always exists in procuring any for use. One writer on the subject tells us that so closely was the seed guarded from all who would be purchasers, that very few years ago none could be obtained, even at the most exorbitant offers. It is stated that a labouring man on one occasion obtained permission of a woad-grower to glean the straw and stalks from a field of 12 acres, where woad seed had just been grown and harvested: he cleared off the rubbish, as he said, "for firing," and out of it managed to get about 2 lbs. of seed, which he sent up to a house in London, and received no less than £50 for his parcel of gleaned seed.

The dyeing properties of woad are due to a peculiar vegetable product developed in the juices and cellular tissues of the leaves during the fermentative process through which it has to pass in its preparation for the market. Upon the knowledge and skill of those employed in this process of preparation the quality of the product, and the consequent profit of the grower, mainly depend; for although the soil and season may be favourable, and the yield great, the quality and market value may be seriously affected by either want of knowledge or of attention in the various stages of preparation through which it has to pass. The various changes which the woad undergoes in the process are all without doubt susceptible of a chemical explanation; but as the changes in vegetable substances induced by fermentation are still very imperfectly known, and as the investigations of chemists in reference to such subjects have been directed almost entirely to madder, we think it best not to attempt any explanation of the process, but merely to describe the *modus operandi*, so as to render the preparation itself intelligible to those interested in the cultivation.

A knowledge of the various indications by which any opinion can be formed as to the progress of the operation in its different stages, can only be acquired by experience and careful observation in the houses where the woad is prepared. The rules by which the process is regulated, though entirely empirical, are still susceptible of a scientific elucidation, consequently the process would be far more readily comprehended, and far more likely to be improved upon, by one who had previously made himself acquainted with the principles upon which his manufacture was based (*the chemistry of fermentation*), than one who was satisfied to continue working by the "rule of thumb."

The first process in the preparation or manufacture of woad is that of grinding or crushing the leaves to the state of pulp. This is effected by submitting them to the action of large and heavy wheels (edge-runners), attached to a central upright shaft, and travelling in a circle on a floor, either in iron or granite prepared for the purpose. A rotating motion given to the shaft is of course communicated to the wheels, which are either made of wood bound together by iron tire-hoops, or they are skeleton wheels in iron, with thick and heavy peripheries, and "coned," so as to reduce the friction in moving round small circles of unequal diameters. The amount of "coning" required is determined by the relation between the "sweep" of the mill and the breadth of the wheels employed, bearing in mind that a small sliding action is desirable, as that combines a tearing or grinding, with the simpler crushing force of the wheel. The mill is fed with the fresh leaves as they are brought from the field, and the pulp, when sufficiently ground, is removed from time to time, and laid up in small heaps to drain, until the mass is sufficiently dried to cohere when taken up in the hand and moderately pressed. It is then ready for the next process, that of "balling," which is performed by the hand, the pulp being squeezed and made up into flattened round or oval-shaped lumps, of about 4 to 6 inches diameter. A stout lad or man is able to "ball" as much pulp as is ground by each wheel or edge-runner worked in the mill. The "balls" are then taken to the drying shed, which is usually economically built of rough materials, tiled at the top, and weather-boarded, "louvre" fashion, at the sides, the object being to give free access to the passage of air throughout the range, and at the same time to keep the interior perfectly rain-proof. The interior is fitted up with skeleton frames or shelves, carrying rows of "wattled" hurdles, one above another, on which the "balls" are arranged, and left until they are sufficiently dry. The time required for this of course varies with the hygrometric conditions of the atmosphere, and also with the internal arrangement, more or less perfect, of the shed. Great care is needed that the balls be perfectly dry before they are removed, as unless such be the case, fermentation will be set up, and the produce proportionately injured.

The colour and the handling of the balls are the best indications of their fitness for removal; the outside should have become very nearly black, and the inside be of a purplish tint, and if a small portion be taken and rubbed between the forefinger and thumb, it should have a tendency to separate, and not rub down into a paste. Much of the future value of the woad depends upon its condition at this stage, the quality and consequent market price being in proportion to its specific weight, clearness of colour, and freedom from grit or other impurities. As the "balls" are from time to time removed from the drying sheds, they are stored away in a dry and ventilated place appropriated to their reception, until the cropping season is over, when the entire produce of the year is submitted to the last process of the preparation, the fermentative action, technically known by the term "couching." This process requires more judgment, skill, and careful labour on the part of those engaged in it than any of the previous operations, either of growth or manipulation, and as it is carried on during the winter months, it retains and occupies profitably the skilled labour required for the general cultivation of the crop. The only preparation required for "couching" is to reduce the "balls" to a coarse powder, which is readily effected by the same machinery used in the first grinding process; the ground woad is then spread on the floor of the couch to the depth of 2 to 3 feet, where it remains until the fermentative process which it has to undergo is sufficiently carried out.

