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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

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VOLUME I.

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AND EDINBURGH AND GLASGOW.

TO THE
AGRICULTURE

Ag. Dept. Agronomy

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

ADVERTISEMENT.

NOTWITHSTANDING the vast facilities of intercourse which the Railway System has opened up to the Farmers of the present generation, and the development and diffusion of Agricultural Literature by a Cheap Press and a Cheap Postage, it is a matter of surprise to many who have had their attention called to the subject, that the practices of one district should so often be comparatively unknown in another, and that such different modes of treating the same subject should continue to exist.

In Agriculture, as in all Arts dependent upon the laws governing the physical world, there are certain "principles" or fundamental rules which never vary—they are alike, always and everywhere—wherever cultivation is carried on they are the same. Practices, however, necessarily vary; varieties of soil, of climate, and the markets, necessitate modifications, to compensate for the altered circumstances, whatever they may be. These modifications, to be successful, must be in harmony with the causes that gave rise to them; in no case can the principles of cultivation (vegetable reproduction) be departed from with impunity.

The object of the present Work is to discuss the principles and practices involved in the cultivation of "OUR FARM CROPS"—to make known in popular language, and as free from technicalities as possible, those which are based on sound deductions, and to offer such evidence in their favour as may induce a comparison between them and the existing practices of a district, and thus, in some cases, it is hoped, lead to improvements in the general system of Cultivation.

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In this country there is, happily, a large and increasing class of Farmers to whom these remarks are not applicable—men in whose hands the character of British Agriculture is not likely to suffer; but there is also another and a larger class to whom they may with propriety be addressed—those who have not had the same advantages for acquiring a knowledge of their profession, or, having had, have not made the same use of them. Still, there may be some matter in our pages for both classes. In Agriculture, each day brings with it its lesson; every Farmer, from the highest to the lowest, has every day something to learn—when he ceases to be a Student, he ceases to fulfil the duties his profession imposes on him.

Without attempting to estimate the relative number of the two classes, we may fairly assume that, out of the 350,000 Farmers of Great Britain, there are thousands who have not yet become practically acquainted with the Thrashing Machine, that there are tens of thousands who have never seen a “Reaper,” and hundreds of thousands to whom “Steam Tillage” is at present perfectly unknown. Yet these are all vast improvements upon existing practices, conferring benefits alike upon the individual who adopts them, and, through him, upon the community at large. In our Cropping and Farm Practices generally well-nigh the same unsatisfactory condition of things is seen. Knowledge, however, must be possessed before it can be applied; and it is with the view of offering that, in a simple and condensed form, to those interested in the cultivation of the soil, that this little Work has been arranged.

In the present Series, the Mechanical Appliances of the Farm will be only treated incidentally, as the particular subject under discussion may require; the ordinary Farm Crops, their Cultivation and Treatment, their Chemistry, and the various Injuries to which they are liable, with the Remedies recommended, will form the staple contents of each number.

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OUR FARM CROPS.

THE WHEAT CROP.

WHEAT is essentially the bread-corn of the northern temperate zone, and claims the first place in our consideration of the "Farm Crops" of our own country. This place, indeed, has been assigned to it since the earliest records of our agriculture; for although, in earlier times, peas, beans, barley, oats, and rye entered more largely than at present into the ordinary food of the people, experience gradually but surely showed that no other grain assimilated so well with the human constitution, and so well represented the two great classes of constituents necessary to sustain the wear and tear of human life. Thus, keeping pace with the increasing civilization and knowledge of the people, wheat has won its way to the head of our market lists, where it now stands, acting as a great social barometer, whose variations are watched with eager anxiety by the peer as well as the peasant.

A few words will suffice to show how wheat fulfils the conditions necessary for human nutrition better than any other of our cultivated grains. The valuable researches in Physiological Chemistry by Liebig, Mulder, and others, so ably followed up by some of our own chemists, have demonstrated clearly that to sustain the functions of animal life two classes of food-constituents are required—the one to support the necessary temperature of the body through the agency of the respiratory system—the other to furnish mate-

rials for the building up of the material parts of the body, such as the bones, flesh, skin, &c. Thus "food fuel" is being constantly required for the one, and "food materials" for the other. The regularity of this requirement constitutes health—any continued departure from it, disease.

It is generally conceded that, under ordinary conditions, these constituents are required in certain proportions; consequently any substance containing these classes of constituents in the required proportions would by itself sustain human life for a longer period than other substances in which the relative proportions were not so suitable. These constituents we are accustomed to classify under the heads of—1, Non-nitrogenous, or heat-giving and fat-forming compounds; and, 2, Nitrogenous, or flesh-forming and plastic compounds; and from experience, both scientific and practical, we have been led to look upon the proportion of six of the former to one of the latter as that which will, under ordinary conditions, most satisfactorily meet the requirements of the human frame in the northern temperate zone. Now, wheat happily possesses the two classes of constituents in these desirable proportions (see page 90), and has therefore been taken as the standard by which the nutritive value of all our other food-grains has been gauged.

In barley, oats, and rye, the relative proportions, though they vary but little, are not so suitable. If they are used exclusively as substitutes for wheat they generally derange the bodily health of the consumer, and we only find them forming the food of the people under circumstances where wheat cannot be procured. Beans and peas show a large excess of the nitrogenous or flesh-forming compounds; while in the Indian corn and the rice of the hotter and tropical climates, the non-nitrogenous constituents form a large proportion of their whole substance. These latter food-grains, therefore, would require to be usually accompanied by some additional substances

to secure the necessary balance between their nutritive constituents, before they could form the basis of a diet equivalent to that represented by wheat. Wheat seems to have been given specially to man as the fittest source of supply of his daily food, the subordinate animals, companions of his daily toil, and necessary for his existence, contenting themselves, nay preferring either of the other grains—barley, oats, or beans—when left to their own selection.

The wheat plant appears to have been known and valued from the earliest periods.¹ In the Bible we have frequent mention of it as being known by the Jews and Egyptians; therefore we may fairly assign to it an Eastern origin.² Its range, however, is greater than that of most of our other food-plants—its cultivation extending from within the tropics to wellnigh the limits of the temperate zone of the northern hemisphere.³

This wide range of climate, which enables the inhabitants of so many different countries to enjoy the advantages of its cultivation, is occasioned by the numerous species and varieties of which the genus Wheat is composed, some being suitable for the climate of India, others for that of Northern Europe, while all seem to thrive well in the zones of intermediate temperature. If we look for the principal wheat-producing countries in Europe,⁴ we shall find them to be England, France, Germany, Northern Spain and Italy, Prussia, Hungary, Southern Russia, Poland, and the countries bordering the Black Sea. In Asia, the countries lying between the Black Sea on the north, and the Persian Gulf and the Red Sea on the south, comprising those regions mentioned in our Bible records, represent

¹ Gen. xxx. 14.

² The original country of our cereals is referred to in *Vegetable Kingdom*, p. 112, and ably discussed in *Gardeners' Chronicle*, 1844, pp. 555, 779.

³ Drontheim, lat. 63° 25' N. ⁴ See Johnston's *Physical Atlas*.

the area where wheat is most commonly cultivated. Egypt, Algeria, and the countries running down to the shores of the Mediterranean, are the principal wheat districts of Africa; while the present produce of Canada and the United States has already shown us the wellnigh illimitable area of wheat-producing soils which America possesses, and which will be gradually brought into cultivation as its surface becomes occupied, and its population increases. In Australia and New Zealand the soil and the climate are both admirably adapted to the growth of wheat. The beautiful samples of Australian wheat sent to the Great Exhibition in 1851, and to the Paris Exhibition in 1855, told their own tale as to quality of produce.

The botanist tells us that the genus of plants yielding the various kinds of wheat is called TRITICUM, and that it belongs to the natural order GRAMINEÆ (grasses), of which it is the most prominent and important member.

This name *triticum* is, according to Varro, a Roman agricultural writer, derived from "*tritum*," ground or rubbed, because the fruit or seed in its preparation as a food for man requires the process of grinding or trituration. We learn, too, from Varro and other authors of that period, the place which wheat occupied in the agriculture of the Romans, and the great pains and consideration they bestowed upon its cultivation. Indeed, many of their rules and recommendations form good comments upon the negligent tillage of our own times, and might be consulted and followed with advantage by most of us at the present day. The Romans appear to have been acquainted with only two species of wheat, the *triticum* or ordinary wheat, and the *far* or spelt wheat; the first they recommended to be sown on good, warm, loamy soils, while they considered the other best adapted for cold clay soils, and for high and exposed districts. Their rules for getting the land into proper condition preparatory

to the wheat crop are well worthy of our attention. They insisted upon the necessity of having the land in good heart, so as to be able to produce and perfect a good plant; that it should be carefully freed from all noxious weeds, which abstract from the soil the food that should support the growing crop; that the soil should be broken down into the finest tilth possible, and that it should be ploughed as deep as the farmer's force would permit, so that the roots of the plant might be able to penetrate the subsoil in search of its necessary food.

The Romans were evidently keen observers of *results*, though they were not so well acquainted with their *causes* as we are. Their farmers had not the advantages which chemistry places in the hands of ours; and yet many of their practices and precepts are even now entirely neglected by the majority of us, and only to be seen exemplified on the farms of our most enlightened and intelligent agriculturists. On heavy lands they recommended fallowing, and exposure to the sun and to the frosts; on good loamy soils they recommended that wheat should follow a crop that differed from it in its habit of growing and its requirements from the soil; and on light sandy or gravelly soils, that the soil should have the necessary firmness given to it by means of the roller or other implement. They were more particular, too, in keeping the seed pure and unmixed, in selecting the best for the purpose of sowing, and in changing their seed and adapting it to the soil in which it was to be used. These are all points which we shall have to refer to as we discuss the subject of this treatise, and which never can be neglected with impunity in the cultivation of wheat.

In describing the different species composing the Genus TRITICUM, wellnigh every writer has adopted a different arrangement, and consequently considerable confusion and misapprehension exist, not only as to the species, but as to

the correct nomenclature of the endless (so-called) varieties,¹ which enter into our ordinary cultivation. By common consent, M. Louis Vilmorin, in France, and Mr. Lawson, in this country, are looked upon as the best authorities on the subject. Therefore we cannot do better than follow the division and classification of the genus, so ably drawn up by the former, while the descriptions and agricultural characteristics of the cultivated varieties, by Mr. Lawson, will enable us to form correct opinions of their nature and suitability to our several requirements.

M. Vilmorin divides the genus "Wheat" under seven heads or "species:"—

1. TRITICUM SATIVUM—Common Wheat.
2. TRITICUM TURGIDUM—Turgid Wheat.
3. TRITICUM DURUM—Hard Wheat.
4. TRITICUM POLONICUM—Polish Wheat.
5. TRITICUM AMYLEUM—Starch Wheat.
6. TRITICUM MONOCOCCUM—One-grain Wheat.
7. TRITICUM SPELTA—Spelt.

The four first species have their seed or grain naked, while the seed of the remaining species has the chaff-scales adhering to it.

No. 1, *T. sativum*, is arranged in two principal divisions, "bearded," and "smooth or beardless." Of the bearded there appear to be seven, and of the smooth or beardless twenty-seven distinct varieties; and these are again divided into sub-varieties according to their colour, as white, yellow, or red, and according also as the chaff-scales are smooth or rough.

No. 2, *T. turgidum*, has two principal divisions—those varieties having simple ears, and those having compound—the sub-varieties being determined by the colour, white, red, or dark, and by the rough or smooth character of the

¹ In the collection of British agricultural produce, exhibited by the Board of Trade at the Paris Exhibition, no less than 128 different varieties (?) were shown.

No. 1. TRITICUM SATIVUM—Common Wheat, var. smooth or beardless.
No. 1. TRITICUM SATIVUM—Common Wheat, var. bearded.
No. 2. TRITICUM TURGIDUM—Turgid or Cone Wheat.

No. 3.

No. 4.

No. 3. TRITICUM DURUM—Hard Wheat.

No. 4. TRITICUM POLONICUM—Polish Wheat

No. 5.

No. 6.

No. 7.

No. 5. *TRITICUM AMYLEUM*—Starch Wheat
No. 6 *TRITICUM MONOCOCCUM*—One-grained Wheat.
No. 7. *TRITICUM SPELTA*—Spelt Wheat, var. beardless.

chaff-scales. Of these M. Vilmorin enumerates eleven distinct varieties, ten having simple ears and one having a compound ear.

No. 3, *T. durum*, has three varieties.

No. 4, *T. polonicum*, only one.

No. 5, *T. amyleum*, only one.

No. 6, *T. monococcum*, only one.

No. 7, *T. spelta*, is divided into two—the bearded and beardless varieties.

Of these seven species only the two first are cultivated in this country, the others being merely grown for experimental or illustrative purposes.

The *T. sativum* comprises all the varieties of winter and spring wheat under ordinary cultivation; the *T. turgidum* being limited to certain districts where the soils are cold and strong, and where a large yield of a coarse quality is desired.

It would not be within the limits of this short treatise to attempt to give a description of each, or of half the various wheats cultivated in different parts of the kingdom; it must therefore be confined to those most generally esteemed varieties met with in our best cultivated districts, their characteristics being given in the briefest possible manner.¹ The simplest division between them for our purpose is that of colour, white or red, the yellow varieties being classified either with the one or the other according to the darkness of their tint. Amongst the most esteemed of the white varieties, we meet with

Brodie's Wheat.—Fine sample, superior to Hunter's; straw longer, about a week or ten days earlier at harvest, and more productive; suited for spring sowing, cultivation increasing in good districts—Lothians, Berwickshire, &c.

¹ Those who wish for more detailed particulars, should consult the *Essai d'un Catalogue Méthodique et Synonomique des Froments*, par L. Vilmorin; the *Synopsis of the Vegetable Products of Scotland*, P. Lawson & Son; and the articles "Triticum" and "Wheat" in the *Cyclopædia of Agriculture*.

Chidham.—Fine quality; short, compact grain, with fine transparent skin; meals well, and fetches a good price at market; largely grown in the southern counties; increasing in Scotland.

Dwarf Cluster.—Short, firm straw; tillers well; yield generally good both in quality and quantity; suitable for rich, humous (vegetable mould) soils; grown chiefly in the south, but stands the north climate very satisfactorily.

Essex.—Resembles Chidham; probably the same wheat slightly altered by cultivation in a different district; fine thinskin variety, with square head and no awns; esteemed highly by millers; yield good in good districts.

Fenton.—Hardy, with short, strong straw; rarely falls; good cropper; suitable for rich soils; quality of grain good.

Hopetoun.—Resembles Hunter's, rather finer quality perhaps; hardy; good cropper; largely cultivated in the north; esteemed in the markets.

Hunter's.—Rather thick ear, tapering towards point; grain rather large, plump; top dull white or a light brownish tint; quality excellent; hardy; grown extensively in the north; succeeds well in the south.

Pearl.—Resembles Chidham and Essex; fine quality of grain; straw long and stout; early at harvest, and suitable for either winter or spring sowing, on rich warm soils; meals well.

Spring.—Bearded; ear shortish; grain thin, with transparent skin; straw generally shortish and weak; ripens quickly even when sown late in spring.

Talavera.—Ear long and thin; grain very large, plump, with rounded ends; quality excellent; meals well, and always tops the market; tender habit; sown in spring, and requires good soils; has not succeeded in the north.

Uxbridge.—Apparently same as Chidham, improved by climate; ears larger; grain small, short, and plump; fine white colour; sample beautiful, and much sought after

by millers for finest flours; good cropper; succeeds well in good districts of the north.

Velvet-eared, or Rough Chaffed.—Straw short and stout; grain medium size, of pearly white colour; excellent quality, and good cropper; requires dry climate, or apt to mildew; largely grown in the eastern counties.

Of the Red varieties the following are those generally preferred:—

Burwell.—Straw long, stout, and coloured; ear large; chaff coarse and deep coloured; grain long-shaped and dark; sample generally good; large cropper, and very hardy.

Browick.—Straw long and stout; ear bold and full; less colour than the foregoing; grain short, plump, and well shaped; skin moderately thick; very productive and hardy; sample generally classed among the finer varieties.

Bristol.—Very similar in character to the Browick; straw strong; grain rather coarser and longer; very hardy; yield generally good; sample inferior.

Clovers.—Straw long; grain and chaff stout, but of a lighter colour than the preceding; sample fair; good cropper.

Hickling's Prolific.—Straw long and stout; ear large, and of a compact square form; grain short and roundish, of a deep yellow colour; chaff white; yield large, but of inferior quality.

Kessingland.—Ear large; grain large, dark yellow colour; somewhat coarse, but very productive.

Lammas.—One of the best varieties of red wheats; grain dark coloured, plump, and fine skinned; straw stout and clean; should be cut early, to prevent shelling; sample good, and liked by the millers; fair cropper.

Piper's Thickset.—Straw short and tough; ear square and compact, tapering towards top, with awns which

gradually fall off when fully ripe; grain round, and reddish in colour; sample fair; yield large.

Spalding's.—Straw long and stout; hardy, and very prolific; grain large, oblong in shape; good average quality.

Velvet, or Woolly-eared Bearded.—Ear long, dark red colour; grain large, flinty, and coarse; chaff hard and close; difficult to thrash, unless in good condition; early, hardy, and prolific.

The species *Triticum sativum* was formerly called *T. vulgare*, and was frequently divided into two classes—the winter, *T. hibernum*, and the summer, *T. aestivum*. This classification is no longer recognized, as it is now well known that wheat, by being constantly sown in the spring, quite changes its habits as to its time of ripening. The produce of wheat sown in the spring acquires the habit of perfecting its growth quicker than the produce of the same wheat sown in the autumn. Hence, the farmer when he sows wheat in spring should be particular to obtain seed, the produce of spring-sown grain, and not the produce of that sown in the autumn. The same change takes place in all the cereals, and in other crops which we cultivate. The difference also in colour between the red and white varieties is probably due mainly to the nature and character of the soil in which they are grown. Fine white wheats gradually become darker and coarser, and ultimately change their colour altogether when grown continuously on cold ungenial soils—while the coarser red wheats grown, year after year, on rich warm soils, in a good climate, generally lose their characteristics, become of a lighter red colour, then yellowish, and finally, assume the external appearance of a strong white variety. It has been remarked that the grain in this respect is affected differently to the straw, in changing its colour and character more quickly than that does. Hence we have many varieties of red wheats with white chaff and straw, and

varieties of white wheats with red straw—the chaff and straw retaining their original colour after the influence of cultivation has effected a change in the grain.

In the foregoing, and all the other varieties of *T. sativum*, the straw is cylindrical in shape, and hollow. In the following species, the *T. turgidum*, and its varieties, the interior of the straw is occupied more or less completely by a pithy substance which gives it toughness and strength; and the grain or seeds have a less regular and symmetrical shape than those already described.

The varieties of Turgid wheats are generally hardy, vigorous, and very productive, with long, tough, coarse, straw. Having a low nutritive value, and being unpalatable to cattle, it is unsuitable for fodder; but where straw is in demand for thatching, litter, or similar purposes, this description of wheat usually is found to be more remunerative than the finer qualities, especially in cold and heavy soils. The ear is always bearded (awned). In some varieties the awns fall off as the grain approaches maturity, and thus a difference in appearance is given to them. The soils best suited for these wheats are the strongest and richest clays, in which we so often see the ordinary wheats go down towards harvest time—their stout tough straw being fully capable of standing up against the action of ordinary weather, notwithstanding the size and weight of its ear. They all require to be sown in the autumn, and are always backward at harvest, therefore are more suitable for early than for late districts. The yield is large, averaging probably one-fourth more than that of the ordinary wheats. The grain, however, is very coarse; and as it is only used for one department of baking, the demand is very limited, and the market price generally very unsatisfactory.

The following are the varieties usually met with in cultivation:—

Rivet, Common.—Ears smaller and less compact than the next variety; awns stay on longer; grain long and flinty; heavy cropper, but being somewhat later at harvest than the Cone Rivet, is only suited for early districts.

Rivet, Cone.—Ears white and velvety, square and compact; grain whitish yellow, and larger than the Common Rivet; straw bold, long, and stout; generally hardier, and less liable to diseases; sample poor in quality; yield very productive.

Egyptian.—Ear woolly; straw long, stiff, and filled with pith; differs from the other varieties of Turgid wheats by the form of its ear, the lower florets being elongated, and forming in appearance distinct ears. This is the variety so frequently met with under the name of “Mummy Wheat.” It is, like the others, a very productive sort, but of a like inferior quality.

At the Exhibition of 1851 specimens were exhibited of *Hybrid Wheats*, obtained by the systematic crossings of different known varieties, and prize medals were awarded to the successful experimenters.¹ “The specimens excited great interest, from the importance of the process in other departments of the vegetable kingdom, and the known difficulty of hybridizing the *cereal*ia in particular. This arises from the great care required to extract unexpanded anthers from one parent, and to replace them with the pollen of another—preventing, at the same time, the stigmas to be fertilized from receiving any other pollen than that artificially applied, and guarding them afterwards from the attacks of birds, and a variety of disturbing operations. The result appears in most cases to be an offspring stronger than either parent.”—(Jury Report on Class III.)

In discussing the agricultural relations of wheat, the

¹ Mr. Maund, of Worcester, and Mr. Hugh Raynbird, of Basingstoke.

soil, of course, claims our first consideration. Wheat, we know, has a very wide range of soils. In this country we see it grown on wellnigh every variety, from the light siliceous soils met with in the eastern counties, and in the Green Sandstone and New Red Sandstone formations, to the difficult and disheartening soils of the London, the Wealden, the Oxford, and the Lias clays. Some soils, however, are clearly more suitable for it than others. Those best adapted for it are of course such as contain the ingredients necessary for its growth and perfection in the best proportions, and in a condition most available for the plant. We know that wheat will not flourish in any soil unless there is a certain amount of silica and potash for its stem, of silica and lime for the chaff or outer covering of the seed, and of potash, phosphoric acid, magnesia, and ammonia for the seed. These substances are generally found to exist in clays to a greater extent than in other descriptions of earth; consequently, we are accustomed to look upon our different soils as strong, medium, and light wheat soils, according to the proportions of clay they severally contain in their composition. *Pure clay*, which is a chemical compound of silica and alumina, would be unsuited to any description of vegetable growth; but clays are always more or less mixed up with other substances which give them their fertilizing value, while their own substance acts mechanically in a very beneficial manner, by giving tenacity—staple—to the soil, and by increasing its powers of absorption and retention of moisture, and also of condensing and retaining the ammonia so necessary for plant life. In soils containing large proportions of sand, or of organic matter, but deficient in clay, we often see the young plant very luxuriant at first, but without the power to build up its stem, and consequently unable to assimilate those substances necessary to perfect its growth and to produce its seed.

In all descriptions of soils it is essential that they should not retain more moisture than is natural to their composition—that all the surplus should be got rid of by drainage, as owing to the habit of the growth of wheat under suitable conditions, it requires less moisture after it has once sent out its roots than most of our other crops.

The preparation of the land for wheat depends very much upon the character of the soil and the general practice of the district. In some of the unmodified clay districts, especially if undrained, of the London clay formation, as in Essex—of the Wealden in Kent and Sussex—of the Oolite clays in Oxford—and of the Lias in Gloucester and Worcester, it is still the practice to give it a summer fallow, keeping it well stirred and cleaned, and sowing it down early in the autumn. This expensive and unphilosophical practice is, however, gradually disappearing as thorough-draining makes its way into the districts, and as the farmers recognize the immense advantages which the rapid development and adaptation of mechanical power, in the shape of farm machines and implements, now place at their disposal. Except under very rare circumstances, we should not admit the practice of an open fallow as a necessary preparation for wheat; but we should endeavour to occupy the ground profitably, by a crop which would take from the soil such ingredients as the wheat will not require, and which would leave in the soil behind it sufficient organic matter to satisfy the demands of the succeeding crop. This may be readily secured to the soil by growing a green crop, either a regular fallow crop of roots, as turnips, potatoes, &c., or a forage crop, as clover, such crop being determined either by the particular character of the soil or by the practice of the district. If the soil be of a light friable character, the Norfolk, or four-course system (wheat after clover), is generally followed, the spreading roots of the clover giving that firmness to the soil which

experience has shown to be so desirable for wheat. On such soils, too, the roller, either plain or ribbed, is a good friend to the farmer: it closes the surface, stops evaporation, and consolidates the body of the soil generally.

On strong lands again, root-crops are certainly the best preparation for wheat, provided the land can be cleared in time to allow for wheat sowing. In the north and other districts, where the five or six-course system is carried out, either turnips, or potatoes, or mangold precede the wheat. All form good fallowing crops, allowing the land to be well cleared, requiring for themselves mineral ingredients different in proportions from the wheat, and at the same time leaving on the land a supply of organic matter for its use.

On very heavy soils root crops are rarely attempted, owing to the difficulty in obtaining a sufficiently fine tilth for the seed-bed, and also to the difficulty in getting them off the land before the bad weather sets in. On such soils beans are sown alternately with wheat. This rotation, though suitable as regards the chemistry of the two crops, has one great fault, that of preventing to a great extent that mechanical treatment of the soil, which we know adds so much to its fertility. The bean stubble is ploughed in with its accumulated weeds; the wheat sown, and generally, on such soils, left unhoed until harvest; the ploughs are sent in again as soon after the field is cleared as possible; manure either ploughed in now or before seed-time in the spring, and the land is left for the winter fallow. In the spring the first chance of getting the beans sown should not be lost; and the only opportunity of getting the land clean is during the early period of their growth; and then the chances of weather on strong clay soils are considerably against you, and the weeds remain masters of the field, until a twelvemonth's fallow and a large expenditure in labour again clears your land

of those unprofitable occupants. The addition of a third crop to the rotation, which would admit of a better preparation of the land, might be obtained in the smooth-leaved Rape. This, on such soils, grows well; it admits of the land being well worked and cleaned before sowing, and of being kept clean during its growth; it comes to maturity early enough to be fed off by the end of September, and leaves a large amount of good dressing for the succeeding crop of wheat. The good effect of the extra tillage in cultivating root crops is always shown in the succeeding wheat crop; and although different practices prevail necessarily in different districts, still, as a general rule, a farmer cannot deepen his soil too much, nor reduce it to too fine a tilth, in preparing it for the reception of his wheat.

Having, then, to the best of our judgment and our power, completed the preparation of the land, the next point for consideration is the *selection of the seed*; and this is a point of far more importance than farmers are generally disposed to concede to it. We have no series of properly conducted practical experiments to refer to, which are always desirable in cases where scientific principles are so opposed to general practices, as in this instance; but to those at all acquainted with natural history—the laws of animal or vegetable life—a little consideration would clear up any doubts they might before have possessed in reference to it. We may be told, it is true, that good seed does not always produce a good crop, while the produce of inferior seed is sometimes of a superior quality. This may be quite true, and there may be many other ways of accounting for the result beyond the mere difference in the seed; but, as a rule, the law of production—“that like produces like”—cannot be disregarded; therefore, if we wish to secure the best results, it is important *that the seed sown should be of the best quality—that it should*

*be perfect in itself—and that it should be fully matured.*¹ The temptation of the higher price too often takes all the best grain of the farm to the market, while the inferior qualities, including even the tail corn with all its immature and injured grains, are, with a sadly short-sighted economy, considered good enough to risk the next year's crop upon.

Another point to be attended to in reference to seed corn, is the advantage of changing it, as often as circumstances will permit, for seed grown in a different district, both as regards soil and climate, from your own, as seed constantly produced year after year on the same soil is apt to deteriorate in quality, and to produce a crop less vigorous and more liable to disease than if its conditions of growth had been frequently changed.

This practice of changing seed is becoming every year more followed, experience satisfactorily confirming the correctness of its principles. Not only is a more healthy plant secured, but an opportunity is offered to the farmer,

¹ In the *Journal d'Agriculture Pratique*, for November, 1856, a report is given of some experiments by M. Lucien Rousseau, of Angerville, on the growth of various kinds of wheat, under the same conditions of time of sowing, soil, and climate. There were fifteen lots of different wheats experimented with, and the sixteenth was composed of equal portions of the fifteen mixed together. Throughout the growth of the plants, the mixed lot appeared always to have the advantage, and at the time of harvest, its produce, both in grain and straw, was considerably in excess of any of the others. M. Rousseau seems to consider the superior produce of the mixed grain to be due mainly to the more perfect impregnation of the floret, by the ears making their appearance at as many different times as there were varieties sown; for if the first flower, he says, which has lost its pollen, has not been fertilized, owing to the badness of the weather, it may still be capable of being impregnated by the pollen from a later ear. M. L. Vilmorin, in commenting on the experiments, says:—"A mixture of grain arising from sorts selected as suitable to the district, does not present usually any marked difference of appearance so as to be lessened in value. On the other hand, the increase in yield, and the greater chance of success arising from the variety of different constitutions of the kinds sown, gives the results obtained by M. Rousseau an importance which ought not to be disregarded. By taking care not to mix sorts, the grain of which has not the same market value, and does not ripen at about the same time, it appears that very important advantages may be derived."

by using as seed the grain of an earlier district, to accelerate the time of his own harvest, which in some seasons and in some places is a matter of considerable importance to him. Thus the light chalk and gravelly soils of Kent furnish a good exchange with the strong alluvial and clay soils of the opposite coast of Essex; and the fen soils of Huntingdon and Lincolnshire exchange seed beneficially with the wolds and the chalk soils of Cambridgeshire, and the green sandstone soils of Bedfordshire; while the strong cold clays of Northumberland and Berwickshire, and the rich alluvial Carse soils of the north, would find the seed corn of the warm, friable soils of the new red sandstone improve the wheat produce of their broad and well-tilled fields.

A little consideration will clearly show the important relations which exist between the parent seed and its offspring, the young plant, and why it is desirable that the finest and most perfect seed should be used. All grains or seed contain, besides the germ (A), a certain amount of substance, sufficient to carry out the process of germination as soon as the vital principle has been excited and the action of growth commenced. This action of growth consists of the simultaneous development of the embryo stem, called the "*plumule*" (B), and of the rootlets (C), these being formed out of the materials stored up in the grain (seed), which gradually diminish as these two organs or necessary parts are increased. When the whole of this store is exhausted, the young plant is then left to its own resources, and has to seek its own food instead of relying on its parent for support; and much of its future growth and productiveness depend upon its condition and strength at this period of its existence. If it has been well fed, and

been enabled to throw up a stout and sturdy stem, and to send down strong and vigorous rootlets, it passes through this trying period—this weaning time—without suffering any check to its growth, and speedily shows its healthy condition by the deepened colour of its flag-leaf, and by its general more erect habit. If, however, the parent seed was but imperfectly developed in itself—if it had not been perfectly matured—or if it had received any injury, such as too frequently occurs in the operations of the barn where the antiquated flail and faulty machinery are used, then the store of food provided for the young plant would necessarily be deficient, its organs would probably be imperfectly developed and weak, and it would be cast upon its own resources, a weak and sickly plant, to struggle against all the vicissitudes of its new existence, in the shape of weather and the numerous ills and enemies to which the wheat plant, during the whole period, ay, every stage, of its life is subject.

So many enemies, indeed, has the wheat plant to encounter during the successive stages of its growth, and such injuries does it receive from them at times, that, although but little attention comparatively is given to the securing a well-grown healthy seed, still the advantage of some treatment of the seed previous to sowing, for the purpose of securing it against some of these attacks, is very generally acknowledged and followed throughout the country. This process is called “pickling” or “steeping,” and consists in immersing the seed wheat for a given time in a solution prepared for the purpose, which neutralizes, more or less perfectly according to its composition, the chance of injury from certain parasitic fungoid plants, known by the ordinary name of “smut,” “bunt,” &c., which are extremely detrimental to the growth and yield of the plant.

The composition of these “steeps” varies in different

parts of the country, according to the different opinions as to their efficacy. The most common, probably, is the solution of sulphate of copper (*blue vitriol*), used in the proportion of 1 lb. to each sack (4 *bushels*) of grain to be steeped, and dissolved in sufficient water to completely cover the grain when placed in the tub. The grain is left in the steep for twenty to thirty minutes, then removed, drained, and laid out on the floor to dry, when it is ready for use. If time presses from any cause, the drying process may be accelerated by dusting it over with lime, or, better still, with gypsum; and, in all cases, it is desirable that it be sown as soon after it is dried as convenient. Sulphate of iron (*green vitriol*) is also used, and in the same proportions; but, although a little cheaper, is not so efficacious. In the eastern counties particularly arsenic is largely used for the purpose, combined with an alkali (*soda*) to assist its solubility. This composition, "arsenate of soda," is largely manufactured in Glasgow and other places, and sold to the farmers in a crude state, and at a cheaper rate than they can purchase the blue vitriol. In some districts a solution of caustic lime in water is the simple form of preparing the steep liquor; in others again, a fermented chamber lye, or putrid urine, is the favourite composition. This, until lately, was the steep commonly used in the north, where, indeed, it still is frequently to be met with. Another alkaline steep is used on the Continent, and is recommended by Mr. Berkeley in his *Introduction to Cryptogamic Botany*. This is a solution of Glauber salts (*sulphate of soda*), dried off with quicklime. The lime combines with the sulphuric acid, and so forms sulphate of lime (*gypsum*), while caustic soda is set free.

These represent the composition of the two generally used forms of steep liquors—the metallic and the alkaline—the action of both of which can be readily ex-

plained. A third exists, however, and has its advocates, though it is not very easy to understand its special virtues. This is the solution of chloride of sodium (*common salt*), which is recommended to be prepared for use strong enough to float an egg on its surface. The *modus operandi* of these steep solutions comes more appropriately before us in the description of the diseases for which they are applied as remedies (see page 66). The practice of steeping seed preparatory to sowing was followed by the Romans; indeed, we find it mentioned by the earlier Greek agricultural writers. Their ideas of its efficiency were based upon the superstitious belief in some tutelary deity, and the success that followed it was assigned to the favour of that presiding guardian over their crops. The blood of a capon was considered to preserve the seed macerated in it from the attacks of all noxious diseases; and the immersion of the seed in a solution of nitre was supposed to endue it with greater vitality. Here we have the germ of our present practice of steeping, and also of the attempts that have been made from time to time to introduce a steep solution that should exert a manurial effect upon the seed, equal to that effected upon the growing plant by the usual system of applying manures. Happily, these attempts have never met with any success, though they were supported by a certain amount of plausibility, and by the still stronger inducement of a very great (asserted) saving in expenditure. The value of the applications, whatever they were, might readily be calculated according to the money worth of the ingredients composing them, which could derive no higher value from their being attached to the grain itself, than if they had been merely placed in the soil for its natural use. The quantity that could possibly be attached to the bushel of seed would be too minute to have any practical manurial effect on the soil whatsoever. The

practice of simply steeping seed, for the purpose of insuring a more regular and early germination, is very generally and successfully followed with many seeds—turnips, mangold, carrots especially—and in all cases common water will be found to be more efficient than any nostrum that may be recommended.