The presence of moisture is necessary to all fermentative action, which indeed is mainly controlled by its absence or presence in proper proportions; so that in this case, beginning with a dry substance, the addition of water is necessary to set up, in the first instance, the fermentative process, while its judicious administration during the subsequent periods of the operation places a power in the hands of the skilful workman, which enables him very materially to control the changes that take place in the mass, and thus to obtain a satisfactory result in the shape of superior quality of produce. It is of the utmost importance that the fermentative action should pervade the whole mass *equably*, and this can only be secured by frequent and regular waterings, and by constantly keeping the mass turned over and over, as notwithstanding all our endeavours, the action of decomposition will be proportionately more vigorous as we descend below the surface, and the only way to check and regulate it is to keep shifting the lower layers to the top. Considerable care and skill are required in turning the mass with the shovel, so as to separate any portions that are disposed to cling together, and to leave each shovelful lying as light and as separate as possible.

As the process proceeds, various gases, resulting from the gradual decomposition the mass is undergoing, are generated; these are indications of its progress that call into play another organ of sense—the nose—an experienced workman being able to form a very correct opinion as to the state of the mass—whether the fermentation was proceeding too fast or too slowly—by the peculiar odour emitted, and which, to those unaccustomed to a "woad-house," is extremely offensive and injurious. If the fermentation flags the woad is liable to become "heavy," and to soil the fingers on rubbing it, which it ought not to do if properly prepared; water requires to be added, and the couch to be less frequently moved until the temperature has risen to its proper elevation again. If the fermentation be too vigorous, and the heat of the mass too great, it may be checked by the addition of fresh woad, and by moving the couch without giving it any more water until the temperature falls to the desired level. When too much heated the woad becomes "foxey," and can never be restored to its former condition, its value being diminished proportionately to the injury it has sustained. When the fermentative process has been carried far enough, and the desired condition produced, no more water is added, and the couch is kept moved until the temperature has fallen sufficiently low to allow of its being "packed" in the casks, in which it is sent into the markets.

The cost of labour in the cultivation and subsequent preparation of the crop is very great; the ordinary labour, that of hoeing and weeding, is either paid for by the "day" or by the "piece;" while the skilled labour, that of cropping and preparing, is usually paid for according to the amount of produce manufactured and sent to market, the relative prices paid for the different parts of the process varying according to the state of the markets. The produce, and also the money returns, are subject to great variations; about 2 tons of manufactured woad per acre may be taken as a fair average yield; and this, at the price it has for some years past been sold for in the markets, leaves but a small return for the expenditure incurred in rent, labour, use of plant, &c., in its manufacture—certainly not enough to induce any healthy competition with the present growers, as even a small annual addition to the supply sent into the markets, would necessarily tend to lower the prices, and thus render it still less remunerative than at present.

Woad is a hardy plant, and although subject, no doubt, to the same *diseases* and *insect injuries* as the turnip, rarely suffers from them to the same extent. Owing to the class of soils in which the crop is grown, the "mildew," which sometimes visits it in the autumn, is not followed by such severe consequences. The "fly" (which is the same that attacks the turnips) is the only enemy to be dreaded, and the whole of the late sowings are sometimes swept off by this insect pest. It is therefore always desirable to get the seed in as early as the season will allow, for the double purpose of getting the young plants well up before the "fly" makes its appearance in the fields, and of being able to re-sow the crop before the season is too far advanced, if the plant be destroyed by it.

We know little or nothing of the *chemistry* of woad. Before the chemistry of agriculture was thought worthy of occupying the attention of scientific men, and, indeed, before the processes of chemistry, especially of organic chemistry, were sufficiently advanced and definite to give their results any reliable value, woad was a rapidly declining cultivation, and its foreign substitute—indigo—was taken into the laboratory and investigated in its stead.