The quantity of seed per acre is the next point which claims the farmer's attention. This is one of the questions—"thick or thin seeding"—that has been of late years the most discussed in agricultural circles, and one about which the greatest difference of opinion still exists. There are some plain principles connected with this point, which, if admitted, ought to render the solution of it less difficult than it appears to be, by limiting the range of difference to certain conditions. We can readily conceive, and long experience has confirmed it, that under equal circumstances, a plant like wheat will increase more in nine or ten months (if sown in October), than in five or six months (if sown in February or March), and that the produce will be greater in a rich deep-tilled soil than in a poor shallow one. The deductions we should make from these facts are very obvious:—1. That the earlier we get our seed into the ground, the more opportunity it has to increase, and the less the quantity required to produce a crop. 2. That the better the soil and the deeper it is tilled, the greater the proportion of food, and the greater the range the roots have to procure it in, and consequently the more vigorous and productive each plant will be, and the less necessity is there for multiplying them by thick seeding, in order to secure a sufficient crop. Therefore, as a general rule, we may consider that, to obtain a given return, it is desirable to increase the quantity of seed sown according to the lateness of the time of sowing, and also according to the character and general condition of the soil. For instance, on land where

1 bushel would be considered sufficient for October sowing, it would be advisable to increase the quantity to $1\frac{1}{2}$ bushels in November, to 2 bushels in December, and to $2\frac{1}{2}$ to 3 bushels for spring sowing, according as the season was advanced. On rich deep soils, compared with soils of inferior quality, the same rule should be observed, bearing in mind always that the character of soil, and the period of getting the seed in, have each of them an influence on its powers of produce.

The Roman farmers were very strict followers of these rules, and have left us the benefit of their observations. They divided their wheat soils into three descriptions—fat, middling, and lean; and they agreed that the quantity of seed should be varied according to the character of the land, the season of sowing, and the weather. They, however, appear to have had no mechanical arrangements for depositing their seed, as we have, in the shape of drills, dibbling machines, &c., but distributed it universally by the hand, broadcast. With us the different methods of sowing have a considerable influence upon the quantity of seed to be used.

The great object to be effected in sowing is to distribute the seed equally over the field, so that each plant should have an equal area for its growth and support, and to deposit it at an equal depth below the surface, so that the seed should germinate equally all over, and thus come to maturity and harvest at the same time.

There are three different modes of effecting this practised in different parts of the country—"broadcast," "drilling," and "dibbling." In the north the first, broadcasting, still is generally practised. In the midland and southern districts drilling universally prevails; while the dibbling process is only to be met here and there, under peculiar circumstances either of soil or labour. The preparation of the soil for each mode of sowing is the same.

It should be ploughed as deep as possible, carefully cleaned, and the mass, not merely the surface, reduced to the finest tilth, so that the rootlets of the young plants may have no obstacles in penetrating the soil,* and may have their feeding surfaces increased.

The process of *broadcasting* is a simple one. The seed to be sown is carried by the sower in a bag (sowing sheet) or basket (seed-lip), of a convenient form, suspended from the neck, in such a position that the sower can have access to it either with one or with both hands, according to the manner in which he intends to distribute the seed, whether with one, as is usually done, or with both hands. At starting, he marks off with a "feering-pole," on the headland, a distance equal to the breadth he can cover in his cast, so that on his return down the land again he may keep a perfectly straight line, and thus avoid leaving any portion unsown, as is frequently the case with careless sowers. The breadth covered by each cast is from 6 to 8 feet, and from 10 to 12 acres is quite sufficient for a day's work.¹

The operation is purely that of a skilful and careful manipulation, and a few acres more per day sown are not to be considered for an instant in comparison with the regular and careful distribution of the seed on the sur-

¹ It is very easy to estimate the amount of all descriptions of work (surface) that ought to be done in a day, when the rate of motion is determined upon. By calculating the number of square inches in an acre (6,272,640) they would be found, if placed in a straight line, equal to 99 miles (63,360 inches in a mile); consequently, an implement 1 inch in width, would have to travel 99 miles to cover an acre. If the implement or machine were 1 foot wide, it would require to travel one-twelfth of 99 miles, or $= 12\frac{1}{2}$ miles, in order to cover the same area. "Therefore, if you multiply the breadth of each turn of the machine by the rate of motion (miles travelled per day), and divide the product by 99, if the breadth be given in inches, or by 12.25, if it be given in feet, you have at once the amount of work that ought to be done in the day."

In this case we have a man covering a width of—say 6 feet—at each cast, and moving at the average rate of—say $2\frac{1}{2}$ miles per hour, for 8 hours, or, in all, 20 miles per day. Therefore, we have $20 \times 6 = 120 \div 12.25 = 9.707$ acres sown per day.

face, which is usually only acquired by long and careful practice.

In *broadcasting*, whether on the harrowed surface or on the ploughed ridges, which is frequently done for the purpose of more readily covering the seed, a certain proportion of the seed is always left under conditions unfavourable to germination, either by being left on the surface or by being buried too deep; consequently it is always customary to allow for this by increasing the quantity sown. This increase should be about one-third to one-half more than that used by the drill; say, for instance, where 2 bushels of seed are drilled, 3 bushels should be broadcasted. The use of the broadcast machine insures a more equal distribution on the surface, but leaves the other imperfections of the method the same. The necessary quantity of seed should be carried into the field, and left in sacks at intervals most convenient for the sower.

The practice of *drilling* was introduced by Jethro Tull, to obviate the difficulty, nay impossibility, of keeping the land sown broadcast free from weeds. Owing to the vast improvement in the adaptation and manufacture of agricultural machines generally, this practice has widely spread itself of late years. The advantages it offers are—a considerable saving in the quantity of seed necessary (from one-third to one-half), owing to the greater regularity in the proportion of seed sown, and the depth at which it is deposited; and the power it gives to sow the seed in parallel lines at any distances apart that may be desired, so that the surface may be stirred after the heavy rains of winter, and kept free from weeds, either by the hand or the horsehoe, during the early growth of the plants. The quantity of land to be drilled in a day depends upon the size of the machine used, and this is generally determined by the size of the farm, or rather the arable portion of it. This can readily be calculated by the foregoing rule: thus, if

the amount of labour, both manual and horse, with an allowance for the use, or wear and tear, of the machine, be summed up, and divided by the area of the land sown, the cost per acre for drilling is readily ascertained.

The third method of sowing, that of *dibbling* the seed in, is very rarely met with in practice to any extent in reference to wheat sowing, though it still prevails to a considerable extent with beans, mangold-wurzel, and similar crops. The object gained by this process is a great economy, even in comparison with the Drill, in the quantity of seed necessary, an equal distribution of the seed over the whole surface, and security against any of it remaining on the surface uncovered. The proportion of seed for dibbling is usually from one-third to one-half the quantity that would be used for drilling under the same circumstances—that is to say, when from $1\frac{1}{2}$ to 2 bushels are drilled, from 2 to 4 pecks would be sufficient for dibbling.¹ The process of dibbling is a very tedious and expensive one, notwithstanding the certain amount of success which has attended several attempts to substitute mechanical for manual labour. These may be seen well described in the *Cyclopædia of Agriculture*, under the head of “Sowing Machines.” In all the operation is the same, though effected by different means: a hole or depression in the soil is made to a given regulated depth, at the bottom of which a certain proportion of seed (usually about three grains) is to be deposited—these holes being made at certain regular distances from each other, and in as perfectly

¹ In the *Agricultural Gazette* for 1859, p. 681, a correspondent thus writes, in reference to his produce from dibbled seed:—“Of wheat I never planted more than 2 pecks of seed per acre; of barley 2 pecks, and oats 3; but I shall reduce the quantity of oats. Of produce, I had on one field of wheat, four years in succession, averaging 44 bushels per acre, from 2 pecks of seed, or 176 bushels, in four years, from 2 bushels of seed; of barley, from 2 pecks of seed, I had $7\frac{1}{2}$ quarters, which the master said was the finest he ever saw, and it fetched 46s. per quarter,” &c.

straight lines as with the drill. It is a very difficult matter to estimate the quantity of land to be dibbled per day, as it is entirely governed by the mode of doing

Newington's Hand-dibble.

the work. Where, through an erroneous idea of social economy in relation to the application of labour, the operation is done by hand, both the proportion of seed, and the depth at which it is deposited, are always irregular and unsatisfactory, and the work done is very small. These drawbacks, however, more or less disappear by the use of the machinery placed at our disposal. The only comparative trials that I have had an opportunity of making have been with Newberry's dibbling machine; this is a costly and cumbersome, but, under suitable conditions, an effective machine for the purpose. With this machine about 4 to 5 acres a-day can be got in, with the same amount of horse and manual labour as would, with the drill, enable you to sow about three times that area, or 12 acres; consequently, the expense of dibbling

under these favourable conditions would amount to rather more than three times that of drilling, as the sum allowed for wear and tear of machine would be considerably increased.

The relative advantages and disadvantages of these three methods seem to be as follows:—

Broadcasting enables the farmer to get his seed in at a quicker rate, and at a less cost than by the use of machines; while, at the same time, in adverse seasons, he is less dependent upon the weather at seed-time; and, if his land is kept well cleaned in his fallow crops, he may not suffer much by leaving his crop beyond the reach of the hoe during its period of growth. On the other hand, if his land be foul at sowing, it necessarily becomes worse by harvest time, and the crop must have been injured, as every weed grown on the surface has abstracted from the soil a certain amount of food, which otherwise would have gone to increase the crop under cultivation. This condition of things soon tells its own tale on the debtor side of the farm ledger, while another item to be entered there is the extra quantity of seed required to be sown. This generally amounts to considerably more than the entire cost of machine sowing.

Drilling offers the great advantage to the farmer of being able to regulate the exact quantity of seed to be sown—to sow it equally all over the field—to deposit it at a given regular depth in the soil—to insure its being properly covered. A saving of seed to the extent of one-third to one-half as compared with broadcasting is effected, and by being deposited in the ground in straight parallel lines, great facilities are afforded for keeping the surface free from weeds, either by hoeing or hand-pulling.¹ The produce also per acre is, under equal conditions of soil,

¹ The experiments on the relative produce of broadcasting and drilling wheat, by Mr. Vernon Harcourt, recorded in the *Agricultural Gazette* for 1848,

climate, &c., shown to exceed that of broadcasting. The only charge that can be advanced against drilling is, that perhaps it offers some assistance to the wireworm in its destructive attacks on the young plant, by forming a furrow of loosened soil, along which the wireworm takes its course without any difficulty, destroying each plant in succession. This, however, on soils subject to it, may easily be checked by running a ribbed roller, either Cambridge or Crosskill, across the line of drills, by which the continuity of the furrowed course is stopped at each indentation of the roller. The wireworm then, owing to its small powers of forcing itself through the soil, can only move from plant to plant by coming up to the surface; this materially checks its progress, while its presence there is being constantly sought for by various insectivorous birds.

Dibbling is to be recommended chiefly for the more perfect manner in which the seed is deposited in the soil, both as regards the equality of its distribution, and as regards the proportion of area allotted to each plant. The amount of seed saved by this method is an item of consideration—drilling requiring twice, and broadcasting four times the quantity. The seed, too, by being deposited in separate unconnected holes, is not so liable to be destroyed by the wireworm as when sown in drills, while the parallelism of its lines of plants offers even greater facilities for cleaning than in ordinary drilling. Some care, however, is necessary that the dibbling machine should only be made use of when the soil is suitable, and in a suitable condition. If it is too light, or too dry, the sides

show a great advantage in favour of the latter, as compared with the former. The returns are thus given:—

	Grain.	Straw.
Drilled wheat, per acre,.....	40 bushels,.....	77 trusses.
Broadcasted, „	33 $\frac{3}{4}$ „	66 $\frac{3}{4}$ „ ..

These results confirm those of similar series of experiments given in our earlier farm records.

of the holes are apt to fall in with the seed, or before it is quite deposited, and then the depth is irregular, often too little. If the soil is heavy, or too wet, the dibble forms a hole, or cup, with compressed sides and bottom, in which the water collects, checks the germination of the seed, and materially injures or destroys the vitality of the young plant.

We have now selected our seed, steeped or pickled it by means of one of the preparations already described, and deposited it under satisfactory conditions in the soil; the seed-harrows have been sent over the field, and the operation of sowing has been completed. Then the initial act of reproduction—the process of germination—commences; and as this process is a very beautiful and extremely interesting one, though, at the same time, very little understood, it is worth more than a passing remark. It can, however, be more readily and appropriately discussed in the next Part. When barley comes before us, as in the steep of the malt-house, the same effects are produced on the mass of grain as on the individual seed when placed under suitable conditions in the soil. In the malt-house the effects produced by the various changes in the grain are known and carefully watched, the success of the operation depending on their regular progress, while in the soil the grain is hidden from our sight, and passes through its various gradations of vegetable development unheeded and uncared for by those who placed it there, and whose success is largely influenced with its own.

Certain conditions are absolutely necessary for germination; these are—absence of light, the presence of a certain amount of moisture and of temperature, and access to air (on account of the oxygen contained in it). If these conditions are not secured to the seed, your wheat will not germinate, and you will have no plant. This state of things is often met with practically on a farm. The land,

when sown, may have been too dry to allow of the absorption by the seed of sufficient moisture for its purpose; or it may have been too wet, and thus kept the temperature too low for the germinative process to be set up; or the seed may have been left too near the surface, and exposed to the action of too much light; or it may have been deposited too deep to admit of that access to the air which is absolutely necessary to carry out those changes which the vital principle existing in the germ of the seed sets in motion before the plant can be produced.

Let us suppose, however, that we have secured all these desirable conditions—that the seed has been deposited in the soil by one of the methods described, and that the germinative process has proceeded satisfactorily—as vegetation advances we see the “plumula” gradually increasing in length, until it shows itself above the surface, in the shape of a slight cylindrical filament, which, on exposure to the action of light, speedily changes from a pale yellowish colour to a darker green, while at the same time a number of very fine fibres or rootlets are being sent out from the seed, downwards in different directions, through the soil, as far as they can penetrate. If we were now to take up the young plant and examine the state of the parent seed which we had sown, we should find it little more than a shrivelled husk—all its interior having disappeared under the influence of those changes which were necessary for the support of the young plant; while, if we were to take the young plant itself, and submit it to a rigid analysis, we should find its ultimate elements to consist merely of those substances which before existed in the seed, but combined together under different laws, in different proportions, and with the addition of a large quantity of water.

The food of all plants consists of the two classes of bodies, organic and inorganic; the portion of the plant above ground has the duty of supplying the former, while

those portions beneath the soil are furnished with powers to appropriate the latter. In the parent seed a supply of both organic and inorganic food is stored up for the young plant; but as soon as this is all consumed, the plant is thrown upon its own resources, and unless it then has vigour and power sufficient to supply itself, it becomes debilitated and stunted, or gradually dies away altogether. It is at this period of plant life that the difference is most forcibly shown, between the produce of good, fully-matured seed and that of inferior quality—the one exhibiting itself in the shape of a bold, erect plant, with a broad, green leaf, withstanding the change in its circumstances from its parent seed to its own resources, with hardly an inconvenience or perceptible effect—while the other, with its drooping stem and sickly yellow leaf, has all the aspect of a debilitated plant, struggling against adverse conditions, readily affected by every variation in the weather, and offering a suitable home for the germs of those diseases which so materially influence our crops.

As soon, then, as the supply in the parent seed is consumed, the leaf and the roots of the young plant ought to be sufficiently developed to obtain a continuous supply for its use from the air and the soil in which its life is to be passed—the leaf providing the necessary amount of organic food from the atmosphere which surrounds it—the roots having the duty of furnishing the supply of inorganic (mineral) food from the soil in which they are placed. The change, however, from the food furnished by the parent seed to that furnished by the soil is always accompanied by a slight effect upon the organism of the young plant. This, of course, is more felt by the weak and half grown than by the strong and well developed plant. It is analogous to weaning in the young animal; and, indeed, is frequently known by the name of “weaning” or “speaning” brash.

As soon as this change has been effected, and the plant recovers from it and assumes its independent functions, a knot or node is formed at the surface of the soil, just above where the stem and roots meet, and from this other roots and stems branch out, forming independent plants, and materially adding to the produce of the original seed. This is what is known by the term "tillering" in the wheat, and never is commenced until the plant has assumed its independent functions, and the roots have begun to assimilate inorganic food from the soil. Here the vigorous and healthy constitution of the plant exhibits itself, by the "tillering" power it possesses in the formation of new roots and stems; while the condition and quality of the soil are also seen by the manner in which the subsequent development of the plants is carried out, as, unless it contains plenty of food in a suitable condition for the crop, the roots, vigorous though they may be, will not, of course, be able to obtain the necessary supplies. We should then see that an increased number of plants does not always produce an increased return—that, in fact, the stock was in excess of the keep; for, if we have increased numbers, we must have an equivalent increased power of supplies, or their vitality will be affected, and their produce diminished.

In suitable soils, and under favourable conditions, this power of increase in the cereal plants is remarkable. Pliny relates that in the time of Augustus Cæsar a sheaf of wheat, containing 400 perfect stems rising from a single stock, the produce of Mauritania (now Algeria), was exhibited at Rome, and that at a later period, another sheaf, containing 360 perfect stems, the produce of a single grain, was presented to the Emperor Nero. There are numerous well authenticated instances of the reproductive powers of the cereals, under favourable conditions of soil and climate, in our own, as well as in other countries. At the Exhibition in Paris, 1849, two plants of wheat were shown, the one

carrying 122, and the other 152 perfect stems. Again, at the International Exhibition of 1855, several similar instances of the fecundity of the wheat plant were to be seen. In the Museum of the Royal Agricultural College, a barley plant may be seen, consisting of seventy-eight perfect stems, which yielded 1780 grains, the produce of a single seed sown in the neighbourhood of Cirencester, in the spring of 1847. These, of course, are all exceptional cases; still, they have their value as instances of the enormous increase the reproductive powers of the cereal plants are capable of when acting under favourable conditions.

Although the individual farmer may never be able to realize in general practice anything like these returns, still he may rationally expect that the more he strives in his practice to meet the requirements of the plant he cultivates, the more likely he is to secure successful results. In agriculture especially, *effects* are readily seen—say in the shape of good or bad crops—though, in the present defective state of our knowledge, it is very difficult to assign their exact *causes*. The best way to insure success is to deserve it, and we can only deserve it when we have fulfilled all the conditions which experience in principles, as well as in practice, has pointed out to us.

In the cultivation of wheat we have, first of all, the *soil* to look to, to see that that is in a proper state, both mechanically and chemically, for the growth of the plant—mechanically, that its particles are finely divided, and yet sufficiently coherent to form a firm bed—that they absorb moisture, but admit of free percolation of superfluous wet—and that the tillage processes have been carried down as deep as possible, so as to give the roots the maximum amount of feeding surface. The Roman farmers were accustomed to till their land 2 feet deep.¹ If we care-

¹ Non contentos esse nos oportet prima specie summi soli, sed diligenter exploranda est inferioris materiæ qualitas, terrena necne sit. Frumentis autem sat erit si æque bona suberit bipedanea humus.—*Columella*, lib. ii. cap. 2.

fully examine a vigorous wheat plant in a favourable soil, and trace its roots downwards, we see that they ramify in innumerable branches, and readily penetrate to that depth, which, of course, they could not do under the ordinary conditions of our farm ploughings. By deep cultivation the producing area or size of a farm may be said to be increased, though the surface remains the same. Twelve inches of tilled soil contain, of course, twice as much mineral food as 6 inches do, and 6 inches necessarily twice as much as 3 inches, which, probably, is nearer the average depth of our ordinary cultivation. By removing the soil to this depth (12 *inches*) once in the course only, great advantages would accrue. Air—that necessary ingredient of fertility in a soil—would have full access to its mass; the roots, extending themselves at this depth, would be under more regular and favourable conditions, as regards temperature and moisture, than when nearer the surface, and the plant would, as a consequence, stand the vicissitudes of weather much more securely; while the amount of mineral food would be doubled, so that a largely increased number of plants could be supported on the same surface-area of the field, and an equivalent increase in produce obtained. This doctrine or rule is applicable to all cultivated plants: with some its advantages are more perceptible than with others: no crop, however, shows them in a more marked manner than the one now under consideration.

The *chemical* conditions of the soil are less understood, and far less under our control, than the mechanical; for, not only is it requisite that the soil should contain all the ingredients required by the growing crop, but that these ingredients be severally in a state such as the plant can assimilate or make use of. The roots, of course, are the only parts of the plant through and by which the ingredients of the soil can be absorbed for the use of the grow-

ing plants, and these can only assimilate them when in a soluble state. Without now venturing upon a discussion of the important question of plant-nutrition, as to whether the excretory theory of Decandolle, recently revived and supported by Gasparini,¹ or the simpler mineral theory of the chemists, is the soundest, we may recollect that the power of the roots to absorb from the soil the various substances necessary for the plant is more than a mere mechanical one, as, whether or not they have the power of preparation, they unquestionably have the power of selection, and only select such as are necessary for their purpose, and in a suitable state. They do not absorb indiscriminately all matters they find in the soil in a soluble state—of which the inorganic are, of course, in excess—but appear to have the power of selecting those that are desirable, and of refusing those which are not necessary for their purpose. This power appears to be more developed in some plants than in others; it exists, however, in all, and is controlled, probably, by some difference in the structure and substance of the pores or cells through which the food passes into the extremities of the roots, according to the different orders, or even genera of plants, which exerts an influence upon their general powers of absorption and assimilation. After the substances have been absorbed by the roots, a chemical power or action is called into play, and a change appears to take place in the matter absorbed (food), as it is carried up by the ascending juices (sap) of the plant towards the stem. Of these changes, and the mode in which they are carried on, we know but very little at present; we only know that they do exist, from the changed character of the substances found in the sap.²

¹ *Ricerche sulla natura dei succiatori e la escrezione delle radici*, di Gul. Gasparini, Napoli, of which an excellent digest was given in the *Gardeners' Chronicle*, 1853, p. 19.

² The structure and functions of roots are fully described in Professor Hen-

After the *soil*, the *seed* is the next point which claims attention. Here the conditions of success are simpler, and far better understood. In all cases care should be taken that the seed be perfect (uninjured), and fully matured; and, for the reasons already given (page 21), that it be of the best quality. If the seed be much bruised or injured, its germinative powers may be entirely destroyed, and it decays in the soil, without producing a plant at all. If it be slightly injured or not fully matured, it generally produces a weak and sickly plant, which fails for want of nourishment, before it is able to throw out roots and obtain its own supply; or, if it has strength sufficient to struggle through this period of its existence, its generally debilitated condition renders it liable to the attacks of those fungoid and insect enemies which accompany every stage of its future growth.

Lastly, the mode of *sowing* requires consideration—whether by “broadcast,” “drilling,” or “dibbling,” the best results are to be obtained. By the first, time and labour are economized at the expense of an increased quantity of seed; by the second, the quantity of seed is economized, but the cost of labour is increased; and by the last, the proportion of seed is still farther lessened, while the cost of labour is still augmented. The first mode renders any subsequent operations, as hoeing, weeding, &c., impracticable; while the two latter modes give every facility to them, and, at the same time, more equally and regularly distribute the plants over the surface.

The regularity of distribution over the surface is of some importance to the future yield. An equal, regular plant is usually more productive, both in quantity and quality, than where the plant is patchy—luxuriant in some places and defective in others. The ordinary prac-

tice of seeding is far too close; a greater distance between the plants would, provided, of course, that the seed were good and the soil in proper condition, give much better results, not only as regards the crop—the primary crop—whatever it may be, but also as regards the secondary crop—seeds, for instance, that might be sown with it. The usual width of drills may be taken at 6 to 9 inches; if this be increased to 12 inches the effect on the grain crop, but more particularly on the seeds, is very marked.

The advantages of attention to these points in reference to tillage, and to the distribution of seed on the surface, have received marked corroboration by the successful results of the "*Lois-Weedon* system," which is based upon these two principles. How far the question of seed selection has been observed, I am not aware. This system of cultivation has been so often discussed in the different agricultural periodicals, and is now so generally known, that I need do no more here than give a brief sketch of its practice and results, referring those who may not perhaps have paid much attention to it, to the reports and valuable statements¹ which its author has from time to time published.

The *Lois-Weedon* system resembles much that advocated by Jethro Tull about a century ago—deep cultivation and wide drilling—by which, without any manures whatever, a large crop of wheat could be obtained, it was said, year after year, off the same ground. Here, however, a difference of material importance exists between the two systems. Tull operated on the same ground, while by the *Lois-Weedon* system it is not precisely the same ground that is cropped in each succeeding year; indeed, it is merely a system of alternate fallowing and cropping, the repeated fallowing being equivalent (during a certain

¹ *Word in Season to the Farmer.* By the Rev. S. Smith. Ridgway, Piccadilly.

time) to the manuring of the Essex and other heavy land fallowing practices.

In this, the wheat is drilled in 12-inch rows, and between every set of three drills there is an interval of 3 feet, which is dug or forked, and kept well stirred and pulverized during the whole time the crop is growing and coming to maturity. In fact, it is simply a naked fallow, extending over a portion of the field equal in extent to that occupied by the crop. When the crop is harvested, the empty spaces are quite ready, in a thoroughly clean and mellowed state, for the reception of the seed; this space is then sown in the same manner, and the next year's crop is produced solely upon that portion of the field which was under a naked fallow the past year. It appears to be, therefore, clearly a system of alternate crop and fallow; and by this arrangement of wide drilling and open intervals of space, with *deep tillage* and perfect *freedom from weeds*, the crop on each half acre so cultivated is found to exceed in quantity the average of that grown under the ordinary mode of cultivation upon the whole acre surface, while the sample is always more regular and of better quality.

The returns of wheat produce from one particular piece of land upon which the practice has been continuously tried, since its commencement in 1847, are thus given by the Rev. S. Smith:—

1847	not measured.	1853 }	{ returns good, but
1848	34 bushels.	1854 }	{ not noted.
1849	34 „	1855	40 bushels.
1850	34 „	1856	37 „
1851	28 „	1857	36 „
1852	34 „	1858	40 „

These returns must be understood to be from each *half acre* under crop—the other half acre, thanks to the working it has during its fallow, being in an admirable condition for the next year's crop. The tillage processes

during the fallow, Mr. Smith tells us, amount to 12s. to 18s. per acre. This cost would be diminished to one-half or one-third, now that we have successfully harnessed steam to our ploughs and cultivators. The increased vigour of the plants, owing to the deep tillage and open growth, shows itself in the stoutness of the straw, which frequently exceeds 2 tons to the half acre, and is very rarely laid. A practice of earthing up the plants with a light mouldboard, which Mr. S.'s system of wide cultivation has enabled him to apply to his wheat, no doubt assists in maintaining the stoutness and strength of the plant, as we know it does in Indian-corn and other plants of the same family.

Let us now follow the growth of the plant, whose existence we have traced from the parent seed up to the period when, having passed through the earliest stages of its life, and consumed all the food stored up for its use, it enters upon an independent career, and relies upon its own powers for its future support. During the growth of the plant many circumstances have influence over it: the principal of these are in connection with the soil in which it is placed, or the atmosphere which surrounds it. Favourable conditions are readily recognized in the more or less vigorous appearance of the plant; in some cases, however—for instance, where the soil contains a large proportion of available organic matter—the plant starts off with an appearance of growth which it is not able to sustain in its after stages. In others, again, owing probably to a deficiency of soluble silicates in the soil,¹ the straw, though stout and tall, is of too herbaceous a nature, and lacks the rigidity necessary to carry a full head to maturity; and again, the produce is unsatisfactory. In both these cases, the application of common salt as a top-dress-

¹ Probably the varieties of wheat requiring smaller supplies of silica might be introduced with advantage on such soils. See page 88.

ing, at the rate of 3 to 5 cwt. per acre, is generally found to be followed by good results.

Again, appearances just opposite to these are to be frequently seen in crops growing even on strong and good wheat soils, especially if the season be a dry one, where a deficiency of organic food for the plant occasions a stunted, though at the same time not an unhealthy growth. This may entirely disappear should the weather change, and furnish a supply of moisture to the soil, which would enable the roots to obtain more readily the needed supplies; or it may be materially improved by the judicious application of some manurial substances, rich in the elements which the plant is supposed to require. Here the good effects of nitrogenized manures are generally seen,¹ guano (Peruvian), and nitrate of soda being those usually applied, at the rate of 2 to 3 cwt. per acre. In all cases, these topdressings should be applied immediately before, or during wet weather, so that they may be acted upon by the rain, and carried at once into the soil.

Frequently, after a mild winter especially, the autumn-sown wheats on good soils, present an appearance of luxuriant growth, which is considered to augur badly for the future crop, as rendering the plant more liable to disease, and to suffer from the weather. In this case, a practice exists of feeding it off by sheep, and then allowing it again to resume its growth. This practice does not appear to make its way as it ought to do; chiefly, I am inclined to think, because where it has been tried unsatisfactorily, the necessary conditions and precautions were not properly observed. It should not be attempted too late in the season, certainly not later than the end of March;

¹ Ammoniacal manures are generally found more effective than the phosphatic when applied to our cereal crops; the latter, however, are preferable to the former for turnips and fallow crops generally. The difference in the proportion of the leaf and in organic structure between the orders to which the plants severally belong may account for this.

the land should be sufficiently dry to carry the sheep, of which a large number should be folded on it at once, so as to get over the surface rapidly. The wheat should be eaten down close to the crown of the root, and not merely its leaves only; and then when the sheep are taken off and vegetation is again unchecked, stems are sent up from each knot of roots formed by the "tillering" process of the plant, and being now of equal growth, present at the time of harvest an equal plant all over the field, with none or few of those short straws with small heads (tillers), which not only ripen irregularly, but lessen the produce returns of wheat grown under the ordinary conditions.

There can be no doubt that, *cæteris paribus*, autumn-sown wheat is more productive than spring-sown, it being the growth of say ten months (October to August), against six months (February to August). The roots have an opportunity of developing themselves, and penetrating deeper into the soil, by which they are placed in far more favourable conditions as regards mineral food, moisture, and temperature, than when they are forced to remain nearer the surface. To compensate for these advantageous natural conditions, spring-sown wheat requires a soil richer in available food, so that it may feed quicker; that it may, indeed, be able, in six months, from a limited depth of soil, to abstract as much food as the autumn-sown, obtained from an increased depth of soil in ten months. If this is not provided by the farmer in the superior condition of his land, his returns will not be so productive from his spring as from his autumn wheats; while he must always bear in mind, that the former are more liable to be influenced by climatal effects—rain or drought—than the latter.

The vast increase of turnip cultivation during the last twenty years has greatly affected the period of wheat sowing throughout the country. The practice of spring

sowing has followed the introduction of turnips, into districts where formerly it was never thought of. In instances where wheat follows turnips fed off on the land, a plentiful supply of available food is prepared for the wheat by the preceding crop, while the extra tillage of the turnip crop acts as a good preparation for the wheat.

During the period of growth the wheat requires but little attention. Early in the spring some mechanical assistance should be given to the soil, in the shape of rolling or harrowing, in order to compensate for the effects of winter, and restore the surface to its proper condition. On certain soils—those containing much clay or lime, for instance—the alternate frosts and thaws of winter frequently leave the surface in a very loose and open condition, in many cases, indeed, exposing the roots prejudicially, and in some, lifting the plants completely from their bed. Here the roller does good service to the land in consolidating the surface soil, which it leaves at the same time in a finely divided condition. On soils of a loamy character the heavy rains of winter frequently, if succeeded by drying winds, leave the surface battered down and coated with hard dry crust impervious to the atmosphere, and obstructive to the increasing vitality of the plant at that period of the year. This may be readily broken up, and a healthy surface restored, by a double turn with the light seed-harrows.¹ Later in the spring the operation of hoeing should not be neglected, as even on the cleanest farms a certain number of weeds will always be found, and they must abstract from the soil matters which would otherwise be available as food for the growing crop. The introduction of the expanding horse-hoe has been a great benefit to the farmer, as it enables him to hoe his wheat land more efficiently, more quickly,

¹ In all cases iron harrows work more regularly on the surface than those with wooden frames, which are apt to jerk on meeting with small obstacles.

and at a saving of three-fourths to four-fifths, as compared with hand labour. Hand-hoeing is generally piece work. Here the interests of the employer and the employed are opposed to each other, and one generally suffers. The object of the farmer is *quality*, the object of the labourer is *quantity* of work, and if the latter is not well looked after, or above the average honest, the one is sacrificed to the other, and the soil removed by a 6-inch cut with the hoe serves to cover up the next 6 inches of untouched surface; while the agreed price of say 3s. per acre, actually becomes 4s., 5s., or 6s. per acre, according to the proportion left unhoed.

Time, too, is an important element in this operation. Hoeing must not be attempted, unless the ground be in a suitable condition, or it would occasion more harm than good; and this particular condition rarely exists for more than a few days at a time, at the season when hoeing should be done, a shower, if only of an hour's duration, frequently putting a stop to the chance of hoeing for the remainder of the season. Where there is a large breadth of wheat grown, the labour question of hoeing becomes a serious one, as a man cannot fairly and properly get over more than half an acre per day, especially where the drills are of the ordinary width. The horse-hoe¹ relieves the farmer from much of his anxiety. He has only to regulate the depth and width of the cut, and be assured that the whole of his surface will be equally acted upon by it. He finds that, with one man to direct and one horse to draw, the implement will do on the average from eight to twelve acres per day (according to the description of soil and width of drills), in a superior manner, at a cost of, say—horse, 2s. 6d.; man, 2s. 6d.; wear and tear, 1s. = 6s.; which would have required the employment of sixteen to

¹ Introduced and manufactured by Messrs. Garrett & Son, of Saxmundham, Smith, of Kettering, and other makers.

twenty-four labourers to effect, and at an expenditure of from 24s. to 36s. This, like many other machines possessing equal advantages, can only *follow* good farming. Before it can be rendered available, the land must be drained and laid flat, the surface must be well tilled, and the seed must be deposited in parallel lines; then there is no difficulty whatever in successfully working it.

After the hoeing has been accomplished, the wheat must be left to take its chance against the various injuries and enemies which attend upon every period of its growth. These we will discuss after we have harvested our crop, as, although the injuries they inflict are principally during its growth, our knowledge in reference to them is unfortunately far too imperfect to enable us to assign, except to a very few, the exact period of their attack, the part of the plant in which it is commenced, or the mode in which it is effected.

The period of flowering (inflorescence) is one of some anxiety, as the future yield depends greatly upon the conditions, favourable or unfavourable, under which it is carried on. Wind or wet are alike undesirable at this period—the one directly destroying the anthers and interfering with the healthy impregnation of the seed, while the other exerts a general debilitating influence upon the productive powers of the plant at a critical period of its growth, and renders it more susceptible to future injuries. The effect of the first is seen in the diminished quantity of the yield—that of the second rather in the quality of the grain produced. The flowering takes place usually during the month of June, and in about six weeks from the time it is observed we may calculate upon our harvest being ready.