It is said to be an *exhausting* crop; and this we may more freely admit than in regard to the other crops against which the same charge is made, as were we to begin with a rich soil, to which no manure is given, and from which nearly the entire produce is sold, or at all events removed off the land, the soil in which it is grown must as a consequence be poorer at the end of the crop in fertilizing ingredients than it was at the beginning, notwithstanding the benefits received by the careful tillage cultivation bestowed on it, especially in the eradication of the weeds that spring up so plentifully when old grass lands have been broken up.

Besides the woad *blue*, our fields furnished us with a native *yellow* dye; and these two, while securing to us primitive colours, when mixed together in different proportions gave rise to a third colour—green—in all the various hues and tints which it was desired to impart to our textile fabrics. This yellow dye was obtained from WELD, or DYER'S WEED, as it is sometimes called—the RESEDA LUTEOLA—at present a common weed, met with well-nigh everywhere on calcareous soils of a light and poor description. The colouring properties of weld were not unknown to the ancients, as we find mention made of it under the name of *lutea* by Pliny (lib. xxxiii. c. 5); while Vitruvius, in his seventh book, and Virgil, in the fourth eclogue, speak of it, and call it *lutum*. Our knowledge of the technical uses to which vegetable substances (plants) were applied by the ancients is very deficient, from the fact that none of the mechanical or chemical arts were accounted *liberal*, or their practice otherwise than degrading to freemen and men of education. Pliny says of the one now before us—that of dyeing—that he should not have passed it over if it had been one of the *liberal* arts. Hence, these trades were carried on by slaves, who pursued an established routine of operations, without the ability or the wish to improve upon them. In this country weld is not now to be met with in cultivation at all; on the Continent, however, it still retains its place as a regular field crop.

Botanically, weld belongs to the order RESEDACEÆ, and is closely allied with the *R. odorata*, the well-known mignonette of our gardens. It is an annual or biennial plant, growing to the height of 2 to 3 feet, with an erect, stiff, branching stem, clothed with narrow, light-green, somewhat wavy leaves, and bearing at the extremities spikes of greenish-white flowers, resembling those of the common mignonette, but without their agreeable odour.

The plant may be grown in almost every description of soil; its natural selection is those of a light calcareous description. In cultivation, however, a better class of soils always is found to give better returns, and consequently more profit to the grower. There appear to be two varieties, the one being suited for sowing in the autumn, the other in the spring. The former is more esteemed on the Continent than the latter variety, as it requires less weeding. Sometimes it is sown down with a straw crop like clovers, and the crop gathered the following summer. The better practice, however, is to grow it separately, and to get the seed in during the early part of the autumn, the land being suitably prepared for it by some crop—potatoes, for instance—which is harvested early, and whose cultivation has insured good tillage, both as regards the tilth and cleanliness of the land. About 10 lbs. of seed are quite sufficient for an acre; and although the common practice is to sow it broadcast, the drill should always be used, as otherwise the crop can never be kept free from weeds, which not only check its growth, but also reduce its value when harvested. In sowing, great attention should be paid to the condition of the seed-bed; the seed-furrow should be as shallow as possible, and the seed merely brushed in with the bush-harrow, or covered by passing a light roller over the line of drills. In July the flowering process commences, and the crop is then ready for harvesting. This is generally performed without waiting for the ripening of the seed-produce. In some places on the Continent, however, they wait until the seeds are formed, which they separate by thrashing, and crush for the oil they contain.[1] The crop is pulled up by the roots, and left lying for a few days on the ground: it is then tied up in small-sized sheaves,

[1] The seeds yield from 25 to 35 per cent. of oil, suitable for burning.

and set up to dry. When ready for carting to market, the sheaves are made up into bundles of ½ cwt. each, sixty of which constitute the market "load."

Although an indigenous plant, and very hardy in its nature, it is very liable when cultivated to be injured by "mildew," which greatly reduces its yield, and consequently the remunerative return to the grower. Under ordinary circumstances the produce may be taken at from 30 to 40 cwts. to the acre. According to Girardin and Dubreuil the net profit of the crop on the Continent, where it is regularly grown, averages from £7 to £8 per acre. The colouring principle of the plant, upon which its value depends, has been termed *luteoline* by Chevreul, who first discovered it, and whose investigations of its peculiar properties have given it a character much valued by dyers—that of being permanent in its colour, and not changing to a brownish tint.[1] It is equally applicable to vegetable or animal tissues—cottons as well as silks and wools.

[1] Chevreul, *Chimie appliquée à la teinture,* 30[eme] leçon.

THE MADDER CROP.

Madder is another of the dye plants which formerly occupied a place as a regular farm crop in this country, the cultivation of which has now altogether ceased—the home-grown madder having been unable to contend in the markets with the produce of other countries possessing a more congenial climate than our own. The plant itself, and the peculiar colouring property it possesses, were evidently known by the ancients, as, although the history of all of our plants which were not cultivated as articles of food is very obscure, there are many passages in the different writers, both Greek and Roman, which refer to madder and the uses to which it was applied. Dioscorides gives a clear description of the plant under the name of "Erythrodanon," which is confirmed by Theophrastus, in its principal characteristics. Pliny[1] tells us distinctly that the *erythrodanon* was in his native tongue called "Rubia," and that its roots were much valued for giving a *red* dye to wool and leather. The remarkable effect upon animal tissues produced by the consumption of madder,[2] which was only noticed by physiologists in

[1] *Nat. Hist.*, lib. xxiv. cap. 9.

[2] "In the above year (1736), however, a property of it was discovered, by accident, as usual, which rendered it an object of more attention. John Belchier, an English surgeon, having dined with a cotton printer, observed that the bones of the pork which was served up for dinner were red. As he appeared surprised at this circumstance, his host assured him that the redness was occasioned by the swine feeding on the bran and water in which the dyed cotton cloth had been boiled, and which were coloured by the madder used in the operation. Belchier, to whom this effect was quite new, convinced himself, by a series of experiments, that the red colour of the bones had arisen from the madder employed in printing the cotton, and from no other cause;

the first half of the last century, is by some commentators thought to have been known to and made practically available by the Romans. The *sandyx* spoken of by Virgil[1] is supposed to have been our madder, and to have communicated its colour to the wool of the sheep fed on it, which could then be at once manufactured into cloth of a red colour without the necessity of submitting it to any subsequent process of dyeing. At the present day we manufacture the wool of our brown and black sheep in its natural colour, and value it more than that dyed artificially; and this was probably also the case with the ancients. Pliny speaks of cloths of this kind as *panni nativi coloris*, and Martial, in one of his epigrams,[2] also alludes to a dress made of this description of cloth. In the middle ages madder was called *varantia*, a name probably corrupted from *verantia*, which implied the true or genuine red dye, as *aurantia* signified a golden yellow, both of which colours modern science obtains from this same plant. There is but little doubt that madder was grown in this country from a very early period, and that it furnished an article of commercial value to the farmer who grew it, to the merchant or dealer who purchased it, and to the dyer who finally used it for the purposes of his craft—the herbaceous part of the plant being valuable also as fodder during the time required for the due

and he communicated his discovery to the Royal Society in a paper, which was printed in their *Transactions*." See vol. xxxix., No. 442, p. 287, and No. 443, p. 299; Beckmann's *History of Inventions*.—These curious effects have been the subject of experiments by many physiologists and naturalists, and seem to be confined to the plants possessing colouring principles belonging to, or closely allied with, the same order. The common weed *Galium verum* (ladies' bedstraw) possesses this property, while neither woad, weld, nor saffron produce any such effect.

[1] "Sponte sua *sandyx* pascentes vestiet agnos."
Virgil, *Eclog.* iv. 45.

[2] "Non est lana mihi mendax, nec mutor aëno
. . . . me mea tinxit ovis."
—Martial, xiv. 133.

growth of the crop. At the same time it had a certain reputation among herb-dealers and physicians for its medicinal and curative powers, who, on the authority of the ancients, ascribed to it various virtues, which, although doubted by some, are still believed and relied upon at the present day in the countries in which it is cultivated.

Botanically, the MADDER belongs to the natural order RUBIACEÆ, which, by some—Lindley and others—is divided into two orders, Cinchonaceæ, and Galiaceæ or Stellatæ, in which latter division the madder and allied genera are classed. These are mostly natives of the northern parts of the northern hemisphere, where they appear as common weeds, and of high mountainous regions in Peru, Chili, and Australia. First among these in importance is the common madder of cultivation—RUBIA TINCTORUM, one of the most valuable dye plants that we possess—a perennial plant possessing the desired properties in a greater degree than any of the other members of the family indigenous to or susceptible of cultivation in this country, though they all possess a certain colouring principle. The roots of the *Rubia cordifolia* yield the madder of Bengal, and form an article of export commerce to Europe under the name of munjeet. *R. angustissima*, from Tong Dong, has also highly coloured roots, and the *R. rilboun* is the native madder of Chili. The cultivated madder has long branching succulent roots, creeping along the surface, and also descending deep into the subsoil. The stem is harsh, brittle, angular, and armed with hard points at the angles. The leaves grow in whorls of four to six, and even more, are narrowly lanceolate, and bordered by minute, hard, and prickly teeth. The flowers are small, of a yellowish colour, and produced in short axillary panicles; the fruit, which is about the size of a pea, is of a dark purple colour. The flowering process and maturation of the seed of the plant require a