The proper period for cutting wheat seems to be very little attended to, even if it be thought about at all, as it is impossible to travel through the country at harvest

time without being struck by the different stages of maturity of the plant at the time of the operation, no less than the different modes in which it is effected. It is pretty clear that all cannot be right. Some must be more advantageous than others; and if we give the subject a little consideration, we shall probably eliminate something like principles, which it is to our interest to follow as closely as we can under the varying circumstances in which we may be placed.

The best indication of harvest time is given by the changed colour of the straw immediately below the head. When this changes from green to yellow, which it does before the body of the straw changes, the circulation of the plant is arrested, and the head can receive no more nourishment from the roots. We know that it can derive none from the air, and therefore at this period must contain within itself all that is necessary for its perfection, whether it be cut at once or left standing any longer time. If this be admitted, then it is clearly the interest of the farmer to run no further risk of injury from change of weather, birds, &c., and without loss of time to cut it down, and get it safely housed as soon as possible. By commencing harvest at this period of maturity, the risks of bad weather are considerably diminished, the crop remaining without injury for any short intervals of bad weather; whereas, if it were fully ripe, as is too generally the practice, a day or two of wet weather sets up the process of germination, whether standing or in the stook, and the sample is materially injured.

But this is not the only manner in which a farmer's interests are affected by the time of cutting his wheat; for it appears that not only is the gross weight of his produce affected by it, but also the relative proportions of its most important constituents—bran, flour, and gluten. This is an investigation which deserves more consideration at

our hands than has been conceded to it, and forms one of those important questions that come most properly within the functions of our great Agricultural Societies—as, to be of any value, the experimental trials should be all strictly comparative, and as widely extended as possible. This can only be done by a number of intelligent observers acting in concert upon well considered instructions. Too often, in agricultural experiments, the conditions are dissimilar, and the results entirely valueless.

It is generally considered that the last process of maturation of grain is the perfecting of the *testa* or seed-coat (bran). This probably takes place, to a great extent, after the circulation of the plant is arrested by the drying of the straw at the neck. For mealing purposes, and for ordinary use as food, the less the proportion of bran the better; this we secure by cutting as soon as we perceive the change indicated. If, however, our object is to produce wheat for *seed*, and not for consumption, then it is important that it should be fully matured—that the seed-coat or bran should be perfected, to enable it to preserve the seed for the purposes of vegetation. In this case, it is desirable to leave it standing until fully ripe.

Reports have been given of experiments bearing upon this important question. The only one that can be quoted with any satisfactory authority, was carried out at North Deighton, in Yorkshire, upon a field on a limestone formation, the crop of which was cut at three different periods, at intervals of ten days.¹ One-third was cut twenty days before the crop was ripe, another portion ten days afterwards, and the remaining portion was left until it was dead ripe. The produce in grain was severally as 1; 1.325, and 1.26, and the respective proportions of constituents as follows:—

¹ Johnston's *Agricultural Chemistry and Geology*, p. 873. See also paper in *Quarterly Journal of Agriculture*, by Hannam, No. 58, p. 173.

	In the grain cut at		
	20 days.	10 days.	dead ripe.
* Flour,	74·7	79·1	72·2
Sharps,	7·2	5·5	11·
Bran,	17·5	13·2	16·
	99·2	97·8	99·2
* The flour contained			
Water,	15·7	15·5	15·9
Gluten,	9·3	9·9	9·6

This experiment, as far as it goes, is quite in favour of cutting wheat before it is perfectly ripe. It shows that when cut ten days before it is ripe the gross produce of grain is greater—the yield of flour is increased, and the proportion of bran diminished, while the proportion of gluten contained in the flour appears also to be at its maximum compared with its proportion at an earlier or later period of the growth of the grain.

Having satisfied ourselves as to the period at which the grain should be harvested, the next point for consideration is the means by which it should be effected. Here, again, a great discrepancy of existing practices presents itself, and a wide margin of comparative profit or loss is a natural consequence. The sickle, the scythe, and the reaping machine, each hold their sway in different districts, the sickle districts being generally more or less marked by the continued use of the antiquated flail, while the steam-like powers of the reaping machine are followed up by that of the combined steam thrashing machine.

It may be a matter of opinion as to which method does the work best; but the question of cost of each assumes more definite features, which remove it beyond the influence of opinion, and leave it to be opposed by the prejudices only of the district. Let us see how these three methods compare with each other.

The *sickle* is clearly the most ancient, as, notwithstanding the different conditions of the agriculturists of the

present day and that of the ancient Egyptians, the implement we use now for cutting our corn, is identical with that used by them some 3000 or 4000 years ago. This antiquity is no doubt the secret of its continued existence in civilized countries, where mechanical science is understood. The servility of the human mind in the presence of established practices or opinions, will account for even more anomalous practices than the retention of the sickle and the flail in this country in the middle of the nineteenth century. With the sickle or hook, from one-third to two-thirds of an acre per day may be cut, according to the nature of the crop, and the capability of the labourer. This is invariably piece-work, and probably 12s. per acre, including binding and stooking, may be taken as the *average* price. Taking a 10-acre field, therefore, as an example, we should require twenty men, at a cost of £6, to cut it and stook it in a day.

The *scythe* (cradled) is used for harvest work in several well farmed districts in different parts of the country. In Essex, Suffolk, Norfolk; in Cornwall, the Midland Counties, and in Yorkshire—the East and North Ridings especially—it is very generally met with, where it has prepared the way, by its own great superiority over the sickle, for the successful introduction of a more advanced system of harvesting by the reaping machine. In reference to the advantages which the scythe offers to the farmer in the harvest field, we cannot do better than reproduce an article which appeared in the *Agricultural Gazette* for August 31, 1850, giving details of harvest work then in operation:—

“ In one of your recent numbers appeared some remarks on the relative advantages of mowing and reaping corn. The writer was evidently a strong advocate for the latter practice, and, as strong advocates frequently do, somewhat exaggerated the data upon which he based his comparison. Now, as harvest operations are pretty generally commenced throughout the kingdom, and as the weather seems to be very unsettled, I venture to ask you to give insertion to

the results of my experience in the matter, and thus afford to those interested in such questions, an opportunity of judging how far their individual circumstances may be best suited for the one or for the other practice. My object being more to place the practice of mowing in a fair light before your readers than to oppose the writer's assumptions, I will briefly describe my own harvest arrangements, which are now in active play, and which have been tested by the past two years' experience on the same farm.

"Economy of labour being as necessary in the manufacture of corn as of calico, I have endeavoured to arrange mine so that the manual labour employed shall be suitable for the particular portion of the work required—that a man shall do a man's work, and a child a child's work, and that there shall be a harmony throughout the whole machinery.

"I have now ten scythes at work. Each mower cuts in, and lays the mown corn up against the standing corn. He is closely followed by a child, as small as you please, whose work is merely to draw bands, and lay them down at proper intervals in a straight line, ready for the sheaves; then follows a stout girl (or boy), who takes out the mown corn in her arm, and lays it, in sufficient quantity for a sheaf, on the band already prepared for it. I now require a good active man as bandster. He follows as closely as he can after the sheaves are laid, and firmly binds them, leaving them lying on the ground, whence they are lifted by another man, whose work is to place them in stooks in the usual manner. One bandster and one stooker are found to be sufficient for every two mowers. The binding is the hardest work, and the men generally change places with the stookers at dinner time.

"Taking the corn crop through—wheat, barley, and oats—I find that each scythe can easily get through 2 acres a day; and, at that rate, the other hands are kept steadily at work. The cost of this I give you in the exact wages I am now paying—mowers, 3s. per day; children drawing hands, 6d. to 8d.; girls taking out the corn, 1s. to 1s. 2d., bandsters and stookers, 2s. 2d. per day. Thus a day's work with the ten scythes is as follows:—

10 Mowers	at 3s. 0d.	£1 10 0
10 Children	at 0s. 8d.	0 6 8
10 Girls	at 1s. 2d.	0 11 8
10 Bandsters and Stookers...	at 2s. 2d.	1 1 8
3 Rakers.....	at 1s. 9d.	0 5 3

£3 15 3

This sum, taking 20 acres as the work done, would amount to about 3s. 9d. per acre; for wheat alone it would be a little higher. Taking

15 acres as the day's work (and we are cutting more than that now), it would give 5s. per acre as the cost. These payments include the usual allowance for beer.

"As a matter of cost, there can be no question between the two; and as the writer has given its disadvantages, I will conclude by attempting to show its advantages. By mowing you are enabled to concentrate your strength, and get through the harvest much more quickly. By this division of labour you nearly double the effective power of the individual, and thus half the cost, and you have all the labour under your eye at the same time. You leave far less on the ground than by fagging or reaping, as the horse-rake goes over the field after the stooks are carted, and thus takes up anything the drag-rakes may have left. The corn is ready to carry sooner than if reaped. The stubble is left much shorter, and the land is ready for the plough directly the crop is carried. The only practical disadvantage that I can admit is, the extra work in thrashing, and this is even reduced to a very small amount where steam-power is available. The carting, stacking, and thatching, are of course affected in direct proportion to the length of stubble left by the two operations under comparison; but taking the average difference in the stubble at 6 inches, and the height of the crop at $4\frac{1}{2}$ feet, it would only give in bulk about $\frac{1}{3}$ th, or 11 per cent., and in weight, only about 5 per cent. of increase. This would, I think, be fully counterbalanced by the cost of mowing the reaped stubble (about 2s. 6d. per acre), and of carting it home at a time when the teams are most wanted in the field."

These were the results of the harvest operations of about 200 acres of grain crops each year, and which subsequent harvests have confirmed, allowance being made, of course, for the different rate of wages in different districts and in different years. In some districts where the scythe is used, the labourers undertake the cutting, stooking, and loading, and in some instances stacking, at a given price (about 10s. usually) per acre. Here, as in reaping, much time is lost, and much labour uneconomically applied, in changing from one operation to another, and in the man occupying himself with work which a child or boy could do as well—in leaving off mowing for the purpose of making bands and collecting his sheaf.

Throughout the vast range of the United States and

Canada, with a population now exceeding that of Great Britain, such an antiquated tool as a sickle is not to be seen, the whole harvest operations being effected either with the scythe or with a reaping machine. Assuming the details of mowing quoted from the *Agricultural Gazette* to be equally practicable in other districts as in the one referred to (where, indeed, it had never been seen before), and taking a 10-acre field as our standard of comparison, we should find that the labour required would be that of ten men and ten children, and the cost not exceeding £2, 10s.

The reaping machine is unquestionably one of the greatest benefits which the application of Mechanics to farm purposes has conferred on agriculture. Although it has not even yet received, at the hands of our farmers, that general acknowledgment which it deserves, and which, sooner or later, its importance will secure to it, still no one, I think, is inclined to question that a machine which so efficiently represents hand labour in the harvest field is a great boon to the farmer; as in all field operations despatch, in a climate like ours, is a matter of importance, and the last processes of ripening are frequently so rapid that it very rarely happens that a farmer can obtain labour enough to cut all his crops at the precise time he would desire, without, at all events, taking it from other operations, probably of equal importance at that particular time.

The practical introduction of this machine to British agriculture, at the Exhibition of 1851, read us a lesson which, it is to be hoped, will not be lost upon us. Every one gazed upon the machine with surprise, as if it had sprung into existence then and there, fully developed in its parts, and matured in its action, whereas the historians of Roman agriculture¹ describe fully a reaping machine used in

¹ See *Pliny*, lib. xviii., c. xxx., and *Palladius*, lib. vii., tit. 2.

well farmed districts at that time, and the records of our own period teem with inventions and attempts, more or less successful, to scheme similar mechanical substitutes for hand labour in our harvest fields. This desirable end, too, had, for some years past, been achieved in the north,¹ but its fame had been confined to its immediate locality, and had never reached the south.

Since 1851 the reaping machine has been tested in each successive harvest, and received certain improvements, and may now fairly be admitted as a necessary portion of the mechanical force on every well-conducted farm. It is beyond my province here to discuss the relative merits of the various forms of machines now before the public. All have a claim upon a farmer's notice. Two horses and a driver are usually required to work the machine, which, under ordinary circumstances, will average 10 acres per day. This quantity of grain will require about ten labourers to bind and stook, so that the cost of harvesting a 10-acre field by the reaping machine cannot be reckoned at less than 35s., or at the rate of 3s. 6d. per acre.

These points are surely worth our more general consideration. By the use of the reaping machine we not only effect a saving of something like 60 to 70 per cent. on the cost of harvesting, but we get it over in far less time, with only half the number of hands, and, withal, do the work far better than it is done by the usual mode of fagging or reaping. The only obstacles to the use of the reaper are those met with in bad farming districts, as surface weeds, narrow high-backed lands, water furrows, small irregular-shaped fields, &c. Where these exist the machine has but little chance of success. The Romans found they could only work them where "the fields were large and their surface level."

Generally speaking the various operations of the harvest

¹ By Patrick Bell, of Inchmichael, in 1828.

field are left to chance, or the will of the labourer, without any special care or directions on the part of the farmer. These matters, though of but small importance, all play their part towards the success of the work. In *binding*, a certain size for the sheaf should be determined upon; if too small, unnecessary labour is bestowed; if too large, they require longer time in the stook, and are more cumbersome to cart and stack; therefore it is found that the medium size sheaf, measuring 10 to 12 inches diameter¹ at the band is the most convenient size. It is desirable, too, that the stooks should consist of the same number of sheaves—ten or twelve probably form the best sized stooks—and these should always be set up *north* and *south*, so that the influence of the sun's rays may be equally felt on both sides. If these dimensions are attended to, a tolerably correct estimate may be formed of the probable yield of the crop per acre.

For instance:—

No.				Stooks.	Sheaves.
1,	A light crop,	yielding 20 bushels,	would require about	18 or	180.
2,	„ medium crop,	„ 24	„ „	22 „	220.
3,	„ good crop,	„ 32	„ „	29 „	290
4,	„ large crop,	„ 40	„ „	36 „	360.
5,	Very heavy crop,	„ 48	„ „	43 „	430.

In some districts it is customary to pay for cutting by the stook. This, on small farms, where there is no command of labour, has its advantages. It enables the employer more readily to shift his labour from one field to another on any emergency; his payments are more easily calculated; supervision is less necessary, as the size and number of sheaves are agreed upon; and it enables the women to earn money in the field during a portion of each day, and to be at home in sufficient time to perform their domestic duties.

In all labour arrangements, whether piecework or day-

¹ A sheaf of this size will vary between 20 and 30 lbs. in weight.

work, it is always desirable, as far as possible, to have to deal with known quantities. By previously determining the size of sheaves and stooks, the arrangement of the after labour of harvest—carting¹ and stacking—is much facilitated. An average day's work for a man to fork up, to load in the field, and to pitch up at the stack, would be about 1000 to 1200 sheaves of the diameter given at the band; and a good stacker, with a boy to take and hand the sheaves, would get through the same number in the day. The wages to be given for day or piecework can thus be easily regulated.

In *stacking*, great difference of opinion still exists. Various methods and shapes are to be met with in different parts of the country. They all, however, are or partake of one or two forms—either circular, with a conical roof, or in the form of a parallelopiped, or rather prismoid, with the roof in the shape of a triangular prism. The nearer the height of the roof approaches the radius (or half diameter) of a circular stack, or of half the breadth of an oblong stack, the better, as such an angle of declination for the roof enables the water to pass off most easily. The height of the eaves from the ground should never exceed 16 to 18 feet, as beyond that height it is difficult to fork up from the cart, and requires extra labour.

¹ The relative merits of waggons and one-horse carts here deserve a farmer's consideration. One or the other must be used, and it is clearly his interest, as a manufacturer, to use that which is most efficient and most economical in its work. We find every where and there throughout the country carts are superseding waggons, but nowhere do we find waggons superseding carts. If some of those excellent articles in the *Roy. Agri. Soc. Jour.* bearing upon this question, were more read, this change would take place more rapidly. A paper by Mr. Hannam "On the Reduction of Horse Labour by Single-horse Carts," in vol. ii., p. 73, and a report by Mr. Pusey, in vol. iv., p. 305, of a comparative trial in Lincolnshire of waggons and carts, contain many points worthy of consideration. In the trial referred to, the work of the carts was superior to that of waggons in the proportion of nine to five; and again, at some public trials at Grantham in 1850, 5 horses in 5 carts were matched against 10 horses in 5 waggons, and the 5 carts beat the 5 waggons by 2 loads in the day's work.—*Roy. Agri. Soc. Jour.*, vol. xii., p. 617. See also *Roy. Agri. Soc. Jour.*, pp. 156, 375, and 398.

The diameter of a circular stack should average between 12 and 18 feet at the bottom, bearing in mind always the height it is intended to be, and the quantity of sheaves it is to contain. The diameter at the eaves should be from one-sixth to one-fourth greater than at the base; this gives a slope to the sides sufficient to protect them from the weather. These diameters can readily be followed, and the symmetry of the stack be preserved, by providing the stacker with a rod or stick, with the desired lengths notched on it, so that he may keep the proper distance from the centre all the way round the stack. After a little practice circular stacks are easier to build than oblong ones; they are always more economical, as a circle contains within its periphery (circumference) a larger area than any other form can do, consequently there is less outside. In large-sized stacks, or in unfavourable harvests, a triangular boss¹ may be advantageously placed on the staddle, and used as a centre in building up the stack. In oblong stacks the breadth should not be less than 4 yards nor exceed 6 yards, and it is generally advantageous to have the stack built up in lengths of from 4 to 6 yards, so that one portion may be taken down and thrashed without disturbing the other.

It is most advisable that all stacks, of whatever size or shape they may be, should be built on staddles. This not only secures them from the attacks of vermin, but by having free ventilation beneath the stack, improves the condition of the grain. Rickstands, in iron complete, are now sold by several firms, or suitable iron staddles may be purchased, and used with a wood frame.²

¹ Three short fir poles, or even rough slabs, tied together at top with a straw band and opened out at their base, are all that is required. In some places draining pipes are used to carry currents of air through the stacks; in others, again, a chimney is kept open in the centre, by building round a sack stuffed with hay, which is drawn up by the stacker as the work proceeds.

² For circular stacks of 16 to 18 feet diameter, the pentagon (5 sides) or hexagon shape (6 sides) is sufficient, care being taken to have the centre staddle

It is frequently desirable, either for the purposes of selling or of buying, or for our own satisfaction, to be able to form some idea of the probable grain contents of a stack of wheat. The cubical contents, of course, fall under the general rules for the measurement of solid bodies. When this is obtained a fair estimate may be formed of its yield in grain and straw, by calculating that in a crop (1) where the straw was long and the head small, it will require 36 cubic feet to yield 1 bushel of grain; (2), in an average crop, 27 cubic feet will yield 1 bushel; (3), in a crop with short straw and full, large heads, about 21 to 22 cubic feet will average 1 bushel of grain.

The straw may be taken at about double the weight of the grain, in average crops, or we may calculate that each cubic yard of the stack will yield, on the average, 1 cwt. of straw. Of course, these estimates must only be taken for what they are worth, as approximative results; there are too many interfering conditions to allow them to have an absolute value. Old stacks have not been admitted into the calculations, which have been based upon experiments made with the stacks of the preceding harvest, and then a mean period taken as the standard.¹

The finishing operation of harvest is that of *thrashing* out the grain for market. Here again our practices differ as widely as in the field work of the crop. The flail bears about the same relation to the steam thrashing machine as the sickle does to the reaper, and is marked by about the same financial results. The cost of hand labour varies, of course, with the district, with the crop, and with the time of year. A wide range of prices for flail work might be given, from which a fair average for comparison with power thrashing might not satisfactorily be obtained.

larger and stronger than the others. Oak slabs make the best materials for the frame, which may be put together by an ordinary carpenter in a day.

¹ Much useful information may be found, bearing upon these points, in Ewart's *Agriculturist's Assistant*, from which several of these estimates are taken.

These points, however, were set at rest by the experiments made under the supervision of Mr. Pusey, in 1851, for the purpose of determining the comparative cost of thrashing and preparing grain for market, by the three modes usually practised—by the “flail,” by “horse-power machines,” and by the “combined steam thrashing machines.” The results of these trials, made with the same grain and exactly under similar conditions, showed that the entire cost, from the stack to the market sack, by the first method (*the flail*) was 3s. 5d. per quarter; by the second (*horse power*) 2s. per quarter; while by the application of steam to the *combined thrashing machine* the cost was reduced to 9d. per quarter—thus giving to steam thrashing an economy of 62 per cent. over horse power, and of 78 per cent. over manual labour.

After thrashing, the amount of grain on the barn floor or in the granary may be readily estimated by cubical measurement. The imperial bushel contains 2218·192 cubic inches; therefore each square foot of the floor, covered 15·4 inches deep, carries 1 bushel of grain, consequently 10·26 cubic feet contain 8 bushels, or 1 quarter. For ordinary calculations 10 cubic feet are usually taken.

In the market we are inclined to attach too much value to the weight per bushel of the samples offered. Some experiments by Reiset,¹ determining the relations between the specific gravity of wheat, its weight per bushel, and its real nutritive value, give us some important and interesting information on this score. The relation of bulk to weight has long been an element in the market determination of the value of wheat. This is shown to depend more on the shape of the grains than on their real weight (specific gravity). It has been deter-

¹ For details of these experiments, see paper by Dr. Anderson in *Trans. of High. Soc.* for 1856, p. 174. Some comparative details also are given in the *Roy. Agri. Soc. Jour.*, vol. vii., p. 657.

mined mathematically that of all forms bounded by curved lines, spheres are those which pack closest together, and leave the smallest amount of interstices. For instance, if a bushel measure were filled with *round* shot, that same shot, if re-cast into *oval* (or any other) shapes, would require much more space than the area of the measure that before contained it. Thus, round, short, plump grains, like the Chidham, always weigh more per bushel than the fine bold grains of the Talavera variety. A smooth-skinned wheat always packs closer in the measure than a rough or wrinkled skinned variety (as there is less friction), and a dry sample always better than a damp one, for the same reasons. In the subsequent analyses of the samples experimented upon by Reiset, a certain relation was invariably observed between the real weight (specific gravities) of the specimens and their real nutritive values (the nitrogen compounds); whereas no such deductions could be drawn from the mere market weights per bushel, which were determined solely by the mere shape and condition of the grains.

Before we proceed to the next portion of our subject, let us just take a glance at the different operations we have described, and see how far, in a money point of view alone, the application of machinery benefits the farmer in this single crop. Let us compare the two types of farming together; the one where the broadcast, the hand-hoe, the sickle, and the flail are still retained; and the other where the drill, the horse-hoe, the reaper, and steam show the action of brains upon the breeches pocket:—

By drilling, $\frac{1}{3}$ to $\frac{1}{2}$ the seed is saved—say, 1 bushel of wheat, worth	£0	7	0
By horse-hoeing, at 6d., instead of hand-hoeing, at 3s.,.....	0	2	6
By reaping machine, 3s. 6d., instead of hand-reaping, at 12s.,...	0	8	6
* By steam thrashing at 9d., instead of the flail at 3s. 5d. (4 qrs. per acre),.....	0	10	8

Saving per acre by the substitution of machines for manual labour, £1 7 8

* From 5 to 10 per cent. more grain is got out of the straw by steam thrash-

These figures, though relating to one crop alone, quite confirm what Mr. Pusey told us in his valuable Report, in 1851—"That the application of machinery to the main branches of farming labour, taken together, has effected a saving on outgoings, or an increase on incomings, of not less than one half."

We have now to consider an important part of our subject, on which, however, very little attention has been bestowed, considering the broad bearing it has, not only upon the individual farmer, but upon the welldoing of the country at large. The effect upon our grain produce by the various diseases to which the wheat plant is liable ere the day of harvest arrives, and by the various injuries it receives during the different stages of its growth, from the attacks of insects, would be startling, if it were possible to ascertain the amount of even those with which we are acquainted; while it will be admitted by all who have paid any attention to the subject, that our knowledge of their habits and mode of attack is very defective, and that the number of those totally unnoticed by us is probably very great. We know enough, however, to show us the necessity for knowing more; let us hope the day is not far distant when the subject may be taken up by our great Agricultural Societies, and receive at their hands that consideration which cannot be expected from private individuals.¹

The diseases referred to are chiefly of a fungoid parasitic nature, and are commonly classed under the general head of "*blights*."

The "*blights*" more commonly met with attacking

ing than by the flail, which should also be taken into consideration; while, as before stated (p. 31), the produce of drilled seed is considerably in excess of that broadcasted.

¹ The New York State Agricultural Society has specially appointed an Entomologist (Dr. Asa Fitch), who has already greatly benefited agriculture by his investigations.

wheat are known by the names of "smut," "bunt," "rust," "mildew," &c. These are all due to the existence of a parasitic epiphytal fungus attacking the plant in different parts of its structure¹ and at different stages of its growth, each interfering with the healthy condition of the plant, and, consequently, affecting more or less its productive powers.

"Smut" and "bunt" may be considered first, as they more directly tell upon the produce of a crop, by destroying the seed in all the ears that are affected by them. These two are very different in appearance and in their mode of attack, though they are frequently confounded with each other, the two forms of disease being indiscriminately known as "bunt" or "smut" in different parts of the country.²

"Smut," or "dust-brand," as it is sometimes called, is known to the cryptogamic botanist as the *Uredo segetum*. This minute fungus, according to Brogniart, destroys the ear by first occasioning a decay in the innermost part of the flowers, whilst the pedicels become swollen and very fleshy. The fungus then feeds on this fleshy mass, and at length shows itself between the chaff-scales in the form of a black or dark brown soot-like powder.³ At first the form of the ear is pretty well preserved; as the fungus matures, its spores are cast off, and generally by the time the crop is fit for harvest they are all separated and dispersed, the stem standing erect without a single grain or seed upon

¹ "They affect every part of the plant which is sufficiently succulent to admit of their mycelium. Not only the leaves and stems, but the flowers themselves, the stamens, anthers, and the inmost recesses of the seeds, are in turn affected."—*Outlines of Cryptogamic Botany*, p. 320.

² This indefinite nomenclature is very unsatisfactory. Our great authorities Berkeley and Henslow clearly define them, and describe their different characters, while by practical men the term "smut" is universally applied to the effects of the "bunt" fungus, *U. foetida*. Science and practice ought to understand each other better than this.

³ Ad. Brogniart, *Annales des Sciences*, vol. xx. p. 121.

it. Being generally dispersed either before the corn is cut, or by the field processes of harvest, the quality of the sample is seldom affected by it to any extent; the quantity of produce, however, must be decreased exactly in proportion to its existence in the crop. This disease is seen also in barley, oats, and various other grasses.

“Bunt,” or “pepper-brand,” is due to the attacks of the fungus known as the *Uredo* (*Tilletia*) *caries* or *U. foetida*. This fungus confines itself chiefly to wheat, in which it attacks the grains only, where its presence is readily recognized by the rounded appearance and dark colour of the grains, and by the unpleasant odour they emit when crushed between the fingers. It may be detected in the young grain even in its earliest stages, and when fully ripe it occupies the whole interior of the seed, without rupturing its skin, merely causing an alteration in its outward form and colour. When examined under a powerful microscope, these fungi appear to consist of an immense number of minute spores of a dark colour, held together by small web-like filaments; these contain, again, infinitely smaller seeds or sporules, and it is supposed that by the absorption of these into the circulation of the growing plant is the disease spread. So minute are these sporules that it has been calculated (Bauer) that a single grain of diseased wheat may contain 4,000,000 of them, each of which could propagate itself. The spores of the *U. caries* are very much larger than those of the *U. segetum*, while, at the same time, they possess a very offensive odour, which affects everything with which they come in contact. Unlike the *U. segetum*, too, its spores are held together in the ear at harvest time, and are not separated until the process of thrashing, when, owing to their minuteness and numbers, a very few diseased ears are sufficient to infect a large bulk of grain, and thus greatly to depreciate its value in the market. Indeed, were it

not for the ready consumption of that (in this case) useful panary compound called gingerbread, there would be great difficulty in working up this infected grain; as it is, however, both the dark colour and the offensive smell are covered up by the treacle and condiments which give gingerbread its distinctive character.

These two forms of diseases resemble each other so much in their individual characters and mode of attack, that the same remedy has been recommended for both—namely, that of steeping the grain previous to sowing, so that we may, as far as possible, prevent the chance of sowing the seeds of the crop and of the disease at the same time.¹ The various steeps used have been already described (page 23), and we have now to consider their *modus operandi*.

The sporules, or seeds of the fungus, infinitely minute in themselves, are attached together by an equally minute filamentous process (*mycelium*), and are covered by a substance of an oleaginous character, which attaches them to anything with which they come in contact, at the same time probably acting as a preservative to them while in the soil. By immersing the seed-corn in a steep solution, either the germ of the sporule is destroyed, as is probably the case with the mineral solutions (those containing blue vitriol, arsenic, &c.); or, if an alkaline steep is used, the oily matter which attaches the sporule to the grain is saponified and dissolved, and the grain is freed from the germ, which is either left in the steep solution, or, if any portion be carried out with the grain, it rarely vegetates, but, being deprived of its oily covering, undergoes decomposition itself in the soil.

Steeping seed-grain probably acts beneficially in another way also, by destroying the germinative powers of injured

¹ Steeping does not appear to be so effective in the first as in the latter case, probably owing to the earlier maturity and dispersion in the soil of the sporules of the *U. segetum*.

grain, and thus effectually preventing the chance of a sickly, debilitated plant, which always offers a home for the numerous enemies, insect as well as fungoid, that accompany each stage of the existence of our wheat crops.¹ This is a subject worthy the notice of our agricultural societies. A well-considered series of experiments, carried on simultaneously in different soils and different climates, could not but be beneficial to the agriculture of the country.² The loss sustained by these diseases every year is much larger than farmers generally imagine.

"Rust" and "mildew" are other forms of fungoid disease, confining their attacks to the straw, the leaf, and the chaff. The former, known by the name also of "red-gum," "red-rag," "red-robin," is the *Uredo Rubigo*, and is seen in the shape of yellowish, brown, or reddish oval spots and blotches on the stem, leaves, and chaff of the plant. As long as the leaves and stem only are attacked; but little actual injury seems to be done. When, however, it attacks the glumes (the ear), and other parts of the inflorescence, as is the case sometimes with delicate wheats on rich soils, and in hot moist seasons, it frequently assumes a serious character. The blotches or spots are occasioned by the existence of the spores of the fungus beneath the epidermis or scarf skin of the plant, through which they burst when they arrive at maturity. These spores are extremely minute, and are bound together by a network similar to that already described. This fungus, which would appear to attack most of the grasses, has been very generally supposed to be identical with mildew.³ This ques-

¹ This opinion is confirmed by the experiments by Professor Buckman, in *Roy. Agri. Soc. Jour.*, vol. xvii. p. 175.

² In the *Journal of the Bath and West of England Agricultural Society* (old series), vol. xv., and in the *British Husbandry* of the Society for the Diffusion of Useful Knowledge, vol. ii. p. 164, details are given of experiments with steeped and unsteeped grain.

³ Paper "On the Specific Identity of the Fungi producing Rust and Mildew," by Rev. J. S. Henslow, *Roy. Agri. Soc. Jour.*, vol. ii. p. 220.

tion, however, has been set at rest by recent investigations, which assign distinct characters to the *U. Rubigo vera*, while they confirm the connection between mildew and another form of rust—the *U. linearis*, the so-called spores of which are merely the early stage of the common mildew.¹ Rust and mildew frequently occur together on the same plant, and owing to the diversity of colour in the rust spots they may readily be confounded.

“Mildew” (the *Puccinia graminis*) belongs specifically to a different class of fungi, but the circumstances of its growth, germination, &c., are precisely the same. It differs considerably in external appearance from the “rust” fungus, as the ripe spores of the mildew consist of very small and very dark brown or black coloured club-shaped bodies, having the thicker end divided into two compartments, each filled with sporules. In an early stage of its growth the swollen heads of the filaments are undivided, and it is then known to botanists as the *U. linearis*. The dark coloured spots or patches of spores (psori) are composed of multitudes of these sporules, which burst through the epidermis of the stem and leaves (to which parts of the plant it is generally confined), frequently giving them the appearance of having been partially burnt.

Notwithstanding the great losses sustained every year by the attacks of these fungi, we know at present very little about them, either as regards their mode of attack or their remedies. In 1850, attention was particularly called to this form of disease, by the numerous districts in which it occurred, and by the disastrous effects it produced both on the quantity and the quality of the harvest produce. Where a crop is badly mildewed the yield is frequently reduced one-half, while the value of the small produce obtained is again reduced on the market. The

¹ Berkeley's *Cryptogamic Botany*, p. 324.

wheat mildew, though rarely met with on the other cereals, seems to be common to all the inferior grasses; and as many of these are to be found in all conditions of growth, either in our fields or the hedges, ditches, or waste places surrounding them, thus offering ready means for supporting the fungus, a suggestion was made some years ago by Mr. Tycho Wing, the eminent agent of the Bedford Level estates, that no reeds or loose grass should be allowed to remain in the ditches, but that everything should be regularly cleared away and consumed at once. This appears to be a very sensible remedy, especially applicable to the district with which he was connected; and if we were to follow it up throughout the country, by keeping our ditches and waste spots clean, and by cutting our grain crops low down, leaving as little stubble as possible, and carrying out a system of autumn cultivation, we probably should do much towards limiting the attacks of this powerful enemy.

It has generally been observed that mildew is more prevalent on light than on loamy and clay soils, and that the earlier kinds of wheat are the least affected. In all cases, strong healthy plants are less liable to it than sickly ones.

If these diseases are generated in the manner supposed, by the absorption of the sporules into the tissues of the plant at an early period of its growth, the feeding the crop close down by sheep in the spring would be likely to produce good results.

Wheats sometimes appear covered with a black soot-like fungus, dusting the ears all over, and thus giving evident indications of disease. This is often mistaken for mildew, but is, in fact, very different from it, being a result or consequence of previous disease in the plant, and not, like the mildew, a cause of disease in itself. This fungus, which always accompanies decay in vegetable

tissues, is frequently met with on strong crops when laid and injured by the rain, especially if the soil and weather at the time be of an ungenial character; in that state the whole plant is a ready recipient of the germs of this fungus. When examined carefully through the microscope, the spores, instead of having the club-shape of the *Puccinia graminis*, are more irregular and branched, whence the name of *Kladosporium herbarum*¹ has been given to it.