RUBIA TINCTORUM—Common Madder.

more genial climate than our own. In the madder districts of France its growth and reproductive functions are complete; in Holland again, where large quantities are grown, it sometimes flowers, but never perfects its seed.

The soils suited to the cultivation of madder are confined to those of a deep, friable, loamy class, as the object of the cultivation—the roots of the plant—being below the surface, the produce would be considerably diminished, and the cost of labour in harvesting the crop be considerably augmented, were the soil selected to be of a more compact and argillaceous character. Soils of natural fertility are, of course, preferable always to soils of an opposite class; the long branching roots of the madder, however, ramifying through the lower strata of the soil, give the plant a great range of feeding ground, and render it capable of supporting a vigorous growth, even in soils of moderate fertility. In France the principal seat of the madder cultivation is in the department of Vaucluse, where it was introduced and first grown in a systematic manner about a century ago, by a Persian, John Althen by name. Some of the soils of this department are particularly suited to its growth, being composed of an alluvium formed by the rivers Sorgue and Durance, which have brought down a large quantity of calcareous detritus, and formed a deep light soil, locally called "paluds," containing large proportions of lime, and retaining sufficient moisture for the requirements of the crop. In Holland the cultivation is chiefly in the province of Zeeland, where the soils are low-lying, deep, and also of an alluvial character, formed by the mixture of marine and river deposits, and containing a proportion of sand sufficient to insure the proper percolation of surplus water; for although the crop grows more freely where moisture is present, nothing affects it more injuriously than water in a stagnant condition.

The preparation of the ground does not differ from that required for any other cultivation. In the previous autumn it is thoroughly cleaned of all weeds, and left with a deep winter furrow. In the spring the cultivator, or, if necessary, the ploughs, are again sent into the field, and the land is worked until the proper tilth be obtained—the manure intended for the crop being either covered in by the winter furrow, if farmyard dung be used, or broadcasted in the spring at the time of preparing for sowing, where any dry artificial manures are applied. Manures are generally applied to the crop liberally, in order to excite and support a vigorous growth.

There are two practices followed in commencing the cultivation—either that of sowing the seed, or of using "sets" or shoots from growing plants. In the Vaucluse the former practice is followed, and in Holland, where the climatal conditions are much the same as with us, and where the same cultivation could be carried on, "sets" are invariably used. The month of April is the best time for getting the seed in. The drill should always be used, and the rows set at from 15 to 18 inches apart. In France a system of cultivation still prevails similar to that of the "lazy bed" potato cultivation in Ireland. Beds are laid out about 6 feet wide, with shallow divisional trenches of 18 inches to 24 inches wide, the soil from them being thrown up on the surfaces of the interlying beds. On these the seed is sown by the hand, either in rows or broadcast; the subsequent operations of singling, cleaning, &c., being the same as when drilled in the ordinary manner. When the plants are about 3 or 4 inches high they should be cut out to about 6 to 9 inch distances apart in the rows, the most vigorous being left for the crop. Constant attention is given to the crop during the first season—the land is kept well stirred and cleaned, blanks are filled up, and any weak and sickly plants replaced by spare plants, which it is always good policy to secure for that purpose, either by having a small nursery piece in a corner of the field, or other convenient spot, or by leaving the plants of one or more of the rows a little closer on the ground at the time of "singling." Where "sets" are used, as in Holland, the planting is usually delayed until May. The sets are obtained from the surface roots of old plants, and planted in rows about 18 inches to 2 feet apart, and at 6 to 9 inch distances in the rows. They are either planted with the dibble, or a light furrow is run with the plough, and the "sets" laid against the furrow-slice, when they are covered in by another turn of the plough, in the same manner as already described in cabbage-planting (vol. i. p. 376).

Under favourable conditions the plants grow freely, and give a large amount of herbage, which may be cut once the first year and two or three times in the second and third years, and given to the cattle. The stock generally eat it readily and thrive on it, many farmers considering it equal to lucerne or clovers in its feeding qualities.

About the month of November the practice, both in France and Holland, is to earth up the plants. Where sown or planted in "beds" the soil is taken from the intervening trenches; where sown in regular rows they may be earthed up by the plough. This practice, though very general, is of questionable benefit, except where "sets" or shoots are desired for the next year's planting, as it encourages the plants to make surface-roots or "runners," which have no value for dyeing purposes, at the expense of the other portions of the roots which constitute the marketable produce of the crop.

The crop is supposed to have reached its maximum productiveness in the third year; the root produce is then harvested and prepared for market. This is a tedious and expensive operation, every plant having to be lifted separately, and carefully removed from the soil. The mode of harvesting chicory or carrots, already described under their respective heads, would serve equally well for this crop. The work is usually commenced in August, as where the cultivation is carried on to any extent, time and a large amount of manual labour are required to get through the crop, which, at that period of the season, undergoes its first process of preparation by simple exposure on the field to the drying action of the sun. The drying process is subsequently completed in sheds or rooms artificially heated; the roots are carefully cleaned of every particle of dirt, and then ground to a fine powder, and packed up in barrels ready for the market. The amount of produce per acre, and its selling price, are subject to great variations; while the expenses of cultivation, which are always considerable, remain uninfluenced by the market returns. In drying, the roots lose on the average about 75 per cent. of their weight, so that 4 tons of fresh roots only yield 1 ton of marketable produce.

Our information in regard to the *diseases* and *insect injuries* to which the madder crop is subject is very scanty, notwithstanding the extensive manner in which it is cultivated in different parts of the Continent, and the great attention that has been bestowed on its chemistry, especially in reference to its industrial bearings. In Holland, Germany, and some parts of France—Alsace, for instance—the plant frequently suffers from the effects of the winter's frosts. In that case, the cultivation is brought to a close the following season, and the produce harvested as circumstances may dictate. In some districts it is considered advantageous to let the crop stand for a fourth or fifth year's growth, the increased produce amply compensating for the additional expenses for tillage, rent, &c. This practice, however, is frequently interfered with by the appearance of a fungoid growth of a

Rhizoctonia (a genus of parasitic plants very imperfectly known at present) on the roots of the madder, which speedily covers them with a thick filamentous network and destroys them.[1]

The value of madder consists in the colouring matters contained in the roots. If a transverse section be made, a difference is readily seen not only in the structural formation, but also in the colour of the different parts—the centre being the darkest, and the colour declining gradually in hue to the outside layers, where the red has changed into an orange yellow colour. In some cases the roots are divided, and the different portions treated separately, the finer qualities being obtained from the heart or inner parts of the root. In like manner roots of old plants contain more of the valuable colouring principle than those of younger plants; in the countries of the East, where the dye is prepared, this fact is well known. The two principal dyes obtained from madder are red and yellow in colour; the one, whose discovery was due to a French chemist, Robiquet, is known by the name of "Alizarine," the other by the name of "Xanthine." The roots of European growth contain more of the yellow and less of the more valued red dye than those grown in the Levant and other countries of the East, and as a consequence fetch a lower price in the market.

The fresh roots contain about 80 to 85 per cent. of water; 12 to 18 of extractive matter, and about 1·5 to 2·5 per cent. of salts or inorganic matter.

The composition of the dried root is thus given by John—

Fatty matters,	1·0
Red resin,	3·0
Colouring matters,	20·0
Extractive matters,	5·0
Gum and cellular fibre,	43·5

[1] De Gasparin, *Memoires d'Agri.* tome ii. p. 284.

Tartrate of lime and potash,	8·0
Potash, as sulphate and chloride,	2·0
Phosphate of lime and magnesia,	7·5
Silica,	1·5
Oxide of iron,	0·5
Water,	8·0
	100·00

The inorganic constituents of the roots have been determined by Köchlin and by May as follows:[1]—

	Zeeland Madder.	Alsace Madder.	
	1.	2.	3.
Potash,	3·42	29·67	27·47
Soda,	25·76	11·96	0·23
Lime,	16·29	34·92	30·16
Magnesia,	3·17	3·78	3·80
Oxide of Iron,	2·67	1·19	3·47
Phosphoric acid,	16·84	5·31	4·76
Sulphuric acid,	2·86	3·72	2·20
Silica,	16·41	1·66	5·52
Chloride of Sodium,	12·58	7·79	22·39
	100 00	100·00	100·00

The relative proportions of some of the ingredients, as will be seen, vary considerably, especially between the samples grown in the two different countries, the percentage of lime in the Alsace greatly exceeding that contained in the Dutch madder, while the latter contains phosphoric acid, silica, and soda in excess.