The common berberry tree has been charged with exerting a pernicious influence on the wheat crop, and producing a blight—*Æcidium Berberidis*—similar to that of the regular mildew. The tree is, without doubt, liable to the attacks of this peculiar fungus, but its structure is so very different from that of the mildew fungus that their identity is scarcely probable. It has been the subject of investigation by many eminent men; by Jussieu at Trianon; by Horneman at Copenhagen; by Knight in England; and recently by the Agricultural Society of Lille, the results of which, however, leave us in the same state of uncertainty as before.

A few general remarks may not be out of place here in reference to the nature of the parasitic fungi, the principal of which have been so briefly sketched.

All fungi grow upon some kind of organized matter; none of them derive their food directly, either from the soil, air, or water, as other plants do. They aid Nature greatly in setting up and carrying out the process of decay and decomposition. Some may appear to grow on healthy spots, but these no doubt originated on a spot where disease had already effected some alteration in the tissues, which alteration they soon caused to spread to other parts. They, none of them are of any size—many so minute as to require the practised eye of the microscopist to detect

¹ κλάδες, a branch.

or identify them. Many of them live within the very substance of certain plants, encased beneath the epidermis (scarf-skin). In the progress of their growth, they raise small blisters under the epidermis (as in rust and mildew), and when arrived at maturity, they burst through it, and then form spots or irregular blotches of various colours, which have different hues according to their peculiar nature, and are seen usually red, orange, brown, or black. Now, these spots are masses of fructification, and are surrounded by the tattered edges of the ruptured skin. A large number are known to botanists, and like animals of a parasitic nature, they seem to be restricted in their mode of attack, being able to live on certain species only, and sometimes even then, only on particular parts of particular individuals of these species. In parasitic animals the same peculiarity is seen; some live only in the skin, others beneath it; some in the bowels, and others again in the substance of the muscles and the flesh. Some of these fungi confine their attacks to the seed, as the *U. caries*; others again, as the *U. segetum*, to the short stalk or pedicel on which each flower is placed; whilst others, as the *U. Rubigo* and the *Puccinia graminis*, are restricted in their range to the stem, leaves, and chaff-scales of the plants they take possession of. All of them, however, commence their existence beneath, and not upon the epidermis.¹

We must now pass on to another class of injuries to which "our Farm Crops" are liable—that due to the attacks of insects. These are, happily, more readily recognized, and less mysterious in their agency, and therefore have generally made more impression on, and received more attention from the agricultural community. The valuable

¹ A very comprehensive and interesting account is given of these diseases, in a little work by the Rev. E. Sidney, entitled, the *Blights of Wheat, and their Remedies*, published by the Religious Tract Society.

papers in the *Journal of the Royal Agricultural Society*, on the subject, contributed by Mr. Curtis, and now published in an enlarged and separate form,¹ are worthy of the consideration of every one engaged in agriculture, as they comprise well-nigh all that is known respecting the nature and habits of these minute, though formidable enemies. Before, however, we take the insects proper into consideration, we must describe a form of disease peculiar to the wheat plant, which is the result, not of vegetable, but of animal action, and this comes within this section of our subject. This peculiar form of disease is that known by the names, "ear-cockle," "pepper-brand," or "purples," names given to it from the changed appearance of the ear and grain of the plant attacked by it. The disease attacks the grain itself. The infected grains in the first stage turn dark-green, and then a purplish-black, assuming gradually a rounded shape resembling a pepper-

1. Infected grain in the ear. 2. *Vibrio*, magnified. 3. Egg with worm in it. 4. Diseased grain, magnified. 5. Diseased grain divided, showing worms and eggs.

corn, but generally with one or more deep furrows on the surface (fig. 4). The husks of the chaff spread open, and

¹ *Farm Insects*, being the Natural History and Economy of the Insects injurious to the Field Crops, and also those which infest Barns and Granaries. Blackie & Son, Glasgow and London.

the awns become twisted and curled, which readily indicates the diseased ears (fig. 1). If one of the grains be taken and carefully divided, the inside is found to be then filled with a cotton-like substance, the original starch, &c., having all undergone this curious change. In the centre of this bed, an ordinary microscope will readily show you a number of small eel-shaped animalcules twisting about in all directions; if placed in a little warm water, these may be seen with the naked eye (fig. 5). The animalcule causing this disease belongs to the order Infusoria, and the significant name of *Vibrio Tritici* has been given to it, as, so far as we know, it is met with only in the wheat plant.¹ The disease has been the subject of very interesting investigation by Raffredi, Henslow, Needham, and others, by which it appears, that in the event of a sound grain being sown by the side of an infected one, the young plant grows up all right until the spring, when the animalcules find their way out of the diseased grain into the soil. They then fix upon the young plant growing beside them—gradually ascend within the stem until they reach the ovule—there they form their nidus, deposit their eggs, and die. Fortunately, the diseased grains are generally the smallest and lightest in the ear, and thus in the process of dressing and winnowing they get separated, and are less likely to be sown with the seed corn.

The earliest injury the young wheat plant receives from the insect tribe, is from some of the numerous family of wireworms which are to be met with in all our fields, and which attack indiscriminately well-nigh all our crops. Wireworms are often confounded with the millipede, which exist in equal numbers, though under different conditions. The true wireworms are the offspring of the click-beetles

¹ So far as my own experience goes, it is far more commonly met with in the coarser varieties of the *T. turgidum*, the rivet cone, and so-called Egyptian wheats, than in the finer varieties of the *T. sativum*.

(*Elateridæ*), which lay their eggs in the soil where they hatch, become larvæ or wireworms, in which condition they remain during five years before they arrive at ma-

1. True wireworm, *Elater lineatus*. 2. Wireworm attacking wheat plant.
3. Millipede (*Iulus londinensis*), or false wireworm.

turity, when they change into pupæ, from which in due time the perfect insect, the click-beetle (*Elater lineatus*, or *E. Ruficaudis*) emerges.

These worms eat into the stem of the young plant just above the root, as it rises from the ground, and destroy it, or they may be met with at a later period high up in the stem, feeding on it and the young leaf. They generally, at the approach of winter, bury themselves deep in the soil, as they cannot support either much cold or much drought; they are there, too, beyond the reach of the various birds and insects which feed upon them. Moles as

well as birds devour enormous quantities of them, and a small ichneumon fly (*Proctotrupis viator*) eagerly searches after them in every chink of the surface soil.

Numerous remedies have been suggested to counteract the damage they inflict on our crops.¹ Deep cultivation brings them up to the surface in winter, and gives both the birds and the weather more chance to destroy them. Rolling the crops attacked with a ribbed or grooved roller obstructs their ready passage through the soil, and forces them up to the surface, where they are more exposed, and where they may frequently be handpicked, especially if slices of potatoes or turnips be placed on the ground. In the transactions of the Entomological Society, details are given where no less than 12,000 were thus picked off a single acre. Topdressings of various kinds have also been recommended, though their action does not appear very clear. There are some forty species of *elaters*, whose larvæ (wireworms) are known to be injurious to our crops.

Among the insects infesting our wheat fields, the "wheat midge" (*Cecidomyia Tritici*) is the best known. Those persons who pay attention to what is going on in the fields, must often have seen, in the evenings of early summer, myriads of minute, gnat-like flies swarming over the wheat crops, which they select as the most suitable spots for depositing their eggs. These are deposited in the culms while the wheat is in flower, and when they are hatched, the little lemon-coloured larvæ abstract the juices, and cause the grain to shrivel. Nothing is more common, if you examine an ear of wheat, than to find one, two, or more of the grains defective, or entirely destroyed by the attacks of the larvæ of this insect. When full-grown, they either enter the earth to become *pupæ*, or

¹ Curtis estimates the quantity of wheat seed destroyed by this insect alone at 60,000 bushels.

remain through the winter in their pellucid skins, and do not produce flies until the following summer.

The natural history of this little fly is very interesting, and one which every one should read, as we therein see a marked case of the beautiful provision made by Providence to prevent the undue multiplication of a species capable of inflicting such injury upon one of the food plants of man. The reproduction of the species is controlled within certain limits, by the existence of an ichneumon fly (the *Platygaster Tipulæ*), which may be seen

1. Infected floret. 2. Larva, natural size; and 3, magnified. 4. Pupa, natural size; 5, magnified; 6, attached to grain. 9 and 10. Midge, natural size and magnified. 11 and 14. Ichneumon fly, natural size and magnified. 13 and 12. *Macroglènes penetrans*, natural size and magnified.

running over the wheat ears, seeking out the midge everywhere, for the purpose of depositing its own eggs in the midge's body, and thus restrains an increase which would otherwise so prejudicially affect our crops. The *Macroglènes penetrans* also assists in checking the ravages of the midges.

Another midge (*Cecidomya destructor*), called the Hessian Fly, has been, and still is, from time to time, such a fearful scourge to the wheat fields of North America, that in some of the States the cultivation of wheat was abandoned throughout extensive districts for many years. Happily this member of the family has but very rarely been met with in this country. Its powers of increase, however, are materially kept in check by certain parasites, especially the *Ceraphron destructor*, which relieves the farmer from myriads of his most dreaded enemies.

The "Thrips" (*Thrips cerealium*) is the little black, slender lizard-tailed insect which so frequently alights on the face in hot weather, causing an irritation and annoyance which prevents those who have once made its acquaintance from readily forgetting it. This little fellow is charged, also, with doing a great deal of injury to our corn crops, especially wheat and rye. It appears to take up its residence in the spathes and husks of the ear in June, causing the grain to shrivel up; or, at an earlier period, effecting the abortion of the ear altogether, by puncturing the stems above the joints. They are so numerous in our corn-fields that Kirby¹ says:—"Of all the insects that are found in wheat, this is, in all its states, by far the most numerous. I don't recollect ever examining a single ear in which it was not found, and my opinion remains unaltered, that it derives its nourishment from the grain." Linnaeus also noticed it, and accused it of emptying the ears of corn. It appears to exhaust the juices of the wheat, and to cause that shrivelled appearance in the grain so often met with in certain seasons and in certain districts. The crops on strong soils are said to be more subject to it than those on lighter soils, and the late sown than the early; the remedy, therefore, is to sow as early as possible. Here, again, a check is

¹ *Linnean Transactions*, vol. iv.

placed upon their ravages by a minute white parasite, the *Thrips minutissima*, which feeds upon them.

The "Corn Saw Fly" (*Cephus pygmaeus*) is a small fly, of a shining black colour, not uncommon in our corn-fields, and abounding on umbelliferous flowers, and the long grasses that are met with in the hedgerows and waste places, in June and July. The young maggot, of a wrinkled yellow colour, with a dark head, is found inside of the stem, which it consumes. About the time the ear is formed, it has gradually increased in strength, sufficient to enable it either to cut right through the node of the stem, or, at all events, to cut so deep into it as to destroy its vitality and its power to perfect the grain. The head then rapidly assumes a ripened appearance, and readily

separates from the stem at the severed part. The maggot then descends the stem, and incloses itself within the knotted stump of the straw, where it rests secure through the winter, and in the early spring changes to a *pupa*, which, in due course, is transformed into the regular "saw-fly." Here, again, we have to record the presence of a friendly insect, the small ichneumon fly (*Pachymerus calcitrator*), which you will always find busy at work, hunting after and destroying our enemy the saw fly.

1. Female saw-fly, magnified; 2, natural size. 3. Maggot in the stem of plant; 4 and 5, natural size and magnified. 6. *Pachymerus calcitrator*; 7, natural size.

There are numerous other insects found in our wheat crops, with whose habits we are not so well acquainted,

but whose presence there naturally leads a farmer to connect them with some of those injuries which his crops sustain, and for which he can assign no distinct cause. Many of these, no doubt, like those already described, are directly injurious to our crops; while again, many of them are placed there for the purpose of controlling the ravages of those injurious to us. Considering their numbers, and the vast bearing they have upon the general welfare of a country, it surely is our interest to pay more attention to them than we have hitherto done—to seek to know the nature and habits of those which are injurious to our crops, so that we may do our best to prevent their ravages, and also how to distinguish them from those friendly insects, which so materially limit their powers, and which it should be our duty, as it is our interest, to protect and encourage.

Amongst those we see infesting wheat we find the wheat-plant louse, the *Aphis cerealium*, a fat, pale, green coloured insect, with longish dark coloured horns, frequently very abundant in the ear immediately before harvest time. It is said to suck the stem, and thus impoverish the grain. Whatever damage it may be capable of doing—and but little is known about it—is materially lessened no doubt by the check placed upon it by the presence of a parasitic fly, the *Aphidius Avenæ*, which destroys it by puncturing its body, and depositing eggs in it.

The Corn-bugs, *Miris Tritici* and *M. erraticus*, are very common in the wheat plant from the time it appears in ear. Here again our knowledge is sadly defective. Curtis tells us they have a proboscis for sucking, bent under the breast, but it is not known whether this is for piercing and sucking the grain or the bodies of other insects. It is not improbable that in their larva and pupa states they are carnivorous, and in their perfect state

granivorous, or at all events subsisting on the juices of plants. The grubs of the common cock-chaffer, *Melolontha Agricola*, and *M. Ruficornis*, are very injurious to the young plant, as is also the caterpillar of the winter-moth, *Noctua Tritici*, which attacks both the root and young stem, and leaves, and thus entirely destroys the plant.

Köller, in his excellent and interesting work on *Insects injurious to Gardens, &c.*, tells us of a ground beetle, *Carabus gibbus*, which causes great havoc in the corn-fields on the Continent. In 1812, the whole country round Halle was devastated by swarms of this insect, and so serious was the effect produced, that the authorities consulted together respecting its ravages, and the best means of getting rid of it.

The *Scopula frumentalis*, or corn-pebble moth, a native of Sweden, whose larva feeds upon the plant, has lately been met with in our corn-fields about the months of June and July.

Not only have we to contend against the attacks of insects in the field, but they also follow our crops into the granary. Here the greatest losses are inflicted by the numerous family of "weevils" (*Curculionidæ*), most of whom are very destructive. The one most injurious to the farmer is the *Calandra granaria*, or "corn-weevil," which lives in stored grain, whether it be wheat, barley, oats, maize, or rice. Early in the spring, as soon as the weather is warm enough—for being natives of southern regions they do not like cold—the beetles pair, and as soon as the female is impregnated she buries herself in the heap of corn, makes a puncture through the skin of one of the grains, and there deposits her eggs, one only in each grain. The hole is not perpendicular to the surface, but runs obliquely, or even parallel to it, and the small aperture is closed by her excrement. The eggs then are safe even if the grain be moved about. The maggots soon hatch and feed upon

the contents of the grain, until the husk alone is left, which lasts them until they have arrived at maturity and

1. Grain of wheat, showing the punctured hole; and 5, the exit of the perfect weevil. 2. Pupa; 3, magnified. 4. Grain of Indian corn, with weevil inside. 6 and 7. Corn-weevil, natural size and magnified. 8 and 9. Rice-weevil (*C. oryzae*), natural size and magnified.

changed to pupa. In about six to eight weeks from the time of impregnation the perfect weevil is produced, which eats its way through the husk, and is then ready to propagate its species. In five months a pair of weevils have been known to produce 6045 individuals, each of which required for its cradle a grain of the farmer's crop. Owing to the workmanlike manner in which the female deposits her eggs, it is very difficult to detect their presence in the grain, which is generally not discovered until the perfect animals are seen walking over the heap, when the empty husks are readily picked out. Their specific gravity being much lighter than sound grains, they may always be discovered if placed in a basin of water—the sound grains sinking, and these floating on the surface. They are very soon destroyed by a low temperature; granaries, therefore, in which they have been noticed, should be opened, and exposed as much as possible to the winter frosts. Where malt, of which they are very fond, is infested by them,

a temperature of 160° on the kiln is sufficient to destroy the larvæ.

The caterpillar of the "little Grain-moth," *Tinea granella*, is also very destructive in our stored corn. Indeed, so ravenous is its appetite that the name of "wolf" is frequently given to it. The moths abound in summer, and frequent the buildings as well as the fields. They fly about chiefly at dusk and at night, and having paired, the female lays from fifty to sixty eggs, which she deposits either singly or by twos on the grains of corn. From these the larvæ are hatched in the course of a few days, and at once commence their work of destruction on the corn. Frequently shifting the corn about destroys the eggs and the young larvæ. They are also got rid of by currents of cold air passing over the floors; or exposure to a dry temperature of about 80° , either in the sun or on a kiln, will also kill them.

Unhappily, there is a vast number of other insects which prey upon our grain—insects which have been and still are daily introduced, in countless thousands, in the foreign grain that is imported into this country. Some, weak and delicate, sink before the coldness of our climate at once; others, more hardy, manage to exist, and probably multiply their species ere our winter temperature calls upon them to surrender their existence; while others again, whose habits enable them to withstand the lowest temperatures of our climate, become naturalized, and thus add another species to our list of enemies. In all cases, cleanliness, ventilation of the buildings, and frequently moving the stored corn, are recommended as antidotes to this increasing evil.¹ Another remedy, too little thought of, but quite within every farmer's reach, is the careful

¹ These insect enemies will be found more fully described in the *Cyclopedia of Agriculture*, under their respective heads; in Curtis' *Farm Insects*, published by Blackie & Son; and in Kirby and Spence's *Entomology*, published by Longman and Co.

extirpation of weeds from his fields and hedgerows. And every plant which is not productive to him as a cultivated crop, must be looked upon as a weed, and in two ways an enemy to him:—Firstly, as must be obvious to all, weeds abstract from the soil the mineral food which would otherwise serve to increase his crops, and being indigenous to the soil, and of a more hardy nature, they generally get the best share; and secondly, as we have seen in the foregoing sketch, they offer a home, not only for the perpetuation of those fungoid parasites so destructive to our crops, and at present so mysterious in their visitations, but also in some of their varieties they furnish suitable receptacles for the procreative purposes of those insect scourges, whose ravages we have detailed to us in the journals of each succeeding year.

The *Chemistry* of the wheat plant, owing to its importance as the first of our food grains, has received more attention than that of most of our other cultivated plants. Numerous analyses of its organic as well as inorganic constituents have been made by continental, as well as by our own chemists; all of them add greatly to our store of knowledge, though some of them have a more practical application than others. In the early days of agricultural chemistry, the composition of the soil was thought to claim our first consideration, and soil analyses were looked upon as the keystones of the new system. These failed, however, to secure the results expected—not that the chemist was unable to determine the exact constituents of the sample submitted to him, but because it was impossible to supply him with any sample that should fairly represent the mass of the soil whose composition we wished to have made known to us. Every one conversant with farming must have noticed the variations in the soil of different fields on the same farm, and frequently even of different parts of the same field. A sample taken, there-

fore, from one part alone might be widely different from the soil of the other parts of the field, while a number of samples drawn from these differing soils and mixed together, might still more mislead, and represent no portion of the surface-soil whatever. Again, take the same soil under different conditions: take a sample in the early spring, after the rains of winter have acted upon the surface, and carried its more soluble constituents down into the subsoil, or away altogether in the drainage; and take a sample from the same spot at the close of autumn, when no rain has passed through the soil for months, but has passed off by evaporation, leaving behind in the surface-soil the soluble salts it had met with in its upward passage—submit these two samples to the laboratory tests, and see what different indications of fertility they would give you of the same soil. The *spring* analysis would indicate a soil poor in available food for the crop, while that of *autumn* would place the same soil very high in the scale of fertility. Even if the analyses of soils had furnished us with all the reliable data we expected, we should have failed to apply them profitably, until we were equally acquainted with the composition and constituents of the plants we wished to cultivate, so that we might know whether those ingredients which the plant required for its growth, were to be met with in the soil in which it was to be placed. The importance to be attached to a chemical investigation into the composition of our farm plants was at once recognized, and the subject was taken up with great energy and liberality by the Royal Agricultural Society, whose *Journal* promptly made known to the agricultural community, abroad as well as at home, the valuable and very interesting results obtained. In the investigations carried out under their auspices, most of our crops are comprised; those specially relating to wheat will be found chiefly in Vol. vii. These investiga-

tions showed us, that although the constituents of any individual plant are always the same, still that there is well-nigh as great a variety in the composition of different plants as in that of different soils; which at once gives us a reason—not the only one though—why certain plants thrive better on certain soils than on others. They also showed us, that although the constituents of a plant—wheat, for instance—were always the same, still their relative proportions might vary in different specimens or varieties; and thus indicated the probability that one variety might be more advantageous than another for cultivation under certain conditions. In twenty specimens of wheat examined (sixteen English and four foreign), a variation was shown in the amount (per centage) of silica assimilated of from 1·34 to 9·71, the one grown on calcareous rubble, the other on a greensand loam. In phosphoric acid the proportion differed from 34·44 to 49·22; some contained 26·7 of potash, while in another it amounted to 36·6 per cent. In lime and soda a greater difference was shown, the lowest proportion of lime being 1·15 and the highest 8·21, and of soda ·07 and 9·06 per cent. These points of different proportions may have a practical value, as indicating varieties of wheat more or less suitable for soils of different qualities, those varieties with the least per centage of phosphoric acid and potash being evidently better suited for cultivation in poor soils than the others, which require larger proportions of those salts for their growth.

The proportions of the organic constituents of wheat, too, exhibit the same variations as the inorganic do. These, however, have a far more important bearing on the value of the grain,¹ and, in fact, determine its value as a feeding substance, and materially influence the technical purposes

¹ Much valuable and interesting information on the influence of circumstances of growth on the composition of wheat, will be found in a paper by

for which it is made suitable. The principal ingredients in the grain of wheat are gluten and starch; indeed, wheats generally are classed in two great divisions—the “hard” and the “soft;” these divisions being determined by the prevailing characters due probably to the relative proportions of these ingredients in the grain, a large proportion of gluten being the characteristic of the *hard* wheats, while the *soft* wheats have less gluten but more starch. The former are generally the produce of warmer climates than our own—Spain, Sicily, Italy, Algeria, India; the latter are cultivated in climates more resembling our own, as Holland, Belgium, Sweden, Denmark, North America, &c. The *hard* wheats have a fine, semi-transparent skin, are hard to bite, and then break with a white compact fracture; and owing to the large proportion of gluten they contain, they furnish very “strong” flour, particularly suited for the manufacture of pastry generally, of macaroni, vermicelli, &c., and for those rich, paste-like substances of food so plentifully met with in the cuisines of southern Europe. The *soft* wheats, though containing less gluten, are richer than the hard wheats in the proportion of starch they contain. This substance renders them more valuable for other technical purposes to which wheat is applied, as the manufacture of starch, brewing, distilling, and vinegar-making.¹ Probably about 12 per cent. may be taken as the average amount of gluten in our home-grown wheats; yet Vogel found 24 per cent. in Bavarian wheat, Davy obtained 21 per cent. from some Sicilian, and 19 per cent. from wheat from Barbary. Boussingault also tells us that his wheat, grown in Alsace, yielded 17·3 per cent., while, in a specimen grown in the

Messrs. Lawes and Gilbert “On some points in the Composition of Wheat-grain, its Products in the Mill and Bread,” in the *Journal of Chemical Society*, vol. x. p. 1.

¹ The conversion of starch into sugar, then into alcohol and vinegar, being merely the process of oxidation continued.

Jardin des Plantes, he found 26·7 per cent.; and in another specimen (winter wheat), no less than 33·3 per cent. The hard wheats which come into our markets from foreign ports mix well with the inferior wheats of our own growth, and thus enable skilful millers to work up an article (flour) of excellent quality from materials which, by themselves, would have had a low nutritious as well as commercial value.

The great object to be gained from the analysis of the wheat plant is to know what ingredients it takes from the soil, and their relative proportions per cent., so that, when we know these, we have only to obtain the exact weight of the crop, to show us how far the soil has been exhausted by it, and what manurial application is necessary to restore the soil to its normal fertility, by replacing those ingredients which have been removed from it. The crop consists of the roots and stubble which are left in the ground—and thus need not enter into the calculation—and of the straw and grain which are removed from it, and thus have to be replaced by some equivalent in dung or artificial manure. The straw and the grain, however, have to be considered separately, as they exist in very variable proportions in the different varieties of wheat, and, indeed, in the same wheat grown in different soils, or in different seasons.¹ For ordinary market calculations the straw and chaff are usually estimated at twice the weight of the grain. The mean of thirty-eight experiments by Mr. Way, however, gives us a lower rate of difference—viz., as 1 of grain to 1·244 of straw and chaff. Another series gives us 1 of grain to 1·545 of straw and chaff. These, probably, were more or less picked samples, and gave superior results to what the whole produce of the country would furnish.

¹ The season 1840–41 was remarkable for its excessive wetness. The following season, 1841–42, was as remarkable for its extreme drought. In the first, the weight of the grain to the straw was as 40 to 100; in the second, it was as 90 to 100.

Boussingault estimates the relative proportion of grain and straw as 1 to 2·631, and quotes, in support of the probable accuracy of these figures, the results of the following experimenters:—

Thaer	gives for 1· grain, 2· of straw.	
Podewils	1·	2·857
Berger	1·	2·292
Block	1·	3·03
Dierexen	1·	2·564
Schwerz	1·	2·272

In the operation of analysis it has been found that the grain of wheat contains, on the average, about 1·75 per cent. of *ash*, or inorganic matter (varying between 1·2 and 2 per cent.); that the straw contains, on the average, about 4 per cent., but shows a much greater amount of variation in the different varieties—Piper's thickset, for instance, giving 11 per cent. of ash; and that the chaff contains a far higher proportion of inorganic matter than either grain or straw, leaving no less than from 7 per cent. to 16 per cent. of ash when tested in the usual manner. The ash represents, of course, the mineral constituents of the soil which the plant has abstracted for the use of its several parts; which constituents have been determined by our chemists to be as follows:—

Composition of wheat.	Grain. ¹	Straw. ²	Chaff. ³
Potash,.....	27·72	12·44	9·14
Soda,.....	9·05	·16	1·79
Lime,.....	2·81	6·7	1·88
Magnesia,.....	12·03	3·82	1·27
Iron,.....	·67	1·3	·37
Phosphoric acid,.....	49·81	3·07	4·31
Sulphuric acid,.....	·24	5·82	...
Silica,.....	1·17	65·38	81·22
Chloride Sodium,.....	...	1·09	...
	99·5	99·78	99·98

¹ The mean of several.

² Fromberg.

³ Boussingault.

We thus see what we have to return to the soil as a compensation for the mineral substances which a crop of wheat takes from it. Now, of the mineral constituents given in the analyses there are but two which we need concern ourselves about—the potash and the phosphoric acid—as all soils suitable for cultivation may be said to contain the others in sufficient abundance. These two then ought to be supplied either at once to the soil, in the shape of a special manure, or by manuring through the agency of other crops in the course of the rotation. M. Way in his investigations gives 31·37 as the average percentage of potash, and 45· as the average proportion of phosphoric acid in the grain of wheat, and suggests that the mineral constituents of an average crop of wheat may be returned to the soil by a mixture of the following composition.¹—

84	lbs. of Silica (as a soluble salt).
20	,, Phosphoric acid.
4	,, Sulphuric acid.
8	,, Lime.
6	,, Magnesia.
1	,, Peroxide of Iron.
23	,, Potash.
1½	,, Soda.

These mineral (inorganic) substances form, as is shown, but a small portion of the grain, the bulk being composed of water and what are termed proximate organic compounds. In wheat in good condition the average proportion of water is about 12 per cent.,² and the proportion of bran may be taken at from 10 to 12 per cent. also. These two constituents furnish but little alimentary matter to the consumers. The other ingredients, consisting principally of starch and gluten, with small propor-

¹ *Roy. Agri. Soc. Jour.*, vol. vii. p. 676.

² The same quantity is found in both the straw and the chaff.

tions of sugar, gum, and oil, all severally subserve the purposes of nutrition, and give to wheat the high feeding value universally assigned to it. The proportion of starch is about 50 to 60 per cent.; the gluten may be taken at 12 per cent.; and the other substances together at from 8 to 10 per cent. Thus, we may take the average composition of the grain of wheat to be—

Water	about 12 in the 100 parts.		
Bran	„ 12	„	
Starch	„ 55	„	
Gluten	„ 12	„	
Oil	} „ 9	}	}
Sugar			
Gum			

In grinding, the bran is never entirely separated, and that portion which is separated always carries with it a certain proportion of flour—sometimes in sufficient quantity to pay for a subsequent process of separation. Professor Johnston gives, as the results of three lots of good wheat ground for him in Durham¹—

	Lot 1.	Lot 2.	Lot 3.
Fine Flour,.....	74·2	78·1	77·9
Boxings,.....	9·	8·3	6·1
Sharps,.....	5·8	6·6	5·6
Bran,.....	7·8	7·	6·9
Waste,.....	3·2	3·	3·5
	100·	100·	100·

The bran itself, irrespective of the proportion of flour always attached to it, has a high nutritive value, though—probably owing to the shape which its constituents assume to fit them for the duty they have to perform as the “testa” or seed coat of the grain—they are not so readily digested and assimilated as the other portions of the grain. There

¹ Johnston's *Agricultural Chemistry and Geology*, p. 864.

cannot be a question, however, that the process which produces the finest white flour also deprives the grain from which it is obtained of a large proportion of its food value, and that bread containing all but the very coarsest particles of the bran would be superior as an article of food, and, at the same time, much more economical in cost, than the whiter descriptions of bread so generally sought after.

Johnston gives the following as an average composition of bran:—

Water,.....	13·1
Nitrogen compounds,.....	19·3
Oil,.....	4·7
Husk,.....	55·6
Ash,.....	7·3
	<hr/> 100·

Another more critical analysis, by Millon,¹ gives us, by its details, the probable composition of the “husk,” which forms so large a proportion in the foregoing:—

Starch, gum, sugar.....	51·
Nitrogen compounds,.....	14·9
Oily matter,.....	3·6
Ligneous tissue,.....	9·7
Ash,.....	5·7
Water,.....	13·9
	<hr/> 98·8

These researches into the composition of the bran of wheat show clearly that it possesses a high nutritive value, and at the price at which it is usually sold, must be considered a cheap feeding substance. Its very nature, however, would indicate that its constituents are not likely to be so readily available as the other portions of the grain. It requires to be submitted to the digestive process for

¹ *Annuaire de Millon et Reiset*, 1849, p. 485.

a much longer period before it can be assimilated as food—consequently a large proportion is passed through the stomach of an animal only partially digested. This difficulty may be met to a great extent by previous maceration (mixing) with warm water, about blood heat, and allowing the fermentative process to be set up, by which the action of digestion will be commenced, and its constituents rendered far more speedily available as food.

THE BARLEY CROP.

BARLEY is generally admitted to the second place in the order of our cereal crops, oats usually being looked upon as a crop of inferior importance to the farmers of the southern portions of the kingdom. In the north, and especially in Scotland, these two crops have reversed positions assigned to them in the farmer's estimation; our climate and soils being generally better adapted for oats than for barley, the former are much more extensively cultivated.¹

Of what country barley was originally a native, we have no knowledge, as from the earliest historical periods, we find barley mentioned as one of the crops cultivated by the hand of man. In the fields of Egypt, Syria, and the East generally, it was a well-known grain. We are told in the book of Ruth that "she gleaned in the field until even, and beat out that she had gleaned, and it was about an ephah of *barley*." In the agriculture of ancient Greece and Rome it occupied a prominent position. According to Diodorus Siculus the plant was first discovered by Osiris, who redeemed it from its wild condition, and gave it as a boon to that art, agriculture, over which he was supposed to preside. In ancient Greece, too, Pliny tells us, on the authority of the historian Menander, that barley was so highly esteemed as a bread-corn, as to be used by

¹ The oat produce of Scotland for 1856-7 amounted to 938,613 qrs. The barley produce for 1856-7 was only 198,387 qrs.—*Agricultural Statistics for Scotland*, 1857.

the Athenians as the general food of their gladiators, who, from this circumstance, were frequently termed "*hordearii*."¹ Strabo, more exact and explicit than most of the ancient writers, states that cereals grow spontaneously on the banks of the Indus; but this region is so little known to botanical research, that even now we have no good evidence as to whether his statement is correct or not. Colonel Chesney, in his expedition to the Euphrates, found specimens of a barley growing apparently wild in Mesopotamia, with narrow ears, little more than 1 inch long exclusive of the awns, or $4\frac{1}{2}$ inches altogether; and others, from the ruins of Persepolis, with ears "scarcely so large as starved rye." Barley has been found growing naturally in Tartary and in Sicily—two countries very distant and very distinct from each other.

The original country of our cereals appears to be enveloped in doubt; our evidence in respect to it is very scanty and defective, and that which we have appears to be of a very conflicting nature. Meyen,² of Berlin, and Alphonse Decandolle³ have both discussed this point at some length. The latter tells us that many indications, botanical and historical, support the opinion that Persia and Tartary were the native countries of our cereals. We must consider with them, then, that if, after a century or two of diligent and competent research, no indications are obtained of our cereals growing spontaneously in any of the regions of the earth visited by man, either that the native country has disappeared during the great physical changes to which the surface of that portion of the globe was subjected in earlier ages, or that they were indigenous to those districts where bread-corns have been cultivated since the remotest periods. Culti-

¹ Pliny's *Nat. Hist.*, lib. xviii. cap. vii.

² *Grundriss der Pflanzengeographie*, von F. J. F. Meyen, Berlin, 1836.

³ *Distribution Géographique des Plantes alimentaires*.

vation would then have displaced the spontaneous denizens of the soil, to an extent which would render it impossible to distinguish, on the same spot, the successors of those plants which originally were indigenous to the soil, from cultivated plants of the same species. The native country of our principal cereals is therefore unknown, and probably will ever remain so.

In Roman agriculture barley was largely cultivated, and frequent mention is made of it by nearly all the authors whose works have been transmitted to us. Full directions are given as to the time of sowing, the descriptions of soil best suited for it, and the mode of treating the soil; all of which show the great attention they paid to those points of farm management, which too many of us of the present day leave entirely disregarded, to take their chance. Not only was barley cultivated and used by the ancients as a bread-corn, and as food for their animals, but it would appear they were also accustomed to steep it, and thus prepare an intoxicating drink by which the inhabitants of the western nations, Spain and Gaul—countries at that period less civilized than Italy—were accustomed to transgress the rules of sobriety. By this method of treating it they obtained a “scum,” which not only was very valuable to them in the preparation of their bread,¹ but the ladies also esteemed it highly as a cosmetic, and used it in a diluted form as a wash for their faces.² Thus we see that the fermentation of barley, and the conversion of its farinaceous constituents into alcohol—malting and brewing—was known at a very early period, and that the scum arising from it—our “yeast”—was applied by the Romans to the same useful purposes in bread-making as we apply it now; while at the same time we are willing

¹ “Spuma ita concreta pro fermento utuntur. Quâ de causâ levior illis quam cæteris, panis est.”

² “Quorum omnium spuma cutem fœminarum in facie nutrit.”—Pliny *Nat. Hist.*, lib. xviii. cap. vii.

to acknowledge its efficacy as a valuable therapeutic agent in certain diseased conditions of the surface, though our ladies hardly admit it as a general or necessary constituent of their toilette.