These differences no doubt are mainly due to the difference in the composition of the soils in which they were grown. It appears also that the constituents of the soil exercise a marked influence on the colouring principles contained in the root, as it is well known that Zeeland madder contains more of the yellow and less of the red, than that grown in the Vaucluse or other good districts of France.

[1] *Revue Scien. et Indus.*, tome xxiv. p. 77.

CORIANDER AND CARAWAY CROPS.

Although there is a vast number of plants cultivated for the aromatic and carminative properties they possess, these properties generally are more fully developed under the influence of warmer climates than our own, and consequently we rely chiefly upon the cultivation of foreign countries for the production of the spices and other aromatics which we are accustomed to use for our own economic purposes. In former times, when our intercourse with other countries was more limited than at present, many more of these aromatic plants were grown in this country. At the present day, however, we have but two that enter into field cultivation, and these are only to be met with in certain districts, and there only to a very limited extent. These two are the Coriander and the Caraway, both belonging to the same order—Umbelliferæ—and possessing to a great extent the same agricultural characters, so much so, indeed, that they are not uncommonly grown together on the same ground. In this case the coriander, which is annual, comes to maturity, and furnishes the harvest of the first, while the caraway, whose growth is biennial, is left for the next year's crop. Notwithstanding this agricultural connection between these two crops, it will be best to take them separately in our brief sketch of their cultivation.

The Coriander—Coriandrum sativum—is an annual umbelliferous plant, growing wild in the warmer countries of Southern Europe, and also occasionally met growing in that state in the southern parts of England. It is

Coriandrum sativum—Coriander.

readily recognized by its general appearance, and by the peculiar smell and strong and offensive taste of its leaves and flowers. It grows to the height of 3 to 4 feet; the stem is smooth, and surmounted by the characteristic umbels of whitish pink-coloured flowers. Its radical leaves are pinnated, with broad, oblong, or roundish notched leaflets, while the stem leaves are divided into numerous linear segments. The fruit or seed vessel is globular, and consists of two hollow hemispheres, each having on its back nine ribs, five of which are zigzag, and four straight (*see woodcut*).

The cultivation is never attempted except upon the best descriptions of soils; loams of good staple, marsh lands that have been well drained, and old grass lands in good condition, are those best suited to its growth and requirements. It is rarely met with as a crop save in Essex, and occasionally in Suffolk and the opposite coast of Kent, where the class of soils and the climate are suitable to it. In growing these special crops no order of rotation is adhered to; they are generally taken as the markets or the particular circumstances of the farm offer inducements or otherwise to their cultivation. In all cases, whether the crop is to follow a straw crop, or to succeed to fresh broken up ground, it is advisable to get the work of preparation as forward as possible in the autumn, in order that the seed may be got in and the plants well rooted before the winter sets in. If old grass land be broken up, the sward should be well covered in by a deep furrow; if the crop follow a straw crop, the ground should be well cleaned, and a good dressing of dung given to it before it be finally prepared for cropping. October is perhaps the best month for sowing. About 20 lbs. of seed are used, care being taken that it is quite fresh; the drills should be run at from 16 to 18 inches apart, the harrows and a light roller finishing the operation. When the young plants have made a little growth, they should be set out at about the same distances in the rows, and the field left provided with surface drains—"grips"—to carry off any surplus water during the winter. Early in the spring the horse-hoe should be sent in between the rows to give the soil a good stirring, and to keep down the weeds; hand-hoeing between the plants in the drills will also be necessary for the same purpose.

At the end of June or the beginning of July, the flowers make their appearance, and in about another month the crop is ready for harvesting. Great care is required in the operation, as the seed very readily parts from the stem and diminishes the produce. The stems are cut with hooks, and then laid gently on the stubbles until quite dry and ready for thrashing, which is generally performed on the field with the flail in the manner described (p. 310, vol. i.) in treating of the turnip seed. The straw has no value, and is generally collected in heaps and burned on the field, and the ashes distributed over the surface. The produce and its market price are subject to considerable variation—from 10 to 20 cwts. to the acre may be taken as the range under the ordinary circumstances of cultivation. The consumption of coriander seed is limited to articles of confectionary or condimental purposes.