Of all our cultivated grains, barley has the greatest range of cultivation; it comes to maturity in almost every climate in the world, and thus is grown in the torrid, as well as in the brief but hot summers of those countries verging on the frigid zones. It is largely grown and used as a bread-corn in those cold climates where wheat cannot be successfully cultivated; and it is equally grown and used as a food for horses and cattle in the arid countries of the East, whose dry and hot climates render the cultivation of the oat impracticable. In the northern parts of Sweden and Norway, in Lapland and Siberia, it is more cultivated than either of the other cereals, chiefly on account of its quicker growth and earlier maturity, it not requiring to be more than seven or eight weeks in the ground, between seed-time and harvest. Linnæus found barley growing as a crop at Lullœa in Lapland, lat. $67^{\circ} 20'$ N., where it was sown on May 31, and was harvested on July 28, having reached its maturity in fifty-eight days. If we follow its cultivation towards its northern limits in Europe, we see how well it illustrates that beautiful arrangement conceived by Humboldt, and worked out by himself, Dove, and others, that, vegetable life being influenced mainly by temperature, cultivation is consequently determined by the *zones of temperature*, and not by zones of latitude or distance from the equator. These zones of temperature were arranged for the purpose of marking or joining together all those places where the same *annual* mean temperature exists, and are then termed *isothermal* zones; and also of marking or joining together all those places where the same *summer* mean temperature exists, in which case they are distinguished from the others by

the term *isothermal*. Some of our cultivated plants—those for forage purposes, for instance—thrive best where the climate is equable, where the variation between the winter and summer temperature is comparatively small, and where extreme temperatures are not met with; others again, those cultivated for their seed, whether as articles of food or commerce, generally require a more constantly higher temperature at the time of their maturity than at any other, and thrive best where they can secure these conditions, so necessary for their reproductive powers.

We have many places in our own country where barley cannot be successfully cultivated; yet we find it grown in Shetland, lat. 61° , and in the Faroe Islands, lat. 61° to $62^{\circ} 15'$. According to Berghaus, in Western Lapland, the limit of its cultivation is near Cape North, 70° lat., the northern extremity of Europe. In Western Russia, on the shores of the White Sea, it lies between the parallels of $67^{\circ} 68'$ on the western side, and about 66° on the eastern side, beyond Archangel. In Central Siberia its limits are between lat. 58° and lat. 59° . Such is the sinuous curve which determines the cultivation of barley, and all the other cereals are obedient to the same laws. A little further north all cultivation of vegetables ceases, at least so far as articles of food are concerned; the people live on the products of the cattle, as in the higher regions of the Alps and other mountainous districts, or by hunting or fishing, as their conditions may determine. But beyond the limits of barley cultivation there occurs a narrow and undetermined zone, in which certain early potatoes are successfully grown, and where the snow does not cover the ground for a sufficient length of time to prevent the growth of some of those vegetable substances low in the scale of nutrition, but still available as food for man, such as fruits, lichens, bark, roots, &c. As the introduction of the potato is, in comparison with barley, recent in those regions, it almost

everywhere forms the limit between the agricultural and the pastoral or nomadic life. From the importance of the cultivation of barley in the North, it is evident that wherever the human species has attained the first stages of civilization, the attempt will have been made to advance it as far as possible towards the pole. If, then, it is limited by a sinuous curve, as already explained, it is because circumstances of a purely physical nature oppose to it an insurmountable barrier.

A mean temperature of 46.4° during the summer quarter, seems to be for Europe the only indispensable condition for the cultivation of barley; in the islands of the Atlantic Ocean, and in insular climates generally, a summer temperature of 3° to 4° higher appears to be necessary for its success. Iceland, indeed, where this grain cannot be grown at all, presents in its southern districts, at Reykjavik, a mean summer temperature of 49.4°. It appears that there unseasonable rains are the means of preventing all cultivation of cereals. With the exception of districts where such counteracting influences exist, we may consider that the limit of barley cultivation varies between the zones of 46.4° and 49° of mean summer temperature (isothermal), in those countries where it is of importance as an article of animal food. On continents 46.4° temperature is sufficient, but in islands generally the increased humidity requires to be compensated for by increased temperature in summer. Barley, however, is cultivated as an alimentary plant as far north as either oats or rye; towards the lower latitudes it loses its importance; its cultivation languishes, and ceases altogether on the plains within the tropics, as it suffers more from intense heat than either of the other cereals. It will grow, too, at an elevation far above the range of wheat cultivation. Humboldt met with barley growing at an elevation of 13,500 feet on the Andes, and in Switzerland it may

be seen growing at an altitude of 1950 metres (6530 feet) above the sea-level; while in our own country we see it cultivated in many districts where wheat cannot profitably be grown. In the south of Europe, Sicily, Italy, and Spain, two crops of barley are obtained in the twelve months; the one sown in autumn is ready for harvesting in the early spring, and the second is then got speedily into the ground, and comes to the sickle at the ordinary harvest time. This variety of barley was known to the Romans, and is fully described by Pliny. It came to maturity in April, and is supposed to be the same as that to which reference is made in Exodus,¹ and assists very much in rendering that passage more intelligible.

Barley belongs to the same natural order of plants as wheat (Gramineæ), and botanists have given the name of *Hordeum*² to the genus of plants producing it. Much discrepancy exists between different authorities as to the number of species and varieties forming the genus. Professor Kunth enumerates fifteen, Professor Lowe describes six, Gasparin gives two—the six-rowed and the two-rowed, while Dr. Lindley reduces them all to mere variations from the original type, which he considers to be the two-rowed or common barley of our farms. He says: “The spikelets of this genus always standing in threes, and the threes being placed back to back, it is evident that every ear of barley must consist of six rows of spikelets. If the middle spikelet of each set of threes is alone perfect, the side spikelets being abortive, we have the common two-rowed barley (*Hordeum distichum*) and its many varieties; if the two lateral of each set of threes are perfect, and the centre spikelets imperfect, as sometimes happens,

¹ Ex. ix. 31, 32—“And the flax and the barley were smitten; for the barley was in the ear, and the flax was balled. But the wheat and the rye were not smitten, for they were not grown up.”

² Said to be derived from *hordus*, heavy; because the meal, containing less gluten than that of wheat, makes heavier bread.

we then have the four-rowed barley. If, on the other hand, all the spikelets are perfect, we have the six-rowed barley; but the case of four-rowed barley being merely accidental they may be referred to the six-rowed form, and thus we have only two principal kinds of barley, the two-rowed (*H. distichum*), and the six-rowed (*H. hexastichum*)."

This arrangement agrees with that followed by the French agronomist, Count de Gasparin, and probably is that which, botanically speaking, is the most strictly correct. In this country, however, the four-rowed species, or common "bere or bigg," has so long and so regularly been cultivated as to assume, at all events, the physical characters of a distinct species; and therefore, for the purposes of agriculture, we are inclined to increase the classification, and divide the genus into three distinct species, as follows:—

1. HORDEUM DISTICHUM — The ordinary Two-rowed Barley.
2. HORDEUM VULGARE — { The ordinary Four-rowed Barley,
the "Bere" or "Bigg."
3. HORDEUM HEXASTICHUM—The ordinary Six-rowed Barley.

To these Mr. Lawson, and others, add another—the

4. HORDEUM ZEOCRITON— { Sprat or Battledore Barley,
German Rice or Rice Barley.

No. 1. The first—the *H. distichum*, or Two-rowed Barley—is the species in ordinary cultivation throughout the country, save in the northernmost parts of Scotland, where the four-rowed barley is still considered the most suitable for the district. It differs from the wheat plant in the form of its florets, or rather, perhaps, by its spikelet having only one perfect floret in each; and it is easily distinguished from the other species of barley by the ear being more elongated, and of equal breadth throughout, and by the grains being attached to the rachis in an imbricated manner, partially overlapping each other, instead of standing out from it, as they do, more or less, in the other

species. There are several varieties in cultivation, possessing but very small characteristic differences between them, with the exception of the naked varieties, in which the grain separates from its *paleæ* or chaff in thrashing in the same manner as wheat does, which, indeed, at first sight it very much resembles. These different varieties are preferred in different districts, owing to their real or supposed suitability to the soil, the climate, or the markets of the districts in which they are grown. Lawson enumerates twenty-five as distinct varieties, cultivated in different parts of the country. Of these the following are the most esteemed:—

The Annat.—This is a great favourite in some districts, especially in the north. It was introduced, in 1830, by Mr. Gorrie, of Annat Garden, whence its name. In some districts it is even preferred to the Chevalier, the grain being rounder and more plump, while the colour is quite equal to it, and the skin equally fine. The straw is stout and tall, and possesses a characteristic pinkish colour immediately below the ear when it approaches maturity. This colour more or less disappears when the grain is cut, and been exposed to the air a few days. The awns are easily separated by the hummeller, and the sample is always clean and good.

In some comparative experiments with the Chevalier variety, and with the common barley, it was stated by Mr. Gorrie to have been the best, both as to bulk of crop and period of ripening. The grain weighed $2\frac{1}{2}$ lbs. per bushel more than the Chevalier, and it came to harvest fourteen days earlier. These results, however, do not appear to have been confirmed in other districts, where the Chevalier has gradually superseded it.

The Chevalier.—This is the favourite variety in those districts where barley is cultivated for malting purposes. The ear is long, from fourteen to eighteen grains on a side;

the grain is of a pale golden colour, plump, and round at the end; skin fine, mellow, and less wrinkled than in most other varieties; packs close, and weighs heavy in the bushel. The straw is stout, and stands up well, rendering it suitable for rich soils, where its yield is generally very good. It is somewhat later than the common barley at harvest, but may be sown earlier;

however, it is better suited for early than for late soils. It is largely grown in the north, and is equally productive, though the sample rarely equals in colour that grown in the south.

Common or Early English.—This, as its name implies, is the barley in ordinary cultivation. It is the variety best suited for general purposes, and maintains its position in our fields and markets, notwithstanding the various other kinds that have been from time to time introduced to our notice. It seems to be suitable to a greater range of soils and climates than any of the other varieties, while, at

Chevalier.

Common or Early English.

the same time, it comes to maturity earlier, requiring only from fourteen to sixteen weeks to perfect its growth. The straw is of a bright colour; the ear long; grains hardly set so close as the Chevalier; the awns are long, and re-

quire careful hummelling to remove them. Mr. Haxton found the relative proportions of the different parts of this variety to be as follows:—

Grain,.....	45.4
Awns and other parts of the ear,.....	6.6
Straw cut at first joint above root, and immediately below the ear,	38.1
Stubble and roots,.....	9.9
	<hr/>
	100.0

Golden Drop—probably originated from the Italian or Golden Barley—was introduced, some thirty years ago, by the late James Smith, of Deanston. It is a well-marked variety, having a stout erect stem, of a bright yellow colour—hence its name Golden—surmounted by a short, broad, compact ear, with grains full-sized, plump, and round, with fine skin. It is moderately hardy and early; is a large cropper; grain malts well, and fetches a good price. It succeeds well on rich vegetable soils where wheat will not stand, but is said to deteriorate unless the seed be frequently changed. The yield is large, and the sample generally good, and malts well, though the quality is not equal to the Chevalier.

Nottingham Long-eared.—This is a fine bold-looking variety, and is greatly esteemed in some parts of the country. The sample is excellent; grain rather larger and coarser than Chevalier; colour good; works well in the malt-house. The produce is good, but, owing to the want of compactness in the ear, is less than the appearance of the crop would indicate. In the north it has not succeeded in making a good impression.

Pomeranian or German.—A variety introduced from the Continent, and cultivated successfully in the northern districts of Scotland. It is hardy, early, and generally productive. The straw is tall and strong; the ear long and open, resembling the Nottingham. The grain is of good colour; weighs well; skin thin, and forms altogether

a good market sample. It is a good sort for cold soils and late districts.

Norfolk Short-necked, or Late English.—A very hardy variety, introduced on the Norfolk estate of Lord Leicester. It is a leafy, strong-awned, late variety, suitable for high and exposed districts, and for dry soils and seasons. The straw is very long and tough; the ear compact, with strong awns. The sample is good both in quantity and quality. In wet seasons it is apt to sprout in the ear, and at all times it appears to be very liable to choke in the shot-blade at the time of coming into ear. It has never made much progress in public estimation, but is a useful variety for certain conditions of cultivation.

Naked.—This variety has probably excited more attention than any other kind with which we are acquainted. It has at various intervals been introduced to us, from several different places, and under as many different names, and each time sold in small portions at enormous prices. It is, however, a very old and well-known sort, and has several times been in cultivation, though, probably always from the same cause, it gradually is lost sight of until, after some interval, it is re-introduced, and its value and advantages re-asserted. In the herbals of Gerarde (A.D. 1597), and of Dodoens, there is a full description and drawing of the plant, of its cultivation, &c. The straw is tall, but slight; the ear long; grains (about fourteen to sixteen on a side) large and bare, like in wheat; sample very heavy, 64 to 66 lbs. per bushel; grain elliptic shaped; skin fine and transparent; colour dark; and altogether more like wheat than barley. The yield is generally large, and the grain suitable for malting as well as mealing purposes. At harvest, the field operations are very unsatisfactory with this variety. The straw is too tender to make bands for the sheaves, and, when ripe, it becomes so brittle that the ear frequently is broken off and left on the

ground. This appears to be the reason why it never retains its place among our field crops for any length of time.

No. 2. The *H. vulgare*—Bere or Bigg—is represented by several varieties, whose cultivation, however, is confined to the northern and exposed districts of England and of Scotland. They are rarely met with elsewhere, except upon inferior and ungenial soils, where the finer qualities of barley would not successfully be grown.

The *Common Bere or Bigg* differs greatly in appearance from the two-rowed barley. The ears are thicker and shorter, about $2\frac{1}{2}$ to 3 inches long, and contain about forty to fifty grains in each, arranged round the rachis in two single and two double rows. The straw is about 3 feet high, tough, and bright-coloured. The grain is thin, and pointed at both ends; weighs light, generally 40 to 45 lbs. per bushel only. The awns are long, and adhere to the grain firmly. The sample is always inferior, and is generally used for distilling or feeding purposes. The proportions per cent. of the different parts are given as follows:—

Grain,	50·904
Awns, &c.,.....	5·713
Straw,.....	37·973
Roots, &c.,.....	5·410
	<hr/> 100·000

Black Four-rowed—an improved variety, of a black or dark-bluish colour. Ear much longer than the common bere; grains plumper, and of finer quality. It

is sufficiently hardy to stand the winter, and in such case may be fed off in the spring, and then left for seed. The produce is generally very good, and the quality equal to

Common Bere or Bigg.

malting barleys—though, owing to its dark colour, which is due solely to the skin, it is rarely used for such purposes. If sown in spring, it ought never to be got in later than the end of March, as it is apt to assume a biennial habit if sown late, and not produce its seed until the following year. In harvesting, great care is required, as the straw becomes very brittle below the ear, and much is often broken off and left on the ground.

Victoria Bere is probably the finest and most valuable of all the varieties, and is said to be equally adapted to the soils of our exposed districts in the Lowlands as well as the Highlands. The straw and ear are longer and stouter than the common bere; the grain is much heavier, weighing up to 54 to 56 lbs. per bushel; and the produce is much larger, from 10 to 12 quarters having been obtained to the acre.

Winter White—a coarse, productive variety, suitable for winter-sowing in late, exposed districts, as it then comes to maturity a fortnight earlier than any sown in the spring. On the Continent this is a great favourite, and is used largely for distilling and brewing purposes.

Peruvian—is a *naked* variety of this species, which has been spoken of very favourably by those who have grown it. It is very productive; and the grain, which has the same shape and characters as the two-rowed, weighs well, and is suitable for either malting or grinding.

In general, these *naked* barleys are not so well suited

Victoria Bere.

for our climate as the ordinary barleys. They thrive best where a short but hot summer enables them to carry on and perfect a rapid growth. When grown, however, under favourable conditions, and the produce consumed at home, they give certainly the most remunerative returns, as the yield is large, and the weight per bushel much heavier than the finest samples of ordinary barley. There is generally some difficulty in disposing of them at market, where they never fetch a price equal to their real comparative value.

No. 3. *H. hexastichum*—the Six-rowed Barley—offers but little inducement for cultivation in this country. The only variety met with here is the Pomeranian or six-rowed White Winter Barley, which possesses no qualities to recommend it in preference to the four-rowed barleys already described. It is very hardy and prolific, but later in arriving at maturity than those varieties. The ear is short, compact, with thin, coarse grains, light in weight, generally inferior in quality, and only suitable for distilling purposes. The relative proportions of the different parts of this species are thus given:—

Six-rowed Barley (*H. hexastichum*).

Grain,	51·
Awns, &c.,	5·
Straw,	32·
Roots, &c.,	12·
	<hr/> 100·

No. 4. *H. Zeocriton*—Fan or Battledore Barley.—It is but of little practical importance whether this be classed as a mere variety of the *H. distichum*, or as a distinct species. It is rarely met in cultivation, being only grown

for illustrative or experimental purposes. The ear is short, very broad at the base, and tapering towards the extremity. The grains stand out from the rachis, as in the last species, but having only two grains in a row; the ear is flat, like the two-rowed barleys. A two-rowed variety, known as Peacock's Barley, greatly resembling this species, was introduced some years ago, but seems to have passed out of cultivation altogether. The straw was short; the ears small but broad, and containing from ten to twelve grains on a side; grain heavy, but of coarse quality.

Such are the principal varieties of barley cultivated. In most districts where thorough draining and other improvements have been carried out, the two-rowed is gradually supplanting the coarser four-rowed varieties. We have already, while discussing the wheat crop (p. 16), alluded to the different qualities that a soil should possess in order to render it suitable to the plant, and also to the climatal conditions necessary for its successful cultivation (p. 98). There is a very wide range of barley soils in this country; nearly all the geological formations, save those of a purely argillaceous (clay) character furnishing soils more or less suitable for its growth. In the tertiary formations the drifted soils are more suitable for its cultivation than the alluvial and the strong clays of the London basin, in which, however, we see wheat thrives well. In the cretaceous series we meet with excellent barley soils in the beds of the upper and lower chalk, and in the silicious soils of the Hastings and green-sand formations; while the interstratified beds of gault and weald-clay furnish no soils where barley can be grown.

Battledore Barley
(*H. Zeocriton*).

The oolitic range exhibits a like difference of surface soils; most of them are well suited for barley, while two prominent members of the group—the Oxford clay and the lias—occupy extensive areas on which its cultivation is rarely attempted. Below these formations the sandstones predominate, and no beds of clay of any consequence are met with; they are represented by thin shales which readily disintegrate, mix with the sandstones, and form soils more or less suitable for barley, according to the relative proportions in which they have been originally mixed. A glance at a geological map will readily show the very large portion of the country occupied by these several formations; and assuming that we have everywhere, save in some of the higher districts of the north, a mean summer temperature of 49° , we can easily estimate the extent of our barley-growing soils. Agriculturally speaking, their range is from the lightest gravels up to the medium loams; beyond a medium loam the proportion of clay renders the soil unfit for the cultivation of barley. The quality of the soil generally exhibits a greater effect upon barley than upon the other cereals—the loams or stronger soils showing their superior fertility by their increased produce, while the chalks and lighter soils produce grain of superior quality. The strong loams and clays are very rarely adapted for barley, owing to the difficulty of getting a sufficiently fine tilth for the seed at the proper time for sowing; and even if this be secured, the produce, though in some cases large, is of a coarse quality, and never fetches a satisfactory price in the markets. These soils are essentially wheat soils, and either in wheat or oats give a far better return than if sown down with barley.

The recommendations given for the mechanical preparation of the land for wheat (p. 37), are equally applicable to barley, and, indeed, to all other crops—that

the soil should be freed from all surplus moisture—that it should be stirred as deeply as possible—and that its particles should be always kept in the state of greatest division. These particles, though in a state of minute division, can be consolidated, and the soil rendered as firm as may be desired for any particular crop, by the use of the roller, or any other form of surface pressure; but whether consolidated or not, the benefit of their division remains the same, and the roots of the growing crop have access to a far larger surface of feeding ground, than they can have where the subsoil is left in the indurated and cemented condition in which it is so generally seen on shallow-ploughed farms. It is equally desirable, too, that the land should be in good heart or condition; as although barley is grown successfully on what are termed inferior soils, when compared with our wheat soils, still we find when we sum up the requirements of the two crops respectively, that a crop of barley abstracts from the soil the same substances (see page 130), and in about the same quantities, as the wheat does; and that as its growth is more rapid, it requires these substances to be in a state ready for immediate assimilation. The constitution of the roots of the two plants and their habits differ materially. The healthy wheat plant pushes out vigorous roots, which ramify in all directions, and penetrate deep into the lower strata of the soil in search of suitable materials for its structure, thus obtaining an increased surface for the action of its numerous feeders. The barley plant appears to have less power of root development; cultivation has given to it a speedy growth, and thereby induced a capacity for rapid increase, and a consequent necessity for large supplies of assimilable food; its roots, if examined carefully, are found to be far less developed than those of the wheat grown under similar conditions; their habit is

rather to ramify and distribute themselves laterally through the surface soil than to dip downwards in search of food in the subsoil. But although their extent is far less than the wheat roots, they appear to be fully compensated by an arrangement of root-fibres, which has not been noticed in the wheat, and which enables them by this great increase to the number of *mouths*, so to term them, to abstract from the soil a larger amount of mineral food in a given time, than the more extended roots of the wheat plant are called upon to do.

In order to understand more clearly this beautiful arrangement, which probably exists in all roots, though more fully developed in some (quick feeders, for instance) than in others, we cannot do better than follow Dr. Lindley, who in a recent article,¹ which will amply repay perusal, tells us "that it is not only on account of the extreme delicacy and importance of their points that roots require to be handled with the utmost delicacy. Another microscopical fact has been ascertained within the last few years, and is of hardly less interest. When you look with the naked eye at the skin of a young root-fibre, nothing is seen except an apparently level uninterrupted surface; but in many cases there are present infinite multitudes of little hairs, through which food is imbibed: they are the mouths of the root. Through their agency the sucking or feeding power of the root-skin is very considerably augmented: to remove them is to diminish or destroy that power. But they are so delicate that any ungentle treatment must destroy them." In the words of Professor Henfrey, "they are mostly invisible to the naked eye, and their presence is chiefly betrayed by the adhesion of the soil to them. When young roots are carefully washed, and placed under a magnifying-glass, their fibrils (root-

¹ *Gardeners' Chronicle* for 1859, p. 692.

hairs) are seen very clearly; and on such roots as those of barley, for instance, they exist in enormous numbers."

The accompanying diagram, taken from Messrs. Lawes and Gilbert's paper in the *Royal Agricultural Society's Journal*, vol. xviii. p. 511, will serve to illustrate these

points, by showing the difference in growth between the roots of wheat and barley. The seeds were planted under the same conditions of soil, temperature, &c.; and were examined at the same time, when it was found the wheat had thrown out such a mass of ramifications, that the whole of the surface of the dish in which the pot rested was covered with a thick network of rootlets, as also was the bottom, and to a great extent the sides of the inside of the pot itself; while the barley plant had only sent down one solitary rootlet to the bottom of the pot, and had carried on its growth with the materials it had been able to find near the surface.

These two facts—the quantity of mineral matters required by the barley plant for its growth, and the great powers it possesses for rapidly absorbing them—show us how closely connected the successful cultiva-

tion of barley must be with the condition of the soil in which it is grown. The important bearing of this point comes before us when we consider what place barley should occupy in the rotation. In the absence of any sound direct knowledge of the natural habits and requirements of our various crops, rotations or systems of cropping must be more or less mere guess-work, founded, if you please, upon long practice and experience, but good only where exactly the same conditions can be secured. Consequently we find some strongly advocating one order of rotation as the best, whilst others entirely disapprove of it, and recommend an arrangement of cropping entirely the reverse. Yet both may be equally right—differing conditions would free them from any charge of error—the rotation of each might be the best for themselves, though not necessarily so for others farming under different circumstances of soil, climate, or markets.

The evidence already adduced shows that barley requires a large amount of available food (manurial matter) in the surface soil, and that from its habit of sending out its principal rootlets in a lateral direction through the surface soil in search of food, the soil must be kept in a comparatively loosened state during its period of growth, and be left so after the crop is harvested, and the roots have submitted to the usual process of decay. Hence we may assume that place in the rotation to be the best suited for barley in which the preceding crop has left a large amount of fertilizing matter on, or close to the surface, and in which the crop that follows it may not be prejudiced by the loose and open state of the soil it leaves behind it.

This order of cropping is seen in what is termed the four-course, or Norfolk rotation, which is especially adapted for the lighter descriptions of soils on which the finer qualities of barley are generally grown. Here we have

barley grown between turnips and clover—wheat being the fourth crop, and preceding the turnips. The turnips, to which a considerable amount of manure has been given, are fed off on the land; and their manurial produce, frequently enriched by the addition of oil-cake or corn, transformed into the shape of solid and liquid excrements from the sheep, is absorbed and mixed up with the surface soil. On such soils, especially after the deep ploughing and extra tillage of the turnip crop, a fine tilth, so necessary for the seed-bed, is readily obtained, and the roots are able to spread themselves quickly through the soil. The clover crop, which follows the barley, has large fleshy roots; these naturally thrive better in a loosened soil than if it were compact and hard, through which fibrous roots—those of wheat, for instance—could far more easily penetrate. As the clover roots are developed, the soil gradually becomes firmer and more consolidated; and by the time the crop is finally consumed the pressure on the surface has neutralized the loosening property of the barley, and given the land that compactness which is so desirable for the succeeding crop—wheat. The wheat stubble is ploughed up deep, and left for the weathering influence of the winter months, the manure being either ploughed in with it, or left for the spring ploughing; and the land is then well prepared and in condition for the turnip crop.

If we were to reverse the position of the two grain crops, neither of them would meet with such suitable conditions. The soil would be too loosened by the preceding crops of barley and turnips to suit the requirements of the wheat, while the clover would leave it too firm and compact in texture to be adapted for the growth of barley.

Neither would the chemical conditions of the soil be more suitable than the mechanical. The food would be supplied in the surface soil to the wheat, which has root-power sufficient to seek for it low down in the subsoil;

while the barley, whose habit it is to throw out its roots near to the surface, would find the supplies there more scanty than it would like. Thus this place in a rotation is both chemically and mechanically that best adapted to the special habits and requirements of barley.

We see it, however, frequently very differently arranged. The two and the three course systems are only followed on strong clay soils, which in themselves are not suited for barley cultivation. In the five and six course systems, on soils suitable to barley, the same arrangement can be advantageously carried out. Here, however, it is that we meet with variable practices. Sometimes we find it following another grain crop—wheat commonly—where the soil is supposed to be in high condition, and the present rather than the future crops occupy the farmer's attention, the temptation of putting two consecutive crops in his pocket being too great to be resisted. Under the most favourable circumstances this is a very questionable gain, and under ordinary circumstances a very certain loss. Both crops belong to the same order of plants; they require the *same food* from the soil, and in about the *same quantities*, to perfect their growth. The wheat occupies the ground first, and has about nine months to search about and abstract from it all the food it needs. It is then followed by the barley—a plant less vigorous in its growth—which, however, is expected, during the short time it occupies the soil—four to five months—to obtain from it, in its now impoverished state, the same amount of mineral matter which the wheat had double the time to effect in. The consequence is, that the second grain crop is generally a very reduced one. It may look very well while it is growing; but when it comes into the barn, its yield will be found diminished in quantity, while the weight of the sample shows its deterioration, and lowers its market value. The succession of crops of the same

order, too, tells its tale of injuries sustained by the attacks of insects and plant diseases, which though noticed probably to only a small extent in the first, may, with the powers of increase so remarkable in them, become enormously developed in the second. Where barley follows wheat, the seeds, generally containing grasses—again the same order—invariably suffer; and we all know the value of a good crop of seeds everywhere where mixed husbandry is carried out.

Again, in some rotations, barley is taken after a leguminous seed crop—beans, or peas, or vetches. These, especially the two last, generally leave the land in a very foul and dirty condition—a state very ill suited for barley with which seeds are to be sown down. For these to succeed and give their full return, the land cannot be too scrupulously clean. Besides which, the beans or peas require from the soil the same food as the crop of clover looks for, and are afflicted by the same diseases and injuries which so often diminish our seeds. As a *rule*, we should always bear in mind that *the longer the interval between the same crops, or crops of the same natural order, on the same ground, the better, and the greater the chance of remunerative cultivation*. Expedience has long ago pointed this out to the observant farmer, and science has now proved it, by showing him the cause of it.

Let barley always follow a root crop. Under the ordinary circumstances of our farms, turnips probably, if fed off by sheep, are the best preparation from the crop. If the land, however, is in high condition, the barley is apt to grow too luxuriantly, and to be laid. This drawback may be met, either by carting the turnips off (either wholly or a portion of them), instead of feeding them on the land, or by substituting another root crop altogether, as potatoes or mangold wurzel, either of which provide

the same mechanical conditions in the soil for the reception of the barley seed. In the *Journal of the Royal Agricultural Society*, vol. xviii., the paper by Messrs. Lawes and Gilbert, "On the growth of barley by different manures, continuously on the same land; and on the position of the crop in rotation," giving full details of an elaborate series of experiments, will amply repay perusal.

The different varieties of barley enable the farmer to select that which is the most suitable for his purpose. In light soils of good quality the Chevalier is probably the most remunerative; where the soil is strong, or in late or ungenial districts, some of the coarser varieties frequently give a better return.¹ And where the object is to grow for home consumption only, the naked Peruvian or the black four-rowed barley yields the largest amount of available food.

The same care should be taken in the selection of seed barley as recommended (p. 19) for seed wheat—that the *grain be of the best quality, fully matured, perfectly free from injury, and true to its variety*. All these points deserve and would repay far more consideration and care than are usually bestowed upon them. A regular *change of seed*, too, is strongly advised. The author of the prize essay,² "On the Management of Barley," thus forcibly advocates it—"I am a very strong advocate for a constant and judicious change of seed; and although it may be sometimes expensive to obtain it from a great distance, I believe it will generally repay the cost by an increase of produce and an improvement of quality. A few years ago a very strong instance, confirming my opinion in this respect, came under my observation, on two adjoining farms in a barley-growing district, both much alike as to quality of soil, the occupier of No. 1 being in the habit of

¹ See results of comparative experiments with different varieties of barley. *High. Soc. Trans.* for 1851, p. 519; 1853, p. 179, 482.

² *Roy. Agri. Soc. Jour.*, vol. x. p. 461.

constantly changing his seed, and of sowing rather early, and the occupier of No. 2 systematically never changing his seed, and sowing rather late. The quality of the barley grown upon No. 1, in the year referred to, was remarkably good; and upon No. 2 it was so very inferior as to be quite unsaleable for any but the most common purposes; and 2s. per bushel, or 16s. per quarter, was the difference in the price these barleys fetched at several times during that season, on the same day and at the same market. The produce per acre was also very much greater on farm No. 1." This probably was an extreme case; but it serves to strengthen the policy of a judicious change of seed, by illustrating the wide difference which may exist between the barley produce of one farm where this has been attended to, and of another where home-grown seed alone is used.

The preparation of the soil has already been alluded to—the object to be obtained being a fine tilth. When barley follows turnips fed off on the land, it is desirable to keep the plough as close behind the sheep as possible, as the sooner the manure is covered up by the plough, the better it becomes mixed in the soil. In wet seasons and on argillaceous soils the surface is apt to become poached and wet, and is frequently materially injured by the sheep being left on it in that condition. In such case it is far better to leave it until it becomes dry again before ploughing, than to touch it in such a state, as, if ploughed up then, it is well-nigh impossible to get the desired tilth, and a large portion of the manure is rendered inaccessible, by being shut up in the lumpy masses of the soil. Generally speaking, it will be found beneficial either to give the land a light furrow a second time, or else to run the scarifiers through it and across it. This, where the land has been ploughed at several different times, equalizes the condition of the surface, and at the same time disperses and

mixes up more effectually the manurial matter it contains.¹ Experiments have satisfied us how much the efficiency of all manures depends upon the state of division and regularity in which their particles are distributed through the soil. In regard to barley, where, from any circumstances of cultivation, it is desirable to apply any special manures, we must recollect that those of a *nitrogenous* character are to be preferred, as they appear not only to act as direct manurial food to the plant, but also, by their invigorating influence, enable it to appropriate additional supplies of mineral food from the soil.²

No thought is generally bestowed upon the preparation of barley for seed, yet we find it more subject than even wheat is to the attacks of one of those diseases already described (p. 64), the *Uredo segetum*, or "Smut." How far steeping the seed would be a remedy, we have no direct evidence to show us. The spores are mostly dispersed over the field before the corn is harvested, and therefore are not likely to be attached in any quantity to the grain. Still it is not a troublesome or expensive process, and if any should adhere to the grain, they would be destroyed or removed in the steep, which, at the same time, would prevent the germination of any injured seeds (p. 67), and thus at once prevent the chance of their sickly progeny.

The time of sowing barley is the next point that claims our attention. Here, of course, several modifying circumstances have to be considered, as soil, climate, variety of barley, and the state of preparation of the farm. Barley is a very rapid growing plant when placed under suitable conditions; and we see it constantly being sown late in the spring, long after the other cereals can be attempted with any chance of success. On too many farms the late-

¹ In the article "Barley" of the *Cyclopedia of Agriculture*, these points will be found more fully discussed.

² See Messrs. Lawes and Gilbert's experiments in *Roy. Agri. Soc. Jour.*, vol. xviii. p. 493.

sown turnips are reserved for spring keep for the sheep, and may be seen carrying their stunted flower-stems long after the period when on other farms the barley land has been ploughed and sown. Still, owing to the increasing temperature as the season advances, vegetation proceeds more rapidly, and a crop of barley—inferior, it is true, both in quantity and quality—has sometimes been obtained from seed sown even late in the month of May. As a rule, however, we may recollect that, all circumstances being the same, the longer the plant is in the ground the more food it is able to procure from it, and the greater return it is capable of producing. Barley is naturally a very hardy plant; and although, from constantly sowing it in the spring, we have, no doubt, somewhat induced a more tender habit, still it may in our climate be sown at the earliest period of the spring at which the land can be got ready for it. Indeed, in most parts of the south and west of England, the ordinary barleys would stand the winter without injury. They would tiller out and produce capital and early herbage in the spring, which is very valuable at that period of the year, and might be fed close down up to the middle of April, and then be allowed to stand for a crop.

Great difference of opinion exists among practical farmers as to the effects of early or late sowing. Results have been from time to time given, which, not being comparative, are really of no value—except, perhaps, in their own immediate district—as they do not admit of general application; and probably in some cases, indeed, the results were attributable to other causes than the time of sowing. This is a subject which might with advantage be taken up by our great Agricultural Societies. A series of comparable trials on our barley-growing soils, in different parts of the country, would, no doubt, settle this disputed point. The only experiments recorded are those by Arthur Young, towards the close of the last century, and these are still

quoted by several of the continental writers. These experiments had reference to the comparative yield of barley sown at different periods—in the same soil, and in the same proportions—which is given as follows:—

Sown in February, the yield was as 12·5

„	March,	„	„	11·5
„	April,	„	„	8·5
„	May,	„	„	6·5
„	June,	„	„	3·15

These figures, furnished to us by such an authority on all farming matters as Arthur Young, surely are worth something. The experiment, no doubt, was a solitary one; but then it was strictly comparative, consequently valuable; and at all events, it is quite within our power to test their correctness in regard to the general conditions of barley growing, by a more extended series of trials, which would have the advantage of drawing public attention to the subject, and give us reliable data for our guidance in future operations.

The methods of sowing, or depositing the seed in the soil, are similar to those described in reference to wheat; and the remarks in reference to “thick and thin sowing,” and to the relative proportions of seed required by the different methods, are equally applicable to barley. The broad-cast machine, however, is probably more generally employed in barley than in wheat sowing. The area sown per day is about the same, and may be calculated by the rule given at p. 27. The quantity of seed sown varies in different districts—from 2 to 4 bushels being the usual proportions; probably, for general purposes, 3 bushels will be found amply sufficient for a crop. In all cases, it is advisable that the drills or lines of sowing should not be so close as they are generally seen. If sown by itself, 9-inch widths would probably be sufficient; but, if sown down with seeds in the usual manner, 12-inch drills would be preferable. By these widths the air and sun have

better access to the young plants; they grow stouter, and give a better return both in quantity and quality; while the benefits of its effect on the young seeds are most perceptible. Although, owing to its rapid growth and late period of sowing, it is seldom thought necessary to hoe barley, still there is no grain crop that requires it more, or that would better repay the cost of labour. It is both a delicate plant, and one that feeds very quickly, and can ill contend against the adverse action of any weeds indigenous to the soil, which not only directly obstruct its growth, but abstract from the soil portions of food which ought to be appropriated by the barley alone. In the early-sown crops, a hoeing might be advantageously given, before laying down the seeds; and the wider the drills, the more effectively could this be carried out.

Owing to the period at which barley is usually sown, it is most important that none of the conditions requisite for its successful germination should be neglected. Moisture is most important to it; therefore it should be sown upon a fresh furrow, or, if upon a stale one, only at a time after rain, or otherwise, when that condition can be secured. Besides moisture, a certain temperature, access to air, and absence from light, are absolutely needed; and these are always obtained by properly depositing the seed in a suitable soil. Then the initial process of vegetable life—germination—is set up; and this is such a simple, yet beautiful illustration of the admirable design that pervades Creation, and one so important to be understood by all interested in vegetable life, as to claim our especial consideration.

The seed which is placed in the soil contains starch, gluten, and certain mineral substances (see p. 130); and so long as these substances remain unchanged, the vital principle, which exists in all perfect seeds, remains dormant under ordinary conditions, but in equal force. Directly,

however, the conditions of the seed are changed to those suitable for its new functions, a vital action is set up, which is immediately communicated to the matters forming the body of the seed, these, by a series of beautiful changes, furnish the young plant with a supply of food, until such time as it has acquired vigour of growth enough to throw out its own rootlets and leaves, and thus obtain its food directly from the soil and the air. The first change that takes place in the seed is the formation of a peculiar substance termed *diastase*¹—a substance which, although well known to chemists, is yet beyond their skill to produce. It is clearly the result of natural forces, and can only be produced by natural causes: it does not exist in the raw grain or seed, but is a necessary ingredient in malted grain. This remarkable body is the result of the vital action in the seed acting on certain of its constituents, and is obtained at the expense of the nitrogen compounds (gluten) existing in the seed. It is always found at the end of the seed in which the germ is placed; whence proceed (as is seen at p. 21) both the stem and the roots which constitute the future plant. Here it is that the starch globules first experience a change; under the influence of the “diastase,” with which they are in immediate contact, they are converted into a substance analogous with gum, to which the name of “dextrine”² has been given, and then from dextrine into sugar. Such is the change which takes place in the germination of all our cereal grains; and a small acquaintance with chemistry will enable us at once to recognize the reasons why such provisions should have been made by the Almighty in the structure and constitution of seeds.

The starch, stored up in such large proportions in the

¹ From the Greek words *δια* *ιστημαι*, to stand between, because this substance aids the conversion of the starch into sugar.

² From *dexter*, right hand, owing to the peculiar action of the substance in the polarization of light.

seed, and which is so valuable as an alimentary substance to man, is in itself perfectly insoluble in water, and therefore would not be in that state available to the plant, as it could not accompany the sap when it begins to circulate in the nascent germ. But it is necessary that, immediately vitality commences, a supply of materials should be provided in order to support it: the "diastase," therefore, is found close to the base of the seed, where the vessels terminate in the farinaceous matter. This acting on the starch, converts it finally into sugar, which in itself is readily soluble in water, and in that state is conditioned at once to circulate through the fine capillary vessels of the young plant, and be carried to its extreme points of growth. When this service is performed—all the starch converted into sugar, and all the sugar assimilated by the plant—the functions of this agent (the *diastase*) cease; and it undergoes itself a change, furnishing to the young plant that supply of nitrogenized food which forms a necessary portion of its structure. By this time the plant, if the produce of a fully developed, healthy parent (seed), has reared its head above the ground, has thrown up a stem with true leaves to collect its organic food from the atmosphere, and is provided with roots sufficient to supply from the soil its future mineral or inorganic wants.

Now, had the starch originally existed in the state of sugar, this seed would not have been adapted for the purposes for which seeds are intended, the sugar would speedily have entered into fermentation, and the chemical action thus set up would at once have destroyed its vitality. With starch—although in itself so analogous with, and so readily convertible into, sugar—we find a different condition of stability. This remains unchanged for any period of time, and is always in a state ready for the changes which its functions in the germinating seed re-

quire it to undergo. But place the starch-containing seed in the soil—let its dormant germ be called to life by the conditions necessary, then we see a new agent—“diastase”—called into existence; and the food, before insoluble and unavailable to the young plant, is now rendered soluble, and capable of ministering to its future growth. The first movement of life is the signal for its appearance at the very spot where its aid is most required—there ready at once to effect changes, and to furnish the supply of food demanded by the increasing plant. And then, again, when its duties are all performed, and its existence is no longer necessary, its functions cease—it in itself falls before the power that created it—and thus, in another form, passes into the structure of the young plant, through the medium of the sap, by which it is readily taken up.

Under favourable conditions barley germinates very rapidly; in the course of three or four days it is well up through the ground, and in another day or two has put forth leaves, which, by the time the parent stock of food is exhausted, are able to supply the young plant from the atmosphere. After this period it requires but very little attention; its growth under suitable conditions is very rapid, and it is generally ready for harvesting immediately after the wheat crop. This should be commenced directly the ear loses the last tint of pinkish hue, and assumes the yellow tint of maturity, at which period the neck of the straw also indicates, by its changed colour, that the circulation of the plant is arrested, and the head begins to droop. The grain at this period possesses its highest nutritive value, the after processes of maturation having reference principally to the formation of the seed-coat (husk). If the barley be intended for seed it is desirable that this last process should be fully carried out, and therefore the harvesting should be delayed some few days later, as may be convenient. At all events, by commencing as early as

possible, you have a greater command of weather, and are better able to arrange your labour satisfactorily, than if it be left until the grain is dead ripe. In dry weather the straw becomes very brittle, and a large quantity of the crop is left on the ground; and in wet weather the grain is very apt to sprout in the ear, and thus be effectually spoiled for malting, and greatly deteriorated for feeding purposes.

The mode of cutting is pretty generally with the scythe, except in those advanced districts where the "reaper" has taken possession of the field. The ordinary scythe, with a small cradle, is used, and the corn is cut *out* and laid in swathe, as in mowing grass. From 1 to 2 acre per day may be taken as the average work of a good mower, according to the quality of the crop; if the crop be heavy, with a full growth of clover, from 1 to $1\frac{1}{2}$ acre, and if it be simply barley and no clover, then from $1\frac{1}{2}$ to 2 acres would be a good day's work. The rates of payment vary so much in different districts, and in different seasons, that it is useless to give an estimate, especially as in some districts barley is bound and stooked the same as wheat and oats, while, in by far the greater part of the country, it is left on the ground, and stacked loose like clover.

Where barley is bound and stooked an additional cost of 2s. 6d. to 3s. per acre is incurred. This is always money well laid out where the barley straw is sufficiently long to allow of its being done; it preserves the bright colour of the grain, which so much determines its value in the malting market, and which is so liable to be affected (stained) by the slightest shower that may fall while it is lying out in the field, or even by the heavy dews that prevail at this season of the year. Taking 5 quarters as the produce per acre, this additional expense of binding and stooking is only 6d. per quarter, which, irrespective

of the improved market value of the grain, is fully saved to the farmer in the after processes of harvest, by the increased facilities it gives in carting, stacking, and thrashing out the grain. When the barley is merely cut and laid in the swathe it is important that it be removed as little as possible, as it is so liable to break, and leave the corn on the field; both sides ought, however, to be exposed equally to the action of air and light, which can be effected by merely turning the swathe over as it lays with a fork. In collecting it for loading, care is likewise required; the large collecting forks used in the clover harvest are very efficient for barley also.

In stacking, the oblong form of stack is that most commonly seen; indeed, where the barley is stacked loose, this is the best shape, as it would be less practicable to divide a circular stack for thrashing than one of this form. Where, however, the barley is tied up, the circular form is unquestionably the best and cheapest. In building the oblong stack it is advisable to observe the relative dimensions given in regard to wheat harvesting (p. 58). If the grain is in sheaves it should be stacked in distinct lengths sufficient for a day's thrashing; if stacked loose this is of no importance, as the quantity required for the barn is cut off with the common hay-knife.

In thrashing the same rules apply as with wheat, and about the same relative difference in cost exists between the three methods—the flail, the horse-power, and the “steam” thrashing machine. By each, however, a larger amount of barley is thrashed out, in a given time, than of wheat—on the average from one-fourth to one-third more—and therefore the cost per quarter is proportionably lessened. Barley, however, requires an additional process to fit it for use—that of “hummelling,” or separating the awns from the grain. In the “combined thrashing machine” this forms a portion of the work, and

adds nothing practically to the cost; with the ordinary machine, or where the flail is used, the grain has to undergo an after process, which, of course, entails an additional expense.

Under ordinary circumstances the relative weights of the grain and the straw, in a barley crop, are about the same; therefore, a yield of 6 quarters to the acre (54 lbs. per bushel) would give a gross weight of grain and straw of about $2\frac{1}{4}$ tons per acre. In the stack—the cubical contents being calculated in the usual way for the measurement of solid bodies—the quantity of grain may be estimated as follows:¹—

In a crop where the proportion of grain is—

Small,	it will require	27	cubic feet to yield	1 bushel.
An average,	„	21.5	„	„
Large,	„	18	„	„

The diseases and insect ravages to which barley is liable are, so far as our observations go, very few compared with wheat. Amongst the former the “smut” (*Uredo segetum*), is the only one which appears to be injurious to it to any noticeable extent. This in some seasons (1846, for instance) and on some soils, prevails more than in others. Mr. Berkeley also remarks that in 1844 the late-sown barley exhibited at harvest time indications, though not to any prejudicial extent, of having been attacked by “mildew.” “Ergot,” too, has been occasionally noticed in barley grains; and when the plant has been destroyed or seriously injured by drought, insects, or other causes, the stems and ears are frequently blackened by the *Kladosporium herbarum*. This fungus, however, as has been before observed (p. 70), is the consequence and not the cause of disease. Amongst the latter a wireworm (*Elater obscurus*),² is frequently very destructive in dry seasons and on cold soils;

¹ Ewart's *Agriculturist's Assistant*, p. 102.

² See Curtis' *Insects Injurious to Farm Crops*, p. 191.

the young plant when attacked changes from a dark green to a sickly yellow colour, and then either dies off or remains in a stunted, debilitated state. Notwithstanding the serious injuries they inflict, these insects, and doubtless many others, are, so to speak, "*preserved*" on our farms, and carried on from the barley crop to the wheat crop by means of the rye-grass which is so generally mixed with the clovers in the intermediate seed crop. This practice is opposed to all principles of rotation, as rye-grass belongs to the same botanical order as both the barley and the wheat, and thus *three crops requiring the same mineral food are sown consecutively on the same ground*; while it offers a home between the two marketable crops for the reception and increase of those fungoid and insect enemies which are so injurious to both, and which a perfectly different crop, such as clover, for instance, would, from its unsuitability to their requirements, go far to starve and get rid of.

The large consumption of barley for brewing and distilling purposes, has caused its Chemistry to be more inquired into than it probably otherwise would have been. As it is, we have much reliable information as to its composition, and consequently what it requires from the soil in which it is grown. From the data already given we may take the proportion of grain to straw in the barley grown in this country at about 2 to 3, or 45 parts of grain and 55 of straw in 100. The continental chemists give a slightly different estimate; according to Schwerz the proportion is as 50·7 to 100, or about 1 to 2, and this seems to be generally accepted by them. The amount of mineral matter (ash) in the grain varies, and may be taken at from 2·5 to 3 per cent, and in the straw at from 5 per cent. to 8 per cent. The water naturally contained in the grain and straw (air-dried) is about the same—12 per cent. to 14 per cent. in each.

The composition of the ash of the grain and of the straw is as follows:—

	Grain. ¹	Straw. ²
Potash.....	15·61	9·2
Soda,	5·03	·3
Lime,.....	3·06	8·5
Magnesia,.....	8·04	5·0
Oxide of Iron,.....	1·24	1·0
Phosphoric acid,.....	35·68	3·1
Sulphuric acid,	1·22	1·0
Chloride of Sodium,.....	·45	·6
Silica,	28·97	67·6

The organic composition of barley has been examined by several chemists. Horsford found it to consist of the following substances, in the proportions given:—

Water,.....	14·
Nitrogen compounds, as gluten, &c.,.....	14·
Starch,.....	68·
Fatty matters,.....	2·
Ash,.....	2·
	<u>100·</u>

Even the awns of the barley have been submitted to analysis, and were found to contain 15 per cent. of water and 12·10 per cent. of inorganic matter (ash), of which the composition is as follows:—

Potash,.....	7·70
Soda,.....	·36
Lime,.....	10·36
Magnesia,	1·26
Oxide of Iron,.....	1·46
Phosphoric acid,.....	1·99
Sulphuric acid,	2·99
Carbonic acid,.....	1·98
Chloride of Sodium,.....	1·10
Silica,.....	<u>70·77</u>
	99·97—(Way.)

The principal and most important consumption of barley is for malting purposes; and as the ultimate object—the conversion of its starchy constituents into spirit—is purely a chemical process, the various changes it under-

¹ The mean of several analyses.

² Boussingault, *Economie Rurale*.

goes during the operation have been well investigated, and have been rendered available in feeding experiments which have from time to time been carried on. The most complete of these investigations was conducted by Dr. Thomson, of Glasgow,¹ in order to determine the actual comparative values of raw and malted grain for feeding purposes, which clearly showed that the process of malting converted the insoluble starch into the soluble sugar, but at the expense of a portion of the starch, and also of the nitrogen compounds of the grain, which were entirely lost. These were separated either in the form of carbonic acid, or were dissolved out with a portion of the mineral matter also, in the steep liquor; so that when the process of malting was completed, the barley was found to have lost about 8 per cent. of its actual ingredients by the process of germination, and about 12 per cent. in addition by the evaporation of the water it naturally contained, which was dissipated by the action of the kiln in drying the malt.

Dr. Thomson thus makes up the 8 per cent. of loss, excluding the loss by kiln-drying:—

Carried off by the steep,	1·5
Dissipated on the floor,	3·
Roots, separated by cleaning,	3·
Waste,	·5
	<u>8·0</u>

When the process is completed, the composition of the malt compared with the barley is represented as follows:—

	Barley.	Malt.
Gluten,	3·	1·
Sugar,	4·	16·
Gum,	5·	14·
Starch,	88·	69·
	<u>100·</u>	<u>100·</u>

¹ Report to Government on Feeding Cattle with Malt, by Dr. T. and Dr. R. D. Thomson, of Glasgow, 1844.

Malt thus contains more gum (dextrine) and sugar than barley, and less starch and gluten—the germinative process having generated the formation of the peculiar body, “diastase,” already referred to, at the expense of a portion of the gluten, and this body having had the peculiar property or power of converting the starch, first into dextrine (gum), and then into sugar.

In the soil, the young plant, the produce of the seed, requires for the purposes of vegetation the conversion of the whole of the starch into sugar; but for our purposes, whether of brewing or of feeding, we only require the germinative process to be set up, and the diastase formed, and then we arrest it at the exact point we consider most desirable, by placing it on a kiln, and applying a heat sufficient to deprive it of its moisture, without which we know germination or malting cannot be carried on. In this state malted grain may be kept a long time without injury, the addition of water at any time being sufficient to set up the action afresh, and complete the conversion of the starch into saccharine matter. When used simply for feeding purposes the only object to be attained by previously sprouting the grain, is to assist the digestive powers of the animals, by presenting the food (barley) in a more readily assimilable state. In this case it is necessary only to place the barley in a suitable vessel, and just cover it with tepid water (60° to 70°), when in about twenty-four to thirty hours the required amount of change in the grain will have taken place, and it may be used as food without having sustained any material loss. In the process of malting barley the “plumula,” or *spear* (acrosire), as it is commonly termed, is carried up underneath the “husk,” and not outside the grain, as is seen in wheat (p. 21); the roots, however, are formed in the same manner, and in cleaning the malt for use after the kiln, are separated from it. These generally amount

to about 4 per cent. on the grain used, and are collected and sold for feeding purposes under the names of "kiln-dust," "malt-dust," "combings," and indeed are of a very nutritive character when free from dirt and rubbish. Mr. Lawes' investigations¹ show us that the dry combings, or malt-dust, contain about 88 per cent. of organic matter, yielding nearly 26 per cent. of nitrogen compounds, or about double the amount contained by the grain itself; and Professor Johnston's analyses have shown us that on the average they contain 7·25 per cent. of inorganic matter, consisting of the following ingredients:—

Potash and Soda,	36·78
Lime,	3·09
Magnesia,	5·46
Oxide of Iron,	1·09
Phosphoric acid,	24·87
Sulphuric acid,	4·84
Chlorine,	7·95
Silica (soluble),	1·80
Silica,	13·96
	<hr/>
	99·84

These results teach us the real value of malt-dust, whether for feeding or manurial purposes. They show us that it contains a larger per centage of nitrogen or flesh-forming compounds than the ordinary oil-cakes, whether from linseed or rape, while its mineral constituents are also greatly in excess. If used for feeding, it may be given with chaff as steamed food; and if used as manure, its action is much accelerated by previously moistening it in a heap, which speedily sets up a fermentative process, and renders it more soluble in the soil.

¹ A vast amount of very interesting and valuable information on these points may be obtained from Mr. Lawes' paper in the *Roy. Agri. Soc. Jour.*, from the article "Malt" in the *Cyclopedia of Agriculture*, and from Professor Johnston's *Agricultural Chemistry*, &c., p. 883.

THE OAT CROP.

THOUGH we thus assign to OATS the third place in our consideration of the "Farm Crops" of the country, still in many districts in the north it takes precedence of barley in the farmer's estimation; and if we cross the border line, and refer to the valuable statistics of Scotland, now unfortunately given up, we at once see the value of the oat crop, by the relative acreage occupied by it and by the other cereals. The last returns (for 1857) show us, that while the three other grain crops—wheat, barley, and rye—were cultivated to the extent of 449,135 acres, the area occupied by oats alone amounted to no less than 938,613 acres.

Like the other cereals, the early history of the oat is enveloped in mystery. It has been so long in cultivation, without any distinct records to guide us to its original country, that it still remains unknown. It has been suggested that the cultivated oat originally came from Persia or Mesopotamia, countries to which we are indebted for so many of our cultivated productions. Indeed, Colonel Chesney, in one of his explorations, met with a variety of oat growing wild on the banks of the Euphrates, which would go far to strengthen this belief. Dr. Lindley tells us that although this plant (which he describes¹) differs materially from our common oat, still it is not inconceivable that it may be either the original state of this kind of corn, or that it may be it in a state of degeneracy, arising from many centuries of neglect. No mention, however, is made of it in the Bible, where we find the other cereals spoken of. It would, therefore, appear doubtful whether it was known to the natives of the East

¹ See *Cyclopedia of Agriculture*, article "Avena," in which a full description and a drawing of the wild plant is given.

at that early period. This fact, combined with the known hardiness of its constitution, leads others to look upon it as a plant more likely of northern origin; for it is cultivable up to the most northern latitudes. Yet, in all the countries which have been visited, no trace of its wild prototype has been discovered. Our evidence is certainly very defective in regard to the early history of oats. None of the Roman agricultural writers mention it; and yet we find in Roman history, indications of its cultivation from the story of the Emperor Caligula feeding his favourite horse with gilt oats served in a golden manger. The wide range of soils that oats possess, and the comparatively low temperature under which they come to their maturity, have rendered them well adapted to the cultivation of high latitudes, and especially for insular climates. If we draw a line across this country we should find that north of York the oat thrives better than in the southern half, where the comparative dryness of the air and the higher temperature of the climate render it more suitable for the cultivation of wheat and barley. In Scotland we find oats cultivated to its northern extremity, lat. $58^{\circ} 40'$. In Sweden they are met with as a crop as far as lat. $63^{\circ} 30'$. In Norway their cultivation is pushed still farther northward to lat. 65° ; and in Russia their polar limit corresponds with that of rye—about $62^{\circ} 32'$ N. lat. If we turn southward, we find the climate becoming gradually less and less suited for them. This is well marked within the limits of our own country. South of the parallel of Paris $48^{\circ} 50'$ N. lat., we rarely see oats in cultivation. In Spain and Portugal they are hardly known at all; yet they are cultivated successfully in Bengal, in lat. 25° .¹ Here probably the moisture of the soil compensates

¹ At the New York Exhibition, 1853, a sheaf of oats was exhibited with other agricultural produce from California, 30° N. lat., which measured 10 feet, 3 inches in height, the heads averaging from 22 to 28 inches in length.

for the extreme temperature of the climate, as we find at home that the oat, when once fairly growing in a suitable soil, will stand a drought better than either of our other cereals. On some of the moist alluvial soils in the southern and western counties, crops of oats are grown which would compare favourably both in quantity and quality with those produced in the more genial climates of the north. Oats are cultivated as a food-grain for both man and cattle. In this country (in its northern portions chiefly) they enter into human consumption to a far greater extent than in any other. In some parts of Germany, especially in the south of Westphalia, the inhabitants of the "Sauerlands" live extensively on oaten bread. In other parts of the Continent, in countries where wheat is only cultivated to a limited extent, barley, or more commonly rye, is preferred to oats as a bread-corn for daily use. In most countries, however, of the centre and north of Europe, oats are cultivated as a horse-corn; and, indeed, in the hotter climates of the south and in the east, barley is even preferable for that purpose, as the stimulating effects of oats on the animal system are increased to an injurious extent by the action of the warmer climate.

Oats belong to the same natural order (Gramineæ) as our other cereals, and form the genus to which the name of *Avena* has been assigned by the botanists. This genus appears to be a very numerous one, comprising a large number of species—some forty or fifty—which, however, with the exception of a few, are represented only by grasses and weeds, of no object to our inquiry. These few exceptions are those which constitute the several species in cultivation, and may be taken as follows:—

1. *AVENA SATIVA*—The Common Oat.
2. *AVENA ORIENTALIS*—The Tartary Oat.
3. *AVENA BREVIS*—The Short Oat.
4. *AVENA NUDA*—The Naked Oat.
5. *AVENA STRIGOSA*—The Bristle-pointed Oat.

These comprehend all the different varieties of oats cultivated in this country. There is another species, however, which is largely met with as a weed, and a very troublesome one too, in our wheat fields especially—the *A. fatua*, or Wild Oat.

In form and appearance the oat is very different from the other cereals. The principal (botanical) characteristics by which they are distinguished are, “their lax panicles, their two lax membranous glumes, and the smaller number of their florets, each of which has one of its husks or *paleæ* armed with a twisted beard or awn.” The name oat is said to be derived from the Celtic “aten,” from “etan,” to eat.¹

There are numerous varieties cultivated in different countries to a greater or less extent. In this country we have about thirty, but of these not more than a dozen or so enter into general cultivation—the others are only met with in exceptional cases of soil and climate. These all belong to the two first species, and Mr. Lawson thus enumerates them in the order of their general cultivation:—the Potato, Hopetoun, Sandy, Early Angus, Late Angus, Gray Angus, Blainslie, Berlie, Dun, Friesland, Black Tartarian, and Barbachlaw. In the south, where the cultivation is more limited, the Potato, Poland, Hopetoun, Angus, Dun, and Black and White Tartarian, are those generally met with.

The following are the characteristics of the varieties enumerated of the *A. sativa*, or Common Oat:—

No. 1. The *Potato Oat* is probably the most largely cultivated of all the various kinds. Straw rather short, but clean and stout; grain white, short, and plump; sample heavy (44 to 46 lbs. per bushel), and highly esteemed for mealings or for feeding purposes. It takes its name from having originally been found growing in a field of potatoes

¹ Paxton's *Botanical Dictionary*.

in Cumberland, in 1788. This oat is seldom bearded or awned, except when cultivated too long without changing the seed—the presence of the awn often recurring from the effects of cultivation or climate.

Hopetoun.—Straw rather longer and stouter than the preceding, and not so liable to lodge; somewhat earlier at harvest; panicle larger and more spreading; grain of excellent quality, and not so liable to shell out when ripe; rather darker in colour, and easily distinguishable from it by a small reddish mark in the centre of the front of the grain; very extensively cultivated throughout the north; more suitable for the lighter quality of soils than the heavier clays; by many considered to be more delicate than the Potato Oat, and more liable to the attacks of fungi, &c.

Sandy.—A hardier variety than the Potato Oat, and better adapted for late or uncertain districts. The straw is heavy, firm in texture, and rarely seen lodged or broken down by bad weather. The produce is large, of good quality, and the sample is less affected by bad weather than most others. It was discovered in Aberdeenshire in 1825, and is very extensively cultivated in the adjoining counties.

Angus (Early, Late, and Gray).—Three varieties largely cultivated in the central and in the late and exposed districts of Scotland. Quality similar to the Potato, nearly as early, and less liable to shake out at harvest. The grain of the late variety is a trifle longer and darker in colour than the other, and from ten days to a fortnight later in ripening. In the Gray Angus the grain is still longer, and of a bluish-gray colour. Quality the same.

Blainslie.—This is the favourite variety of the south-east of Scotland, where it is largely cultivated. The grain is round, and well filled, and of good quality. It is an early variety, and well suited to late districts.

HOPETOUN OAT.

Berlie.—There are two varieties of this oat—the English and the Scotch—differing in their appearance and in the quality. The English delights in good rich soils. The Scotch is better adapted for light than for heavy soils. It is very prolific, and rarely sheds its seed. The grain is of excellent quality and meals well. The straw is long and very tender, and is probably preferred to all the other varieties for fodder. This oat is largely cultivated in the districts north of the Tay.

Dun (Common).—Grain long and well filled; skin thin and dark-coloured; panicles large and spreading; straw very long and not apt to lodge. It is somewhat late at harvest, but is well adapted for light elevated soils; and is largely grown in the high districts of the Lothians—on the Lammermuirs and Pentlands.

Dun (Winter).—This variety is better known in the south than in the north, as this is the “Winter Oat” now so commonly cultivated in the southern and midland counties of England, where it is frequently fed down by sheep in the early spring, and then allowed to stand for seed. It is sufficiently hardy to pass our winters without injury, and then produces a finer sample and a larger return than when sown as a spring crop. The straw is shorter and stouter than the common Dun Oat; the grain is also shorter and of the same darkish hue. Where it has been tried in Scotland the reports are equally favourable.

Friesland, or Dutch—Was formerly largely cultivated in Perthshire and the neighbouring counties. It, however, has gradually been replaced by superior varieties. It had the reputation of being early, hardy, and a good cropper, but unequal and uncertain at harvest, with straw particularly tough and pliable, well suited for making ropes for stacking.

Barbachlaw—is a variety in general estimation in the higher districts of the Lothians and the south for its

hardiness, earliness, and adaptation to elevated, poor, and ungenial soils. It is very productive both in straw and grain; the latter, however, is of a rough and bristly character, inferior in quality, and only adapted for feeding.

Poland.—This is a variety very generally cultivated in England. Mr. Lawson, however, doubts whether the so-called Poland Oat now met with be the original variety. In general appearance and character it much resembles an inferior sample of Potato Oats.

No. 2. Of the *A. orientalis*, Tartarian Oat, we have two well-known varieties—the White and the Black—both of which are largely cultivated in the south, while in the north the Black is the one generally preferred. This species differs greatly in appearance from the *A. sativa*, by having its panicle more contracted, and altogether *confined to one side*, and larger glumes. (See following page.)

Tartarian (White).—A very productive variety; straw very tall and stout; grain of a dull white colour; thin and long; forming a light sample. It is late at harvest, and only suited for good soils in early districts, when its yield in horse-corn is very large.

Tartarian (Black).—This is far more extensively cultivated in the south as well as the north than the White. It is an earlier variety, and grows best on the inferior class of soils and in high districts. The straw is shorter, and equally stout; the grain is shorter and plumper, of a dark-brown or blackish colour; meals well, and makes a capital sample for feeding purposes. The yield is, under favourable circumstances, very large.

This brief sketch of the principal varieties in cultivation is sufficient to show the very wide range of soils and climate in which the oat, in some of its varieties, can be successfully grown. These points, however, will be found far more fully discussed by Mr. Lawson in his *Synopsis of Vegetable Products*, and in his valuable paper on the

BLACK TARTARIAN OAT.

"Varieties of the Oat, and the districts suited to its culture," in the 29th vol. of the *Highland Society's Transactions*; and also in the *Cyclopedia of Agriculture*, article "Oats."

No. 3. The *A. brevis*, or Short Oat, is very rarely cultivated, save in small patches for experimental purposes. It is hardy, prolific, and might no doubt be grown with advantage high up on our hillsides, where, if it did not ripen its seeds, it would furnish a large supply of herbage, which is much relished by cattle either in a fresh or dry state. The grain is very plump and of a dark colour. On the Continent it is the favourite oat of the mountainous countries of France and Spain, on account of its earliness and suitability for poor elevated soils.

No. 4. The *A. nuda*, or Naked Oat, has been long known and cultivated on a small scale, and at intervals, in various parts of the country. Gerarde speaks of it (1597) as being in his time in cultivation in Norfolk and Suffolk. It is very prolific, and thrives on very inferior soils, particularly those of a peaty character. Its great drawback is the tendency to shell out at harvest time.

No. 5. The *A. strigosa*, or Bristle-pointed Oat. This, like the *A. fatua*, is frequently met with as a weed in our crops, and is then known by the general name of Wild Oat, though it is really a distinct species, differing in appearance from the *A. fatua*. The Bristle-pointed Oat is shorter in the straw; its panicle generally inclines to one side, while the other's is erect; the lower end of the grain, too, is quite smooth, while that of the *A. fatua* is hairy. On the Continent this species enters into regular cultivation, and furnishes a large supply of fodder, either cut in a green state, or allowed to ripen and given in the straw. In some parts of Scotland, (Argyleshire), it is grown and used in the same manner; and Mr. Lawson tells us that it is still, or was very lately, cul-

tivated in some parts of the north of Scotland, and in the Orkney and Shetland Islands, as a bread-corn.

The range of soils suitable¹ for the cultivation of the oat is, as has been shown, very large; for well-nigh every description of soil, and every climate in which farming can be carried on, we have some variety of oat offered to us for cultivation. The strong, cold clay soils, on the one hand, and the washed gravels and detrital soils of the secondary and older formations, on the other, form, perhaps, the soils which are least suited to its cultivation. On these, however, if the climate be favourable, so as to counteract somewhat the influence of the soil, we frequently meet with very remunerative crops. Oats require a moist atmosphere where the soil is of a dry and porous character, or a moist, deep soil where the climate is dry and warm. Where, however, both the soil and the climate are dry, as in the eastern counties of Norfolk and Suffolk and the chalk ranges of the southern coast; or where they are both moist, as along the west coast-line of the country, from Devonshire to the Clyde, we see them less advantageously cultivated. In the former case, the crops are scanty both in straw and in grain; in the latter, the straw is generally too herbaceous and luxuriant to carry a large yield of grain. In all cases, however, we find the soils of a rich loamy character—those of alluvial origin—and the humous (vegetable) soils met with in the few districts to which a dressing of clay has been given, to be the most productive; and on these, in a good season, very large returns are obtained.

In the south we have a large extent of surface occupied by soils of an ungenial character for oats; and this, combined with the general greater dryness of the atmosphere and increased temperature, renders the cultivation

¹ The papers before mentioned in the *High. Soc. Trans.* and in the *Cyclo. of Agri.* may be referred to with advantage in regard to the soils suitable for oats.

of oats as a crop unsatisfactory, and far less remunerative than barley, to which many of these soils are well adapted. The clays of the London basin—of the weald and gault formations in Surrey, Kent, and Sussex—and of the Oolite (Oxford, Bradford, and Kimmeridge) and Lias formations in Oxford, Somerset, Gloucester, and Northamptonshire, are examples of the unfavourable class of strong soils; while the chalk soils generally, and the detrital soils of the same formation throughout the entire range from the south coast of Sussex, Hampshire, and Dorsetshire, to the north-east coast of Yorkshire—the sandy soils of Norfolk and Suffolk—the soils of the green-sand and the Hastings sand formation in Surrey, Sussex, Kent, and Bedfordshire, and those of the new red sandstone, so largely distributed through the midland counties—may all be looked upon as representatives of the lighter class of soils, which are more or less unsuitable to the requirements and habits of the oat plant.

Where, however, these light and strong soils come in contact, their mixture always forms a fertile soil, well adapted for oats as for other crops. In such soils the climate is the governing condition; if this be favourable, then the suitability of the soil for oats is established; if unfavourable, its powers of fertility are counteracted, and oats cannot be so successfully grown. Although a certain amount of moisture in the soil and in the atmosphere is necessary for the requirements of the oat, still it will not thrive any better than the other cereals in a *wet* soil; and in regard to its habit of growth, it more resembles the wheat than the barley plant, as it sends down its roots deep into the subsoil in search of its necessary food. Consequently, the same conditions are desirable in the preparation of the land as have been detailed for wheat—that the soil be freed from any surplus (stagnant) water, and that it be tilled as deeply as possible.