The Caraway—Carum carui—is an umbelliferous plant of biennial duration, with a long tapering root, which penetrates deep into the soil like the parsnip. From this root there rises in the second year a striated furrowed stem, from 24 to 30 inches high, with spreading branches, clothed by numerous leaves finely divided, of a deep green colour, and on the end of a broad almost sheathing stalk. The head is composed of the well-marked umbels of the family; the flowers are of a pinkish

Carum carui—Common Caraway.

white colour, having no general or partial involucres, except occasionally a small bristle or two in their place. The fruit, the well-known *caraway seed*, is oblong, small, of a brown colour, with five narrow thread-like ridges, and a single oil cyst in every interval, in which the characteristic essential oil, which gives the value to the seed, is contained. It is said to be a native plant, and is seen occasionally growing in rich old pasture lands—on the Continent, however, it is met with far more frequently growing wild on the richer description of soils. Both this plant and the coriander are mentioned by the earlier writers. Theophrastus and Dioscorides have described them, and numerated their virtues. In Gerarde they are both figured; of the caraway he says, "It groweth everywhere in Germanie and Bohemia, in fat and fruitful fields, and in medowes, that are now and then overrun with water; it groweth also in Caria, as Dioscorides showeth, whence it took its name."

In all its agricultural characters it so closely resembles the coriander, that the same soils and the same preparation are equally suited to both crops. Where they form a separate cultivation, however, the caraway may be grown in soils containing a larger proportion of clay—a stronger class of loams—than the coriander delights in. This secures it that degree of moisture which it needs for its healthy development.

Formerly, it was the common practice to sow the caraway either with coriander alone or with both that and teazles combined. This was a very questionable mode of cropping, as even if it were advantageous to devote first-class soils required for this to the latter crop, it would be quite impossible to till and to harvest the three crops separately without doing some injury to the plants remaining last on the ground. Even the practice of sowing down together *two* crops belonging to the same order, possessing the same habits of growth and the same food requirements, is open to great objections. Their success would, in all probability, be far more certain, and their produce more satisfactory, were they grown as separate crops; or if it were desirable to occupy the caraway land profitably during its first year, beans, or any other erect, quick-growing annual, could be substituted with advantage for the coriander of the present system.

The seed should be drilled towards the end of March or the beginning of April. About 20 lbs. are sufficient to the acre, and about the same distances should be kept between the drills and the distances of the plant apart in the rows, as with the coriander crop. The land requires to be well stirred and the weeds kept down by the hoes; and in the autumn the herbage may be fed off with sheep, who are exceedingly fond of it, and always thrive upon it. Care must be taken, however, that it be not fed down too close, as if the crown of the root be injured the plants are likely to suffer, or perhaps be destroyed, by the winter's frosts. In the spring the land requires to be stirred as early as possible between the rows, and the weeds destroyed. The flowering takes place towards the end of June, and in about a month afterwards the seed is ready to be harvested. The operations of cutting, which is done with the hook, and of carrying, require great care, as the seed parts very readily from the stem, and is liable to be left on the ground, to the lessening of the produce. The stems should be left lying on the stubbles until quite dry, and should then be removed for thrashing early in the morning, when the dew is on the pods; this prevents them shedding the seed, which may be thrashed out on the field in the usual manner. After the seed is thrashed out, it should be left for three or four days thinly spread on the barn floor, or other suitable place, in order to get completely dry, when it may be winnowed and sent to market.

Some prefer to pull the stems in the same manner as flax. The labour costs a little more, but the seed is less likely to be shaken out, while the field is cleared of the stubble, which otherwise has to be collected and carried off at the time of ploughing. The produce, which is subject to considerable variations, may be taken at from 15 to 20 cwts. to the acre on the best soils. The demand, however, is always more regular, and the market price better than that of coriander seed.[1] Caraway is a more delicate plant than the coriander, and is liable to injury from frost, and also from heavy winds. But little attention has been paid to the insect injuries to which the crop is subject, though it is probable that many of the insects which infest our other umbelliferous crops—carrots and parsnips for instance—are equally to be met with in the caraway and coriander. The only one, however, that has been observed is a black caterpillar, which visits the caraway in the spring, and at times commits great ravages.

[1] The last market quotations were—

Coriander, 15*s.* to 18*s.* per cwt.
Caraway, 32*s.* to 35*s.* ,,

GLASGOW: W. G. BLACKIE AND CO., PRINTERS, VILLAFIELD.