Good evidence of the importance of these provisions may be seen in the effects following the cultivation of oats on what is termed the "moor-band" soils of peaty and moor districts, for which oats are otherwise generally well adapted. Here the soil is thin, and rests on an indurated, impervious stratum, which in dry weather cuts off the capillary action of moisture from below, and in wet weather acts as a pan for the retention of the rain that falls from above, all of which has to pass off again from the surface. The young oat generally starts away very satisfactorily, and has the appearance of vigorous growth up to about the period when the "shot blade" is formed; it then begins to droop, assumes a yellow colour, instead of the dark green of health, and all hopes of a crop gradually vanish.¹ At this period of growth the plant requires large supplies of food and moisture, and would, if able, send down its roots deep into the soil in search of them. These, however, are obstructed by the "pan" or "band," and are restricted in their range to the thin stratum of soil lying above, which is soon exhausted of its available contents, and its occupants, the oats, suffer accordingly.

The place oats should occupy in the rotation is necessarily determined by the character of the district, as to soil, climate, and cropping, in which they are grown. In the light barley soils (four-course) of the south, they should very rarely appear at all; where, however, the conditions are at all suitable, they may replace either the barley or the wheat in the rotation, according as circumstances (including, of course, the markets) may dictate. Mr. Caird, in his *English Agriculture*, tells us, that on the Sussex Downs oats are grown extensively, the soil being found better suited for them than for barley. He mentions, also,

¹ In Fife, on the south coast, near Auchtermuchty, there is a well-known strip of land of this character; and it is not an uncommon expression in Scotland, where oats are seen suffering in a similar manner, to say—"They are gone to Auchtermuchty."

that in Norfolk he found on farms in high cultivation a crop of oats was frequently taken after the wheat, thus converting the usual four-course into a five-course, and getting an extra straw crop in the rotation. If they take the place of the barley, care should be taken to plough the land to the full depth; and if they replace the wheat, the clover lea should be ploughed up early, so that it may be as much decomposed as possible before the oats are got in. In the five and six course systems, the usual practice is to take them after seeds, mown the first year, and then pastured the second, or merely the third (if with sheep), as the case may be. They may also with advantage follow a root or leguminous crop instead of wheat, if the land be thought hardly in condition to carry a good crop. On the fen-lands (Lincolnshire), where oats are grown very successfully, frequently averaging 80 to 100 bushels to the acre, they generally are sown after roots or rape, and are followed by wheat—wheat again forming the last crop in the rotation of seven years. In this case oats are taken before the wheat, in order to reduce the condition of the land, which would be too rank to produce a good crop of wheat.

Where oats follow a fallow crop, it is generally considered advisable to give the land a ploughing as early after the crop is off as possible, and to repeat it, if necessary, previous to sowing in the spring. This may not be necessary if the land be well laid up, and left to the weathering action of the winter, when there is always sufficient tilth in the soil to cover in the seed satisfactorily. After a root crop, it is not necessary to plough so deep for oats as after seeds, as the tillages for the preceding crop have sufficiently stirred up and opened the soil. When taken after roots, it is customary to sow them down with seeds; and whenever this is done, width between the rows is most important, as otherwise oats have a greater tendency to cover

them up, and obstruct the free access of air and light to them, than even barley has.

We have no very correct data to help us to decide upon the best period for sowing oats. Of course, much must always depend upon soil and climate, and, to a certain extent, upon the arrangements of the farm. These latter, however, are largely under our own control; and if we could satisfy ourselves as to the principle of early or late sowing, and get it accepted as a *rule*, there is no doubt that the oat produce of the country generally would be considerably increased, and our labour arrangements not rendered more difficult. By common consent, however, the oats are everywhere got in before the barley; therefore, if Arthur Young's experiment is worth anything, we may fairly assume that the earlier the oats are sown, the better chance of a good crop. The month of March is probably the best month for general sowing; in warm, early districts, if the land is ready, the latter part of the previous month may be taken advantage of; but nowhere ought the sowing to be delayed beyond the first week in April. Mr. Shaw, of Bogfairn, Aberdeenshire, in his *Report of Experiments*,¹ says, "In sowing the seed as early in the spring as possible, I have found it, for nineteen years past, profitable in eighteen, for one year of loss in consequence of a very hard frost injuring the seed." He also speaks of the effects of *changing seed*, as producing grain weighing 44 lbs. per bushel, whereas the produce of his own seed required much dressing to come up to 39 lbs. per bushel.

The selection of the seed is as important for oats as for wheat, and the same general rules should be observed, viz., *that the seed be fully matured—that it be of the best quality—free from any injury—and true to its variety*. It is less subject to disease than even barley, and conse-

¹ *High. Soc. Trans.*, 1851, p. 530.

quently it is never thought necessary to steep it. The *purity of the seed* is of importance in the oat crop, as it is a crop frequently cultivated under conditions unfavourable to vegetation generally; and unless a particular variety adapted to the climate of the district be sown, the produce may be seriously diminished. At the same time, out of so many varieties, there may be several of habits sufficiently resembling each other to render them suitable for cultivation in the same district; and, under such circumstances, a mixture of several such suitable varieties has been found to give a larger return than either of the varieties when sown singly would do.

The details of some experiments, bearing upon this point, by Mr. Finnie, Swanston, are thus given:—"The practice of mixing two or more varieties for seed has become of late years very common in Scotland. The object for so doing is to obtain a heavier and more prolific crop, by taking advantage of the particular habit of growth of different varieties, so that the excellencies of the one may compensate for the deficiencies of the other. Thus, it is common to sow a mixture of Hopetoun and Sandy Oats, because the former is weak-strawed, stands thin on the ground, but very prolific—while the latter is strong-strawed, grows thickly, but is less productive; consequently, a mixture of this kind generally yields a better crop than when each variety is sown separately. Of course, it is necessary in such cases to select such varieties of oats for mixing as possess about the same degree of earliness, in order that the whole may come to maturity at the same time." From one of the series of trials made by Mr. Finnie to ascertain what varieties or mixtures of oats were best adapted to the best and lowest-lying part of his farm, the following results were obtained from equal portions of land:—

From the Potato Oat	alone,		74 bushels.
„	Hopetoun	„	 65 „
„	Early Angus	„	 77 „
„	Kildrummy	„	 77 „
„	Dun	„	 76 „
„	Blainslie	„	 70 „
„	Gray Angus	„	 63 „
„	Sandy, changed seed,		61 „
„	„ home grown,		56 „

Whereas the following mixture of—

Hopetoun (5 parts) and Kildrummy (1 part),	gave	85 bushels.
Hopetoun and Sandy,	 „	80 „
Hopetoun and Early Angus,	 „	76 „
Potato and Early Angus,	 „	66 „
Potato and Sandy,	 „	66 „

“From this table several instructive conclusions may be drawn:—First, it appears that Potato Oats, sown alone, produced 8 bushels *more* than when sown with either Early Angus or Sandy; secondly, that Hopetoun Oats produced 20 bushels less, when sown alone than when mixed with Kildrummy, 15 bushels more when sown with Sandy, and 11 bushels more when mixed with Early Angus. If there was no difference of soil or treatment in the above comparison, it appears that the average increase of produce, from simply sowing a mixture of oats, amounts, in the cases selected, to 13 bushels, from a space of ground which took 6 bushels to sow it. What that space of ground was Mr. Finnie does not mention; but, taking it at what the quantity of seed would indicate—namely, $1\frac{1}{2}$ acre—we have fully 1 quarter of oats per acre more from the mixed than the unmixed seed—equal to 20s. per acre, or thereabouts, for grain; and of the straw, the increased quantity will not be less than 38 imperial stones, which, at 3*l.* per stone, is 9s. 6*d.*; or, altogether, 29s. 6*d.* per acre for grain and straw. Granting that such results are not invariably obtained

from mixing seed oats, they still furnish a very persuasive argument for every farmer to make the experiment for his own particular case and personal satisfaction." These results are valuable information, as they coincide with those given in reference to mixtures of wheats (p. 20) producing greater returns than when sown separate—the reasons there suggested by the experimenter and by M. Louis Vilmorin being equally applicable to the present case.

The importance of the oat crop in Scotland has secured to it a greater amount of attention and experiment than has been bestowed on the other grain crops; and consequently we have, as the result, a great mass of evidence in regard to the different varieties cultivated, and their relative suitability to different districts. Much of this is of a *special* character, and only valuable where similar conditions exist. From the experiments, however, we may glean some points which have a *general* bearing, and tend to illustrate the principles we should endeavour to lay down. Mr. Mitchell, Wester Alves, Elgin,¹ after giving the details of his experiments in reference to the comparative earliness, gross produce, and profit of different varieties of oats, sown in 1847, under exactly the same conditions, sums up his report with some practical deductions, of which the following three admit of more than a local application:—

1. That land pastured for two years gives a quarter of oats per acre more than land that has been cut for hay when in first year's grass, and pastured the second.

2. That there is a decided loss of nearly four bushels per acre in taking seed oats, however good the sample, from a later to an earlier soil.

3. That there is an advantage in taking seed oats from

¹ "Reports on the Comparative Earliness, Productiveness, and Profit in Grain and Straw of different varieties of Oats," *High. Soc. Trans.*, 1849, p. 129.

a more southern and well-cultivated district, as shown in the comparison of two samples of Late Angus—the one the produce of home-grown seed, the other of seed from Mid-Lothian.

In the same volume of the *Highland Society's Transactions* is another report on the same subject, by Mr. Melvin, Bonnington, Mid-Lothian. His experiments, carried on in a very different district from that of Mr. Mitchell, refer to rather finer varieties of grain; and entering more fully into the economics of the oat crop, he brings out results of considerable importance to the miller or consumer, as well as to the farmer or producer. Mr. Hay's experiments,¹ carried on in Roxburghshire in 1848 and 1850, tend to show that, under favourable circumstances, the finer varieties of oats are the most remunerative, and that the most productive returns would be obtained by selecting the varieties for cultivation which from their habits of growth are best adapted to the district in which they are to be placed. More recently, Mr. Sutherland, Dalmore, Ross-shire,² in conducting a like series of experiments, as to the comparative yield of different varieties in his district, placed the Dyock Oat at the head of the list, as yielding by far the largest returns per acre—the Dyock producing 92 bushels, while the Potato Oat produced only 66 bushels to the acre; whereas, in each of the trials before alluded to, carried on in very different districts, the Potato Oat was equal to the best that was tried. This variety—the Dyock—seems well calculated for sowing on poor soils, and at high elevations: under such conditions its returns compare very favourably with finer varieties. In some experiments at Kendal, Westmoreland,³ on a poor soil, some 500 feet above the level of the sea, the Potato Oats were ready for harvest on the

¹ *High. Soc. Trans.* for 1851, p. 177.

² *High. Soc. Trans.*, 1851, p. 524.

³ *Roy. Agri. Soc. Jour.*, vol. iii. p. 397.

20th September, and gave a return equal to $6\frac{1}{2}$ times the seed sown, the grain weighing $36\frac{1}{2}$ lbs. per bushel; whereas the Dyock Oats were ready for cutting on the 31st August, and gave a return equal to $8\frac{3}{4}$ times the quantity of seed, the grain weighing more than 40 lbs. per bushel.

The quantity of seed used per acre varies considerably, both with the district and the variety used for seed. In an early and genial district a smaller proportion would be used than in a late and unfavourable soil and climate; at the same time, it should be remembered that the varieties suited for such districts are smaller in the grain than the finer varieties, and consequently more seeds are contained in the quantity or measure made use of. From 2 to 6 bushels may be taken as the limits in England, and 3 to 6 bushels per acre as the quantity used in Scotland. Opinion generally is rather in favour of thick sowing with oats, as the plant does not tiller out to the same extent of either wheat or barley. Some experiments, however, carried out in Forfarshire, in 1854, by Mr. Bowie,¹ show, that by limiting the amount of seed you not only save it, but you also increase your crop. These experiments, too, are the more valuable, as they were carried out on a soil "rather in poor than in good condition;" whereas most of those even who are friendly to thin seeding generally consider it only applicable to rich land. Four lots were sown under similar conditions as to soil, time, &c., but in different proportions as to quantity of seed, and the results were as under:—

No.	Seed per acre.	Yield per acre.	Weight per bushel.	Straw per acre.
	bushels.	bushels.	lbs.	cwts.
No. 1,	6	$53\frac{1}{2}$	$42\frac{3}{4}$	$35\frac{1}{4}$
„ 2,	5	$58\frac{3}{4}$	43	$38\frac{1}{4}$
„ 3,	4	$66\frac{1}{4}$	$43\frac{1}{4}$	$45\frac{1}{4}$
„ 4,	3	$66\frac{3}{4}$	$42\frac{3}{4}$	$47\frac{1}{2}$

¹ *High. Soc. Trans.*, 1855, p. 121.

Thus we see a difference in yield between Nos. 1 and 4 of $12\frac{1}{4}$ cwts. of straw, and $13\frac{1}{4}$ bushels of grain, which, added to the 3 bushels of seed saved, makes together $16\frac{1}{4}$ bushels per acre in favour of thin sowing. Still, there are many advocates of thick seeding to be met with both in the north and in the south. In the West of England large quantities of seed are still used in some places, though not now perhaps to the extent mentioned in one of the reports to the Board of Agriculture (Survey of Cornwall), when an old farmer, on being asked how much he would recommend for seed, advised "that oats should be always sown out of a cart with a shovel."

The methods of sowing are the same as has already been described in speaking of wheat—by hand broadcast, and by the drill; and the relative advantages and disadvantages of the two methods have also been discussed. The third method, that by the dibble, is never applied to oats, and therefore need not enter into the calculations of relative cost. The general character of oat soils, moist in themselves, and in a moist climate, is very conducive to the growth of weeds, and therefore would claim even greater consideration for a mode of sowing which enables the grower to get rid of these, by hoeing at any time he may think necessary, than when the soil, such as that for barley, is of a different character. Old seeds, that have been down for three years, frequently offer some obstruction to the coulters of the drill, unless they have been early and carefully ploughed up, and have become well disintegrated. Beyond the chance of this there is nothing to be said against the practice of drilling, which in all cases should keep the rows at good distances—say 9 inches apart. The plants grow all the more strongly, and give a better return both in quality and quantity; and at the same time, the horse hoe may be sent in after the oats are well started, and thus keep them clear of their ever-vigorous com-

panions, the weeds. The drill, as before mentioned, is far more extensively used in the south than in the north; its use, however, there is rapidly increasing, and wherever it has been introduced, its advantage to the oat crop has been fully sustained.

After the seed has been satisfactorily got in, very little is required to be done, save, perhaps, if the weather permits the use of the horse-hoe, to check the growth of the weeds, by hoeing as late as possible; or even this may be effected by giving the land a double turn with the seed-harrows, should it be too moist to admit of the hoe. The same processes of germination, brairding, and speaning, or weaning, take place as have been already described in regard to wheat and barley; and the same phases in the life of the plant—flowering and maturity—occur at about the same periods.

In regard to the time of harvesting oats there is less difference of opinion than with the other grain crops, the opinion being pretty general, that they should be cut as soon as the slightest change shows itself in the colour of the straw immediately underneath the panicle, no matter how green the stem may be, and not be allowed to stand on the ground until they are dead ripe, as in that condition they cannot be cut or moved without separating a large portion of the grain. When cut early they require a little longer in the stook, where the last process of maturation (ripening) is as perfectly carried on as if they were standing uncut in the soil where they had grown. The grain is quite matured, but the chaff having been cut before it was fully ripe and dry, adheres to it, and retains it in the ear more firmly, and thus lessens the chances of “shelling out” as it is being carted and stacked.

The different modes of cutting grain have already been described. The sickle still holds its ground in most places;

the scythe,¹ however, is more used in cutting oats than wheat; and probably the "reaping machine," when it gets fairly received among the necessary machines of our farms, will do even better service in the oat crop than in any of our other cereals. Oats are generally a heavy crop to cut, and are grown chiefly in districts where the harvest is late, the days short, and the weather variable—all points in which the advantages of a well-arranged machine are shown most favourably, when compared with manual labour.

The field work at harvest is much the same as has been described—the only difference, perhaps, is, that in the oat districts, generally speaking, the air is moist and the weather variable at harvest, and the corn has to remain some time in the stook before it is fit to stack. In order to protect it from the action of the weather, it is customary in late districts to "cap" or "hood" the stooks by placing a couple of sheaves, butt to butt, on the top of each stook. This practice also exists in some parts of the west of England (Devon and Cornwall), in regard to the wheat grown on the high districts; but it is but rarely, either there or in Scotland, met with on the lowlands.

The mode of stacking, and the form and size of the stack, are the same as with the other straw crops. With oats, however, it is more important that some means of ventilation, either by "bosses" or otherwise (see p. 59), should be secured, as their condition is rarely so dry as that of wheat or barley; while the straw, being softer and more tender, sinks down into a compact body, and more effectually stops the escape of any moisture they may contain. In Scotland generally, and especially in the oat districts, the stacks are much smaller than the dimensions already given; and in general, the oats are put up in smaller quantities than the other grain. The stacks, too, are invariably

¹ In mowing oats it is always best to cut *up to* the standing corn than *out from* it, as there is less risk of shaking out the grain.

built on the ground, the only preparation being a thin "bed" or "bottom" of straw or faggots, "staddles" or "stack frames" being very rarely met with in the north, where, from the nature of the climate, they would be even more advantageous than in the south. In the field, a rough estimate of the produce may be arrived at, from the number of sheaves per acre :—

			Sheaves.	or	Stooks.
A small crop	(say 32 bushels)	would require	240		24
A good average crop	„ 48	„ „	320	„	32
A large crop	„ 64	„ „	480	„	48

In the stack, an estimate may be made of its grain contents by calculating that, if the yield be indifferent, each 18 cubic feet will give one bushel of grain; if it be an average, then $13\frac{1}{2}$ cubic feet will yield a bushel; but if it be large, only $8\frac{1}{2}$ to 9 cubic feet are required for the same amount.

Oats are less liable than either of our other cereals to injury from disease. The only one that they are subject to is the "Smut" (*Uredo segetum*), and this rarely attacks them to any injurious extent. The leaves are sometimes seen affected both by mildew and rust, as in other grain crops; and in northern latitudes Mr. Berkeley tells us that, in some seasons, "the plant is liable to be checked just as the spike is forming, and a red 'fusarium' sometimes occurs in the stems, probably doing but little injury."

In regard to the attacks of insects, however, oats have not the same immunity. They suffer, perhaps, more than either of the other crops from the "wireworm," owing, no doubt, to the general practice of taking oats as the first crop after old grass-land has been broken up. The best preventive is, according to Curtis,¹ to pare and burn the

¹ See *Farm Insects*, p. 207.

surface before ploughing; or shallow breast-ploughing about two inches deep, by destroying the roots of the grasses, will starve the wireworms. The slug-like larvæ of a beetle (*Crioceris melanopa* and *C. merdigera*) appear to attack the leaves of the oats just about the time they are coming into ear. The insect itself is of a dark colour—green and black—with a shining coat, and antennæ twice as long as the thorax. The caterpillars of the wainscot-moth (*Leucania obsoleta*), also have been observed to attack the leaves, but without doing them otherwise much injury.

Notwithstanding the inferiority of the oat in economic importance to the two cereals already discussed, its Chemistry has been the object of attention of several eminent chemists, whose labours have made us perfectly acquainted with its composition in well-nigh every stage of its growth. On the Continent, Boussingault, Krockner, and Hermbstädt have investigated its composition; while, at home, the elaborate investigations of Norton, Horsford, Way, and Voelcker, have placed us in possession of a full knowledge of its various constituents.

The relative proportion of grain to straw has been estimated by Schwerz—at 37 of the former to 63 of the latter. This estimate, made on the Continent, coincides pretty well with the results obtained by Mr. Norton in Scotland,¹ who gives, as the average of ten samples, the relative proportions as follows:—grain, 6; straw, 9; chaff, 1. These different parts of the plant (Hopetoun Oat) were separately examined by him, and found to contain very different proportions of organic as well as inorganic matter. In the grain he found 2·14 per cent., in the straw 5·8 per cent., and in the chaff 16·53 per cent. of mineral matter (ash), existing in the following proportions:—

¹ *High. Soc. Trans.*, 1846, p. 321.

	Grain.	Husk.	Chaff.	Leaf.	Straw.
Sulphuric acid,.....	...	9·61	5·32	14·8	16·02
Phosphoric acid,.....	49·19	1·04	...	...	...
Chloride of Sodium,....	·35	·24	5·11	2·29	7·14
Phosphate of Lime, }	...	...	5·84	6·13	2·22
Magnesia and Iron, }					
Potash and Soda,.....	31·56	10·26	7·96	14·89	28·02
Lime,.....	5·32	1·95	4·53	6·99	6·77
Magnesia,.....	8·69	·38	1·84	2·55	2·61
Peroxide of Iron,.....	·88	1·58	·24	...	·77
„ Manganese,	...	·92	...	...	...
Silica, soluble,.....	·89	4·46	11·99	5·90	5·80
„ insoluble,	·98	68·39	56·05	45·75	29·57
	97·86	98·83	98·90	99·30	98·92

These results show us that the different parts of the plant require not only different proportions of mineral matter to carry on their growth, but also different qualities, which materially affect their relative feeding values. Thus, in the grain we find phosphoric acid and potash the principal constituents; in the husk and chaff these exist in but small proportions, while the silica appears in excess; again in the straw we find the proportion of silica reduced, and the alkalies (potash and soda) and sulphuric acid occupying its place. The absence of sulphuric acid in the grain, and its presence in such large proportions in the other parts of the plant, is also worthy of notice, as exemplifying the varied food requirements of the plant at different stages of its growth. Messrs. Way and Ogston¹ estimate the quantity of mineral matter removed from the soil by a fair crop of oats (48 bushels) to be as follows:—

48 bushels of oats, at 42 lbs. per bushel, contain $60\frac{1}{2}$ lbs. of ash. } = lbs.
The straw and chaff will weigh 3024 lbs. and contain $138\frac{1}{2}$ lbs. of ash. } = 199

This quantity of ash (mineral matter) contains the different constituents in the proportions given:—

¹ *Roy. Agri. Soc. Jour.*, vol. vii. p. 645.

	Grain.	Straw and Chaff.	Whole Crop.
	lbs. per acre.	lbs. per acre.	lbs. per acre.
Silica,	27·2	69·6	96·8
Phosphoric acid,	15·2	7·1	22·3
Sulphuric acid,	1·1	4·7	5·8
Lime,	2·2	9·8	12·
Magnesia,	3·8	5·3	9·1
Peroxide of Iron,	·6	2·1	2·7
Potash,	9·2	27·3	36·5
Soda,	·9	2·7	3·6
Chloride of Potassium,	...	3·8	3·8
„ Sodium,	·3	6·0	6·3
	60·5	138·5	199·0

The *organic* constituents of the oat have been subjected to examination as closely as the inorganic; and we thus can understand how it is that the oat has obtained such a high character as a bread-corn in Scotland and other northern climates. Although it contains a larger proportion of inert matter—the husk—than is contained in either wheat or barley, still the actual quantity of food—nitrogen compounds—will compare favourably with either of them. The proportions of husk and meal, and the organic constituents generally, vary with the variety of the oat, and with the climate and soil in which it is grown. Thus—

Boussingault obtained in 100 parts	{ 78·	of meal.
	{ 22·	of husk.
Hermstädt „ „	{ 57·8	of meal.
	{ 34·2	of husk.
	{ 9·	of water.
Vogel „ „	{ 66·	of meal.
	{ 34·	of husk.
Norton „ „	{ 76·38	of meal.
	{ 23·62	of husk.
Voelcker „ „	{ 28·5	of meal
	{ 71·5	of husk
	{ 33·7	of meal
	{ 66·3	of husk
		} in white
		} Scotch oats.
		} in black
		} English oats.

Dr. Voelcker also found¹ that the Scotch oat was richer

¹ *High Soc. Jour.*, 1853, p. 552.

in nitrogen compounds than the English oat—the former containing 14·743 per cent., while the latter contained only 13·94 per cent. This superiority of the Scotch oat to the English oat in the quantity of meal it contains, and in the quality of that meal, will tend to explain the cause why oats are so much more valued in the north than in the south as a food material. At the same time, we must only take these results for what they are really worth—the comparison being between the coarse black oat of the south and the fine white oat of the north; and in both countries we know the white to be more nutritious than the black.

The proximate compounds (organic) have been determined by Boussingault, Norton, Horsford, and others. Boussingault gives an average composition:—

Starch,.....	46·1
Nitrogen compounds (gluten, albumen, &c.),.....	13·7
Oil,	6·7
Sugar,	6·
Gum,	3·8
Husk, ash, &c.,.....	23·7
	<hr/> 100·0

Norton, whose examination comprised every portion of the plant, found, on the average, the composition was very much the same as the preceding, viz.:—

Nitrogen compounds (flesh-forming substances),.....	13·6
Hydrocarbons, as oil, starch, &c.,.....	55·5
Vegetable Fibre,.....	14·8
Inorganic matter,	3·3
Water,.....	12·8
	<hr/> 100·0

Horsford's analyses show the average proportion of nitrogen compounds to be 13 per cent., and the other constituents to exist in about the proportions already given. These all tend to prove the high nutritive value possessed by the oat. Its nitrogen, or flesh-forming compounds,

equal those of wheat or barley; while the proportion of oil or fatty substances it contains place it on a level as a fattening grain with Indian corn; indeed, none of our ordinary food-grains contain the combination of flesh and fat-forming compounds in equal proportion to the oat.

The *straw* and the *husk* have also been examined, and their feeding value determined in the same manner as the grain of the oat. The straw was found by Boussingault to contain of—

Nitrogen compounds,.....	1·8
Other organic compounds,.....	65·9
Ash (inorganic),.....	3·6
Water,.....	28·7
	<hr/> 100·0

This hardly gives a sufficiently high value to the straw, as it evidently refers to straw in a partially dried condition. When quite dried (air), and fit for carrying and use as fodder, it only contains about 12 to 15 per cent. of water, and consequently would show a larger proportion of valuable matter.

The *husk* has been examined by Norton, and found to possess a certain feeding value, though far below that of the husk or bran of wheat.

Two varieties of oats were examined, both grown in Northumberland, with the following results:—

	Hopetoun.	Potato.
Proportion of oil in 100 parts,	1·50	·92
„ sugar and gum in 100 parts,.....	·47	·75
„ N. compounds „	1·88	...
„ ash (inorganic) „	6·47	6·99

Some experiments by Dr. Voelcker,¹ in reference to “the relative nutritive value of oats cut green and cut fully ripe,” may be turned to practical account by those who grow oats only for consumption on the farm. Oat

¹ *High. Soc. Jour.*, 1850, p. 250.

straw by itself is generally preferred by cattle to any other straw, and horses especially are very fond of oat-hay—that is to say, oats cut when quite green, and made into hay in the ordinary manner. This method of disposing of the oat crop is convenient, as it takes place somewhat earlier than, and lessens the amount of labour required at, the regular harvest, and is effected at a less cost than that of reaping, binding, &c.; while, at the same time, Dr. Voelcker's analyses show, that by cutting the oats at this early period, they possess a *larger amount of nutritive matter* than when left later, to become fully ripe.

He took two samples of Potato Oats, grown at Newport, Fife, under exactly the same conditions as to seed, soil, climate, &c., which were cut on the same day, the one being fully matured, and the other being quite green, having (purposely) been sown a month later. On examination, both the straw and the grain of the oats cut *green* were found to be superior in feeding value (flesh-forming constituents) to those of the fully ripe sample, in the proportions given in the following table:—

	Ripe Oats.		Green Oats.	
	1st expt.	2d expt.	1st expt.	2d expt.
Nitrogen compounds or flesh-forming substances in the grain, dried at 212°,.....	14·92	15·87	17·93	17·81
Do. do. in the straw dried at 212°,.....	8·31	8·62	10·87	11·23

The proportion of nitrogen compounds in both samples of straw is rather larger than usual. In the sample cut *green* about 2½ per cent. more of these valuable constituents occur than in the straw of the ripe oats. Dr. Voelcker, however, shows that this difference, important though it be, is not sufficient to account for the superiority of the one as a feeding substance to the other. He found that the oats cut *green* contained more watery juices, and less

indigestible woody fibre, than the oats allowed to be fully matured. It is well known that animals fed upon the young shoots of herbage will thrive very well, whereas the same food, at a more advanced period of maturity, is unable to sustain their condition. The reason now appears clear. In young shoots, starch, sugar, gum, and other readily digestible substances, are found in great proportions; in this stage of growth they are soft, and readily assimilated. But as the young plant approaches maturity, more or less of these soluble matters are gradually changed into indigestible fibre, the plant consequently becomes by degrees hard and woody, and less digestible and nutritious. Thus, *green* oats are always more readily digested in the animal organism than when allowed to be fully matured, and owe their superior feeding value to this circumstance, as well as to the absolutely larger proportion of nitrogen (flesh-forming) compounds, which were found both in the grain and in the straw of the plant. In order, therefore, to obtain the *maximum amount of food from the oat*, it should be cut when the seed is fully formed, but before the slightest change takes place in the colour of the straw, made into hay in the usual manner, and then given to the horses or cattle in a cut state, in the form of chaff.

The analyses given will furnish sufficient data for estimating the quantity of oat hay to be given as an equivalent for any other feeding substance, whose composition is equally known.

THE RYE CROP.

RYE certainly occupies the last place on the list of our cereal crops, both as regards the importance of the uses to which it is applied, and also the surface area occupied by its cultivation. In former times it occupied a very different position in this country;¹ it was held in high estimation as a bread-corn, either by itself or mixed with wheat or barley; and it was also looked upon as the most advantageous crop for the great extent of light and sandy soils which existed in the country, and which of course, being more easily worked than the heavier and clay soils, were then used for tillage purposes, while the others were left untouched in their natural pasture. This condition of things happily exists no longer at home. Improved mechanical appliances give us easy mastery over the most intractable clays—the light soils under the four-course system are enriched by manures and root crops, and consolidated by pasturage by sheep and cattle—and under a generally improved system of farming, wheat and barley now cover the acres which before were considered only capable of producing scanty crops of rye. On the Continent, however, rye still holds a very important position; in some

¹ Even so lately as 1760, Adam Smith tells us that it formed the general food of one-seventh of the entire population. The arable land was at that period thus occupied:—

Wheat,.....	3,700,000 acres.
Rye,.....	880,000 „
Barley,.....	730,000 „
Oats,.....	623,000 „

countries it is looked upon as the first—in most, however, as the second in agricultural value. Not only is it commonly used as a bread-corn as we use wheat, but also largely for brewing and distilling purposes as we use our barley. It is, indeed, the characteristic food-grain of Middle and Northern Europe, and forms the principal sustenance (vegetable) of fully one-third of the population of Europe. In the hilly districts of Central France—in Holland and the north of Belgium even—in Germany, Russia, and Scandinavia, where the land is poor and dry, and the cultivation in a low and impoverished condition, rye is largely grown and generally consumed as food. It has the reputation in these countries of being able to grow on their poor soils without any manure—to resist the effects of continued drought—not to be injured by the growth of weeds, but in fact to hold its own in spite of them, and to ripen early, and be ready for harvest before either the earth becomes too dry under the influence of the summer heat, or the temperature decreases with the advancing period of the year.

Thus, says De Gasparin,¹ it can occupy advantageously districts where wheat, more tardy in its habit of growth, could not accomplish its last process of vegetation, and where the physical characters of the soil would be unsuited for any other cereal crop. Von Thaer says, that rye may be considered as the most precious gift of God to the inhabitants of poor sandy soils. In these countries it is largely used for distilling as well as for feeding purposes, and this double use acts providentially in those seasons of scarcity that tell so severely on a country which relies too confidently on a single crop for its principal food supplies. The consumption of rye in the distilleries is very great, and a large store is always kept, greatly in excess of what is immediately needed. As long as grain is plentiful and cheap, the distilleries work and convert it into spirit, but

¹ *Cours d'Agriculture*, tome iii. p. 676.

directly it becomes scarce and dear, they cease their operations, and the stock they would otherwise purchase, and also that which they already possess, are at once set free on the markets for the bread supply of the people. When used in the distilleries, only a portion of the grain is consumed, the remainder forms an excellent food for their cattle, and thus contributes to the fertility of the soil. In the south of Europe rye is rarely met with; there the climate is suitable for grain of a superior value as food, while the grape furnishes the spirituous drinks of the country.

The cultivation of Rye is confined to the temperate zone, and succeeds far better towards its northern limits than in the lower latitudes. It is met with as a crop as far north as the range of cultivation extends. In Scandinavia, on the west side, it thrives up to 67° lat., and on the east side, to 63° or 64° lat. In Russia, the polar limit is indicated by the parallel of the city of Jarensk in the government of Vologda, lat. $62^{\circ} 30'$. Indeed, the Russian traveller and naturalist, Von Middendorf, reports having met with large and abundant crops, finer than any he had ever seen in his native country (Livonia), growing beyond the Yatusk, on the surface of a frozen subsoil.

The early history of Rye, like that of the other bread-corns, is of a very uncertain character. It has been supposed to be a native of Egypt, because we find it mentioned in Scripture¹ as having been cultivated in Egypt, 1491 B.C.; and again, as having been known in Judea;² while in a third place,³ the same word (*kussemuth*), which hitherto has been termed rye, receives a different translation, being there termed "fitches," so that it is very doubtful how far the grain which we call rye was known at all at that early period. Dr. Royle says, "though it is very unlikely that 'kussemuth' can mean rye, it is not easy to say what cultivated grain it denotes." It occurs in the same

¹ Exod. ix. 32.

² Isa. xxviii. 25.

³ Ezek. iv. 9.

passage with all the principal kinds of grain ("take wheat, and barley, and beans, and lentils, and '*fitches*,' and put them in a vessel, and make bread thereof"). Although the conclusions of Dr. Royle point rather to the species of *Triticum Spelta* as the "kussemuth" of the Scriptures, he admits it to be open to farther investigation. Loudon gives its native place as Crete; however, this is very doubtful, as Aristotle makes no mention of it, which he would have done, had it been known in Crete. Indeed, it is not mentioned by any of the Greek or Roman agricultural authors, with the exception of Pliny, who makes mention of a plant called "*Secale*," which the Taurini—inhabitants of a district of Cis-Alpine Gaul, at the foot of the Alps (Piedmont)—cultivated and used both as food for themselves and their cattle. He does not speak very favourably of it, save that it yielded large crops. He tells us, however, that the inhabitants of the district called it "*Asia*," from which it would appear probable that it came originally from Asiatic Tartary, being brought by the hordes of roving barbarians, who passed through the northern to ravage the richer southern parts of Europe. This opinion is confirmed by Karl Koch, who found it growing undoubtedly wild on the mountains of the Crimea, especially round the village of Dhsimil, on a granitic formation, at an elevation of 5000 to 6000 feet above the sea level. In such places its ears were not more than 1½ to 2 inches long.

Rye belongs to the order Gramineæ (Grasses), and consists of a single species, the *Secale*¹ *cereale*, of which some half-dozen varieties (?) are known in cultivation.

The botanical characters of rye readily enable it to be distinguished from wheat or barley; though, to an inex-

¹ According to Ainsworth, the name *secale* is derived from the Celtic name *segal*; by others its derivation is thought to be from the Latin *seco*, to cut, in contradistinction to the *leguminous* plants, or those *gathered* by hand.

perienced eye, it might readily be mistaken, as it is two-sided, and bears naked seeds on a flat ear, with awns like barley (see diagram, No. 1). The straw, however, differs from that of either of the other cereals. The interior, instead of being perfectly hollow and tubular, is lined with a pith-like substance, which gives it a greater degree of solidity and strength, and renders it particularly applicable for litter and certain economic purposes, though it diminishes its value as a fodder substance for cattle. The chief generic distinction between rye and wheat consists in the two glumes or outer chaff of the spikelets of the former being bristly or awl-shaped, while those of the latter are large and valved, or hollowed, so as to contain a considerable portion of the lower florets of the spikelets.

The following are the principal varieties cultivated:—

Common, or Winter Rye is that which is generally grown both here and on the Continent, and produces the bulk of the rye grain which is used as a bread-corn, or for other feeding or economic purposes.

Spring Rye is less cultivated than the foregoing, and is probably the same, only slightly changed in its appearance and habits by being continuously sown in the spring. It is less productive than the winter rye. The straw is shorter, and the grain smaller. It has been remarked that if this variety be sown in the autumn its produce is greatly increased; but if the winter variety be sown in the spring it very rarely succeeds.

St. John's Day, or Midsummer Rye (*S. cereale multicaule*), so called from the period at which it is usually sown. On the Continent, where this variety is largely cultivated, it is sown towards the end of June, and eaten down by sheep in the autumn, and again in the early spring months; after which it is allowed to stand for a crop. It is a very vigorous variety, with a long erect straw, and the ear longer but with smaller grains than

No. 2.

No. 1.

No. 3.

No. 1. SECALE CEREALE—Common Rye.

No. 2. SECALE CEREALE—Diseased (Ergot).

No. 3. SECALE CEREALE—var. Giant Rye.

Natural size.

the winter rye. According to M. Seringue¹ this variety is no other than the common rye, sown continuously at a different period from the usual time of sowing it. When sown in the month of June, it spreads out and produces a large amount of leafy herbage. If the sowing, however, is delayed until the usual period (October), it entirely loses this character, and shows no difference from the common rye.

Russian resembles the St. John's Day variety in the luxuriance of its growth; its straw, however, is longer and stouter, growing under favourable conditions to the height of 8 feet; and the grains are larger and better filled. At the same time it has not the property of tillering to the same extent: in this it more resembles the common rye. This probably is the rye which Von Midendorf spoke of as having seen growing so luxuriantly within the Arctic circle beyond the Yatusk.

Giant, or Tyrolese, appears very much to resemble the Russian in its luxuriance and vigorous habit of growth. It is ten or twelve days earlier than the common rye, and on good soils is generally to be preferred to it. On poor soils the common is usually the more productive.²

This brief description must suffice here; the different varieties of rye, and their agricultural values and habits of growth, will be found more fully described in a paper in the *Royal Agricultural Society's Journal*, vol. vii. p. 334, by Mr. Taunton; and in vol. vi. p. 177 and 179, some valuable practical information is also given in reference to the St. John's Day variety.

Rye is essentially the bread-grain of the light and poor descriptions of soil, while wheat is that of the heavy and

¹ *Annales de la Société d'Agriculture de Lyons*, 1845. xxxi. des procès-verbaux.

² At the Chester Meeting of the Royal Agricultural Society, 1858, a so-called new variety of Giant Rye was exhibited and offered for sale, which was not rye at all, but a fine species of wheat, the *Triticum polonicum*.

rich soils; neither of them succeeding so well on the soils suitable for the other as on their own. For this reason rye is such a valuable crop for the poor and unmanured soils of the higher and northern countries of the Continent, on all of which it is extensively cultivated. Many of our earlier writers speak of it as entering commonly into the farm rotations of their day, when a large proportion of the strong soils of the country were not thought to be susceptible of tillage operations, and were left down in natural pasture. It is now chiefly confined to the poor soils of the districts west and north-west of the metropolis, where a large and remunerative demand always exists for the straw for brickmaking purposes, and to very limited districts in different parts of the country. The "Ryelands" of Herefordshire took their name originally from the rye which was cultivated there to a large extent—a name now hardly known, except as applied to a peculiar breed of sheep, which itself has nearly entirely disappeared, even from its native district, owing to the introduction of new and improved breeds.

There is but little doubt, however, that many of the poor gravelly soils which we see carrying a scanty crop of wheat would give a far more remunerative return if sown with rye; and although rye is inferior to wheat as a bread-grain, and fetches a lower price in the market, the real amount of food suitable for horses or cattle that would thus be produced would be greatly increased.

In this country there is a strange prejudice against the use of rye as a horse-corn. On the Continent it is everywhere largely used for that purpose, either in a crude state as grain, or in a cooked shape as bread. Nothing is more common than to see the driver cutting a slice for himself off his horse's loaf, which is often not much coarser in quality than the dark-coloured "pumpernickel" he himself is accustomed to eat for his daily meal. Although

rye will grow on the poorest description of soils, it of course is more productive on soils of better quality, and may be cultivated successfully on soils of the class of loams, provided they do not contain too large a proportion of clay. It also is said to be cultivated with success on soils in which lime is either entirely absent, or exists in too small proportions to be suitable for either of the other cereals. This appears to be an erroneous statement, as our analyses show us (p. 184) that rye requires lime fully as much as either of them. It must be taken in a very modified sense; and then probably the difference between the *mechanical* action of lime in the soil, as distinguished from its *chemical* action, in relation to the growth of different plants, may account for the power which rye may possess of thriving in soils containing a minimum amount of that substance. Rye also seems to thrive very well on reclaimed peat or moorlands, and has been recommended as a good preparation for subsequent tillage crops. Belonging to the same botanical order as wheat, and resembling it very much in its general requirements, its proper place in the rotation is the same as that which would be assigned to wheat. On light gravelly soils it might be cultivated as a substitute for wheat, and on stronger soils of a loamy character it might alternate with wheat in the rotation, or replace either of the other straw crops—barley or oats. These, however, being generally sown in the spring, would not probably so conveniently be replaced by the rye as a wheat crop could.

On the Continent the practice is, in many districts, to sow it after wheat, if the soil is at all suitable for the latter. In some places, indeed, two crops of rye are taken consecutively—a crop of the spring variety succeeding a crop sown in the autumn, the first being harvested sufficiently early to enable the farmer to take an intermediate crop of

turnips, and still get the land in order for sowing in the spring again. These are both clearly bad and exhausting practices; still they have their followers. In Belgium it both precedes and succeeds to a root crop.

The same preparation of the soil is required as for the other cereals; but, being grown generally only on light soils, this is achieved usually without much labour. In all cases it is desirable to get in the seed as early as possible—a full month, for instance, earlier than wheat, as it is important that the roots of the plant and the rudiment of the ear should be well formed before the frosts of winter. If these points are secured, the plant passes through the winter without injury; if, by being sown too late, a sufficient growth has not been obtained before the winter, the plant is checked, and makes but little progress, and comes to harvest about the same time as that sown in the spring. The mode of sowing is the same as has been already described—by broadcast or by the drill; and the same quantities of seed may be used as it is customary to use in wheat sowing. Less, of course, is required for the autumn than for the spring sown, and less seed would be required for those varieties which tiller well, as the St. John's Day Rye, than for those (the Russian Rye, for instance) which, though bolder in their growth, have not the same tillering properties. Care should be taken in the selection of seed, that it be of good quality, and true to the particular variety it professes to be. In some districts the straw of some varieties is nearly as valuable as the grain; and great inconvenience might occur in the farm arrangements, both as to cropping and labour, by sowing a late instead of an early variety, and thus having your crop on the ground a fortnight later than you had calculated upon.

It is not the custom, either in this country or on the Continent, to steep the seed previous to sowing, as rye does not appear to be subject to either of the fungoid

diseases to which the other cereals are liable.¹ It is subject, however, to one disease, called "ergot," which is rarely met with in the other cereals, but seems to confine itself principally to rye and various of the common grasses. For this no remedy appears to have been yet discovered.

Rye is cultivated largely as a green or fodder crop, as well as for its seeds as a grain crop. In this case it may be sown advantageously on a stronger class of soils, as the object is to obtain abundance of herbage. A larger quantity of seed is usually sown, and those varieties are selected which have the property of tillering to the greatest extent. On the Continent, in districts where but few cattle are kept, or where manures are difficult to be obtained, they frequently sow it for the purpose of ploughing in as a manure. For this purpose it is always sown broadcast, as thick on the ground as possible, and a roller passed over it so as to bruise and break it before being ploughed in. This not only makes neater work, but greatly assists its decomposition in the soil.

In the northern parts of this country a practice of very ancient date still exists, of sowing rye mixed with wheat when the land is supposed to be hardly in condition to produce a good crop of wheat by itself. It is thought by this practice to make certain of a grain crop, as, if the wheat should fail, the rye would in all probability be sufficient to cover the ground. This mixed crop is locally termed "meslin," from the old Norman-French "meslé" (*mêlé*) mixed. The proportions of the mixture vary from one-fourth to three-fourths of rye, according to the fancy of the individual grower; and it is said that "when wheat and rye are grown mixed in this manner, the grains of each

¹ Steeping, however, can do no harm, while it may be the means of destroying any germs of disease that may exist, and also of stopping the germinative powers of injured or broken grain, which always produce sickly debilitated plants.

are larger and more perfect than when grown singly without any admixture.”¹

This is a very fallacious system, notwithstanding these asserted advantages. No doubt the wheat on poor soils and in elevated districts would very frequently fail, while the rye, under similar conditions, would be capable of perfecting its growth, but the reverse was seldom or never the case; besides which, the rye is ready for harvest from three to four weeks earlier than the wheat, and therefore they could not very well be cut together without detriment to the yield of either the one or the other grain. It is true that rye may, without injury, remain longer standing after it is ready to cut than either of the other grains, and that wheat may be cut with advantage at an earlier period than it generally is; but the difference in time between the ripening of the two crops is too great to admit of an intermediate harvest-time for the mixed crop, without one or the other suffering from it.

The germination of the rye-seed, when placed in the soil, is the same as that of wheat (p. 21), and the after-treatment, as regards rolling and hoeing, is generally conducted in the same manner. On light soils, such as are suitable to rye, weeds are generally more plentiful than on the heavy soils, and rye always repays the farmer for being kept free from weeds in its early growth.

The period of flowering is one of vast importance to the rye crop; indeed, the process of flowering has more influence upon the future yield of the rye than upon either of the other cereals. Until this be past no opinion can be correctly formed of the harvest prospects. The time of flowering is about two or three weeks earlier than that of wheat, and then it takes place along the whole extent of the ear at the same time. This simultaneous inflorescence renders the rye very sensitive to the action

¹ *Board of Agriculture Survey of Northumberland*, p. 80.

of any atmospheric influences that may occur at this always critical period. The plants at this time, according to the observations of Bœnninghausen,¹ owing to the abundant inflorescence, appear to be surrounded by a cloud of fine particles of fecundating dust (pollen), which may readily be destroyed by the rain, or driven away by any wind occurring at this moment, and the proper fecundation of the florets be greatly affected by it. Bœnninghausen found that, in districts where rye was in general cultivation, the plants in fields of small extent were always less perfectly fecundated than where a larger quantity was grown together; and, also, that where the field was sheltered from the action of the wind, the results were always more favourable than in exposed situations. The grain-produce at harvest-time, of course, is determined by the successful impregnation of the florets at this critical period of the plant's existence.

In about five or six weeks after this period is passed, the grain is matured and ready for cutting, the straw having changed from its usual green colour to a palish yellow. As soon as this indication is given it may be cut while even the nodes or knots are quite green, or it may be left standing until this colour disappears also. It generally requires but little time in the stook, as both the straw and the chaff are of a more solid and drier nature than the straw of the other grain crops, and, of course, should be carted and stacked as soon as possible. The harvest operations generally have been described, and rye offers no exceptions to the general rules given; and when in bulk (stacked), its quantity may be estimated at the same rate as that given for barley at p. 128. The erect habit of growth and toughness of straw render it particularly suitable to the operation of the "reaping machine;" while the large amount of green food it produces in the spring, and the early period at which it

¹ *Culture des Grains*, par Schwerz, p. 194.

subsequently brings its grain crop to harvest, give it a higher value to the occupiers of poor light soils than is generally conceded to it. The grain crop, satisfactory though it may be in the districts where rye is grown, would amply repay a little more attention on the part of the farmer. At present the average grain-produce is small—about 3 to 4 quarters per acre; the weight from 50 to 56 lbs. per bushel. The straw, however, in some places is an important item in the produce of the crop. Its toughness and length render it valuable for many purposes. The longest and best is used by collar-makers, and as much as £5 per ton is not an unusual price for it. It has also been used successfully¹ in the manufacture of straw-plait, in imitation of the Leghorn plait, and very high prices paid for selected portions. For brickmaking purposes there is always a large demand for it—the price being determined, of course, by the relative demand and supply, but always being considerably in excess of other straw. Some years it has amounted to £5 per load (36 trusses of 36 lbs. each); in general it fetches from 30s. to 50s. per load.

For fodder, rye-straw is less valued than either wheat or barley straw, not so much on account of its real nutritive value, which differs but slightly from them, but because its toughness and rigidity make it less palatable to the cattle, and less easily digested by them. For litter purposes, however, it is the best of all, and is readily sold at a good price in the vicinity of large cities for stable use. Owing to its greater length, it is a good plan to cut the truss or bundle in half with a hay-knife—this gives a more neat and tidy appearance to the stable, greatly economizes the litter, and makes better dung.

The cultivation of rye in this country is so limited that we have not had the opportunities of studying its diseases to anything like the same extent as has been

¹ *High. Soc. Trans.*, vol. vii. p. 286.

done on the Continent, where it occupies a much more important position as a bread-corn than with us. There, however, it is admitted by all to be far less subject to the ordinary diseases than the other cereals: still it is to a limited extent liable to be affected by them; while one disease, the “ergot,” more disastrous in its effects than all the others, seems to be peculiarly a disease to which rye is subject; as, although it has been noticed in both wheat and barley, it is happily of very rare occurrence in those crops. Schwerz—an able cultivator, and a high authority on all such subjects—speaks also strongly in reference to the influence of the Berberry tree in causing mildew in the crop. His observations satisfied him that within a range of 5 or 6 yards of a berberry tree the plants were always mildewed—while in other parts of the same crop at a greater distance, mildew was not noticed; neither did it occur if the exciting cause, the berberry tree, was removed. The chief attention, however, has been paid to the “ergot;” and, although at present we know of no remedy for it, we are sufficiently acquainted with it as to be able to guard against its dreadful effects, by carefully abstaining from using for feeding purposes any grain at all affected by it, which should only be made use of for brewing and distilling, or the diseased grains should be carefully selected and sold for medicinal purposes. The disease seems to originate in some disturbance of the organs of the plant at the time of flowering, and is, no doubt, greatly influenced by atmospheric action at that period. According to Berkeley, “at the beginning of the malady the ovary itself does not appear to be affected. It retains its form and colour, but is more tender than usual. The ovule is at that time white, but surrounded by a yellow viscid substance. It then swells immensely, bursts its integuments, becomes more or less elongated, with frequently a considerable curvature, according to the species

of grass or corn which is attacked—sometimes projecting like a cock's spur (whence its name, which is of French extraction) far beyond the surrounding glumes, assuming a gray, brownish, purple, violet, or, at last, a black colour, and crowned frequently with the withered style and integuments which are carried up with the elongated ovule. Sometimes a large portion of the grains are ergoted (*Secale cornutum*), but more frequently only one or two are affected in a spike, the ovules being abortive, though the diseased structure has not been perfected. Much controversy has taken place respecting the nature of this complaint, which has been supposed to arise from excessive but unwholesome nutriment, from the derangement of the equilibrium of the energies of the anthers and pistil, and other causes equally unfounded. It is now, however, a well-established fact that it is due to the presence of a minute parasitic fungus,¹ which causes a preternatural growth of the ovule."

The peculiar form which the disease assumes is shown (natural size) in the woodcut at p. 170, No. 2. This great change which has taken place in the affected grains enables them to be readily distinguished, and thus picked out from the sound grains. Where they have been, either through ignorance or carelessness, ground up together and used as food, the most distressing consequences have resulted. Experiments have proved that its effects are as fatal to the lower animals as to the human frame, in which its tendency is to set up gangrene of the worst description, with great rapidity, after it has been consumed. In this country many fatal instances are on record.² On the Continent, however, where rye enters more largely into the general food of the people, and where agriculture is less advanced than

¹ The name given to this fungus by botanists is *Spermoëdia*.

² In a paper by Professor Henslow "On the Diseases of Wheat," this disease is fully described, and instances of its fatal effects given. *Roy. Agri. Soc. Jour.*, vol. ii. p. 14.

with us, these instances are far more frequent; indeed, cases have occurred, in certain seasons, where whole districts have been well-nigh depopulated by this disease infecting their bread-corn. In 1816, Germany furnished sad evidences of its direful effects; and history records the fate of the garrison of Küstrin, at its siege in 1813, when the city was provisioned with meal made from diseased (ergoted) rye. Gangrene set in directly the soldiers consumed the meal, and the garrison was speedily decimated—the brave commandant, General Fournier, who placed himself on the same rations with his men, barely escaping with his life from the effects of this hidden enemy.¹ Every year we read in the foreign journals of fatal cases—deaths with fearful suffering—arising from diseased grains being ground up in the meal, and sold for human consumption. This powerful agent, “ergot,” possesses, however, some redeeming properties in a medicinal point of view, and thus, with ordinary care and precautions, may be made to minister to the health and comfort of mankind, instead of inflicting such disastrous and fatal injuries upon us as it does when carelessly taken as an article of food. In both human and veterinary pharmacy it is a most valuable and effective remedy in certain cases, and is largely administered by our most celebrated practitioners.

The “insect” enemies to the rye plant are not so numerous as those known to infest the other cereals. The “corn saw-fly” (*Cephus pygmaeus*) attacks rye in the same manner as wheat (p. 78), by dividing the straw at the joints, and thus stopping the circulation of the plant and arresting its further growth. On the Continent, in North Germany, the worm-like larvæ of a small fly called *Oscinis pumilionis*, commit serious ravages on the crop. They live in the heart of the young stems, checking effectually the growth of the plant, and rendering the ears either

¹ *Cours d'Agriculture* de Gasparin, vol. iii. p. 689.

partially or entirely abortive. The caterpillars, too, of the "rye-moth" (*Pyralis secalis*) take up their abode within the spathe, and completely destroy the ears; while the omnipresent wireworm is as partial to the young rye plant as any other cereal, and, finding it growing on a soil (light) suitable for its operations, frequently sweeps away the largest portion of the crop.

Curtis recommends, as the best remedy against the flies, that all the infested plants, known by their yellowish appearance and checked growth, should be carefully pulled up and burned. This should be done as soon as they are noticed.

Comparatively but little attention has been paid in this country to the "Chemistry" of rye. On the Continent, however, it has been treated with the consideration due to its importance as the bread-corn of so large a proportion of the population.

The proportions of grain and straw, of course, are subject to great variations, both the soil and the season exerting always great influence over them. Boussingault estimates that about one-fourth of the straw is left on the ground in the shape of stubble—the proportion being 27 of stubble to 100 of straw. We have then to consider the relative proportions of the other parts of the plant—the straw and the grain—which are removed from the soil. From a series of experiments carried on during several years, by different individuals, we find the average to be 100 parts of straw to 41 parts of grain.¹

¹ Thaer	gives 100 of straw to	40	of grain.
Podewils	" "	41	"
"	" "	28	"
Koppe	" "	41	"
Bürger (1807)	" "	54	"
" (1812)	" "	51	"
Block	" "	29	3
Schwerz (Hohenheim)	" "	31	"
Moellinger (10 years)	" "	56	"
Dierixen	" "	44	"
Boussingault	" "	44	"
Average		41	

The grain, like that of all huskless seeds, contains large proportions of phosphoric acid, and but little silica.

Although the straw of rye differs much from that of the other cereals, and is rarely used for fodder purposes, its composition would show that it contains a considerable amount of nutritious matter, though, probably, combined in such an indigestible form as to reduce practically its feeding powers. According to Boussingault, its composition may be taken as follows:—

Nitrogen compounds,.....	1.52
Compounds not containing nitrogen, soluble in potash,..	37.10
" " " insoluble in potash,	39.75
Ash (mineral matter),	2.93
Water,	18.70
	<hr/> 100.00

The proportion of ash varies greatly: from 3 to 5 per cent. may be taken as the average amount. This ash is composed, according to Will and Fresenius, of—

Potash,.....	17.36
Soda	.31
Lime,.....	9.06
Magnesia,	2.41
Oxide of Iron,	1.36
Phosphoric acid,.....	3.82
Sulphuric acid,	.83
Silica,.....	64.50
Chlorine,.....	.46
	<hr/> 100.11

The peculiar difference between rye and the bread made from it, and from wheat, for instance, appears to reside in the bran, which not only exists in larger proportions, but possesses hygrometric properties not met with in the bread made from the other cereals, which give it the advantage of remaining moist and fresh to the palate far longer than any other description of bread. It has been observed that the inner skin of the husk or bran

contains a slightly acid substance, that imparts the peculiar flavour to rye bread, and renders it fresh and agreeable to the palate. The bran also contains a much higher proportion of the nitrogen compounds than the flour when entirely separated from it—consequently, for both these reasons, it is always desirable to grind up as much as possible of the bran with the meal for food purposes, so that its valuable properties may not be lost. This is practically well known, and carefully observed in the rye-consuming countries of the Continent, where the meal is not dressed at all, but simply ground up, and used in that state, bran and all, in the form of a coarse, dark-coloured, but nutritious and palatable bread.

THE CANARY SEED CROP.

ANOTHER member of the great and important family of the grasses (order Gramineæ) is cultivated for its seed to a considerable extent, though its cultivation is confined entirely to a very limited district in the southern parts of the country. This is the *Phalaris canariensis*, or CANARY (GRASS) SEED, which is grown almost exclusively on the rich soils of the isles of Thanet and Sheppey, and of the opposite coast of Essex, entering as a straw crop into the regular rotations, and in some seasons producing very remunerative returns. In its early growth it closely resembles the cereal plants; as it approaches maturity, however, it is readily distinguished from them, and assumes more the appearance of the *Phleum* genus (Timothy grass), to which, indeed, it is more closely allied. This cultivated species is an annual, naturally inhabiting the Canary Isles, to which it owes its common name. Another species, the *P. arundinacea*, is the “reed canary grass,” so commonly

met with growing wild on the banks of rivers, marshes, &c., or, when variegated, the “ribbon grass” of our gardens.

In all cases, Canary seed requires a good strong and rich

Phalaris canariensis, or Canary Seed Grass.

soil; in poor soils it is useless to attempt its cultivation. It is generally sown as a substitute for wheat in the usual rotation, whenever the markets are likely to be favourable, as unless there is a considerable probable margin in favour of this crop, it is too uncertain in its results to offer superior inducements for its cultivation to wheat. After green crops fed off on the land, it generally thrives best. If after clover, the land should be ploughed deep, and well laid up for the action of the winter's frost; if after roots, the ploughs

should be sent in as soon as possible, so that the soil may be got into fine tilth by the seed-time, which is rarely delayed beyond the end of February. The land requires to be in good condition, well cleaned, and in fine tilth, and then the seed may be sown at the rate of two pecks per acre, taking care to have sufficient width between the drills—say 12 inches—to enable the hoe to be freely used during the early stages of the plant's growth. This is very necessary, as the plant is thin in the stem and blade at first, and would be considerably checked by the weeds if they were allowed to grow untouched.

Although sown so early, it is very late at harvest—always the last, by three or four weeks, of the straw crops. September is the usual harvest-time, and as the crop ripens irregularly, it is best to wait a few days so as to secure the

largest proportion of fully-matured seed, as the crop will stand until it is cut without injury. At this time it will be about 3 or $3\frac{1}{2}$ feet high. The harvest operations differ somewhat from the usual practices, and owing to the lateness of the season, require more care and attention. In some places the scythe is used, but in others the old mode of cutting with a particular hook called "a twibill" and a "hink," is still followed. It is bound in small sheaves or "wads," and set up in the usual manner, but in smaller-sized stooks. These require to be regularly watched and moved, so as to expose the whole surface equally to the action of the sun and the wind, and great care should be taken not to cart them for stacking before they have been sufficiently exposed, and have become quite dry. A little rain while in the stook does them good, by assisting the separation of the seed from the husk in thrashing, but on no account must they be carted until quite dry.

The operation of thrashing is always a difficult one, especially if attempted too soon after harvest. If this, for market reasons, be desirable, the stooks ought to be kept as long as possible out in the field, for the moisture and wind to exert their full action on them; under other circumstances, the end is obtained by keeping them in the stack until the next spring or summer, and then submitting them to the action of the thrashing machine. The produce varies with the seasons; from 30 to 50 bushels per acre may be taken as the general return. The price, of course, is governed by the relative supply and demand for the seed, which being used only for one purpose—that of food for "cage birds"—offers no inducement for importation from foreign countries. Generally speaking, it is considered satisfactory if it fetches from one-fourth to one-third more than wheat; and frequently it greatly exceeds this, the price having been £10 and upwards per quarter during the last twenty years. Precautions should be taken both

in stacking and, when thrashed, in the granary against mice, which prefer this to any other grain, and commit great ravages in it.

The injuries sustained by the plant during its growth have not—probably owing to its limited cultivation—received any attention. Neither are we in possession of any information bearing upon the chemistry of the crop. The grain is always sold off the farm, and the straw used merely as litter, though, according to the old *Survey of Kent* (Board of Agriculture), “the haulm is a most excellent fodder for horses.”

THE BUCKWHEAT CROP.

NEXT in importance to the seed-bearing grasses (cereals) are the leguminous plants, of which we shall take only beans and peas as our instances, as the other members are better known in this country as forage plants, and will be classified in that section of the series. Before, however, we enter upon the cultivation of these crops, we will briefly describe another of our “Farm Crops,” which in this country is only cultivated on a very limited scale, and then very rarely as a bread-corn. On the Continent, and throughout the northern states of North America and Canada, it is extensively grown and commonly used as food by the inhabitants. This is the *Buckwheat*, as it is termed—the *Polygonum fagopyrum*—a member of a very large and well-known order, POLYGOŒÆ, of which the common dock and sorrel are well-marked examples. The name “buckwheat” appears to be a corruption of the German name *buch-weizen*¹—a name given to the plant

¹ *Buch*, beech; *weizen*, wheat. Another name for it is *heiden-korn*, from its suitability for the most barren description of heath soils.

because its seeds greatly resemble in shape those of the beech tree (beech masts), while their contents, being of a farinaceous character, give them a resemblance to wheat. There are three species of the family cultivated for their grains as bread-corn.

1. *POLYGONUM FAGOPYRUM*—Common Buckwheat.
2. *POLYGONUM TATARICUM*—Siberian Buckwheat.
3. *POLYGONUM EMARGINATUM*—Notched Buckwheat.

They are all annuals. The first, however, is by far the most valuable, and is said to have been brought originally from Central Asia. It is met with wild in China, Nepaul, and Siberia, and enters more or less into the agriculture of every country where corn crops are cultivated. It is a plant of erect habit, from 2 to 3 feet high, with a strong, firm, branching stem, of a purplish red colour, carrying leaves of a heart-shaped, triangular form, much resembling ivy, and hanging bunches of white flowers, or white tinged with red, which give the plant a very pretty appearance (see diagram). The cultivation is carried on very extensively in some countries. In China it has been grown and used from time immemorial as a bread-corn. In Japan it is in general esteem, and is there preferred to most of the other breadstuffs: according to Thunberg, cakes are made of it, and sold at every inn throughout the country. In Russia it is also largely consumed.

In this country it has been known and cultivated for centuries past; having, according to some, been brought back from Palestine by the Crusaders; and, according to others, having been introduced into Spain by the Moors, and thence into France and this country. In France it still is known by its Moorish name, "blé de Sarrasin." Doubtless it is a native of the East, though its exact native country is not very definitely known. In Brittany it forms the bread-corn of the entire population; in the

north of Italy it enters largely into the diet of the lower classes—the favourite “polenta” being composed chiefly of its meal. In all the central parts of Europe and Asia it is

extensively consumed by the people; and in the northern portions of North America “buckwheat cakes” are much relished, and are met with in almost every house.

The flour, being poor in gluten (nitrogen compounds), is better suited for cakes or porridge, or for the confectioner's purpose, than for bread; mixed with wheat flour, however, it makes a very palatable and nutritious loaf. In this country it is grown chiefly for the purpose of feeding game and poultry; indeed, the former are so fond of it, that a small patch of buckwheat will be sure to attract birds from even distant preserves. In the market it readily sells for distilling purposes, the large proportion of starch it contains rendering it very suitable for that purpose.

It is grown to a considerable extent abroad as a manuring crop, being ploughed in green; and also as a forage crop, both cattle and sheep being very fond of it in a young state. When given after it has commenced flowering, it has been noticed to produce bad effects on both cattle and sheep; therefore care should be taken to give it in that state only in very small quantities.

Buckwheat has a strong claim on our notice as an agricultural plant, as it possesses properties which render it especially suitable for certain conditions of soil, and certain positions in the rotations of the farm. It will grow and produce a marketable crop on the poorest natural description of soils, or on other light soils which have been neglected, and allowed to sink into the lowest condition. It can be grown successfully and ploughed in advantageously at the commencement of flowering as a green manure. The late season at which it is sown, and its rapidity of growth, enable it to be taken as an intermediate crop after late turnips, or vetches or rye-grass cut for soiling for instance, and previous to a regular straw crop. When, from any adverse circumstances, the land is not prepared early enough for the barley crop, buckwheat offers a very good substitute for it, and then yields a far more beneficial return. Although sown at the end of May or June, it is

ready for harvesting by the middle or end of September—thus leaving the ground clear in ample time for a succeeding wheat crop; while, belonging to an *entirely different order of plants*, whose soil requirements are both chemically and physically different from the cereals, it may, notwithstanding it is a seed-bearing crop, follow or succeed to them in the rotation, without injury to either.

It is admirably adapted for countries where there are large tracts of poor, light soils, with a hot dry climate, unsuited to either barley or rye. Without this plant, indeed, many tracts of poor land would be totally useless, and unable to support even the scanty population that now occupies their surface. In reclaiming that dreary and barren region known as the “Landes,” in the south-west of France, buckwheat is the crop that is first grown, and with this the cultivation is commenced, and the land prepared for other crops. As a secondary crop it is cultivated to a considerable extent in Switzerland, Germany, and Belgium, where it enters regularly into their rather complex rotations. In this country it is confined almost entirely to the light-soil districts of the eastern counties, where it still retains its place as a regular crop, and is commonly known by the name of “brank.” When met with growing elsewhere, it is generally in the neighbourhood of game preserves, and for poultry purposes. Its cultivation is both simple and inexpensive. It grows upon soils of the poorest description: sands or gravels, that admit of cultivation at all, will generally carry a crop of buckwheat.

On better-class soils, of course, the plant thrives more, and produces larger returns. All that it requires is that the soil be dry, and susceptible of a fine tilth on the surface. On clays or undrained soils its cultivation is never successful. The roots, which are of a fibrous character, rarely penetrate the soil to any depth, but ramify in the surface soil, which requires to be in a state of fine division.

It is a very delicate plant, due probably to its eastern origin, and can only be successfully cultivated in countries where, during a certain period of the year, no frosts are likely to take place, as the depression of the temperature below freezing point for one night would effectually arrest the further growth of the plant, whether in its early stages in the summer, or towards its maturity in the autumn. It is, therefore, only suitable for such places as can insure freedom from frost for the entire period required by the plant for its growth, which is from twelve to fourteen weeks. In this country it is sown usually at the end of May or the beginning of June, after all risk of spring frost has passed away, and is ready for harvest before the cold nights of autumn have had full influence on vegetation. If sown much earlier or much later than this period, the risks from frost, either at the beginning or the end, are considerably increased; if, however, a green crop for fodder or manure is only required, it may be sown up to the middle of July.

In preparing the land for sowing, a single ploughing is generally all that is required, the roller and harrows, on such soils, readily completing the tillage required. It is always better to drill the seed than to sow broadcast, as the crop can then be kept free from weeds, and, as far as the succeeding straw crop is concerned, act, if kept clean, as beneficially as a regular fallow crop. The seed should be deposited very shallow in the soil, at the rate of about one bushel of seed to the acre, and a dry day selected for the purpose; light seed-harrows should be used in closing the drills, and the surface receive a turn with a light roller. If sown as a forage or manure crop, the seed is generally sown broadcast, and double the quantity used. It requires but little moisture during its growth; a few showers just to start it at first, and a few more at the period of flowering, will enable

it to carry through all its various processes until its maturity is completed, and it has produced its seeds.

Its habit of commencing flowering before its growth is nearly completed is a great disadvantage to the farmer, as in no case can he avail himself of all the grain produced by the crop. He therefore must carefully watch it during its progress towards maturity, and cut it at the period when he finds the greatest amount of seed formed. This probably will be the case when the lower seeds are perfectly ripe; the later-formed seeds on the upper branches are then sufficiently advanced to finish their ripening process while in the stook. In this state the crop is recommended to be cut early in the morning, while the dew is on it, to prevent the shaking out of the dry ripe seeds. The crop is cut with a scythe, and bound in small-sized sheaves; these require to be protected from the birds, which are all very fond of it,—care being taken not to cart them until quite dry, and then to place them only in small-sized stacks. The return per acre, in favourable seasons,¹ is generally good for such soils—from 4 to 6 quarters being an average produce.

The Tartarian or Siberian Buckwheat has been strongly recommended as being a hardier species, consequently not liable to such risks from frosts, and capable of growing on even a poorer class of soils than the common buckwheat. It is also said to be more productive; one French authority, Yuart, in his *Cours Complet d'Agriculture* (1820), stating that, in the department de l'Isère, from 12 bushels of seed, he obtained a return of 1296 bushels, or more than one hundred-fold, while many of his neighbours exceeded eighty-fold the same year. This variety is known

¹ In variable climates the yield of buckwheat, however, is *very unequal and uncertain*. Bürger records (*Traité d'Agriculture*, p. 193) its yield on the same farm for sixteen years. In two consecutive seasons (1816 and 1817), the yield was respectively 160 and 2275 litres to the hectare—equal to about 2 and 28 bushels per acre; while the average of the whole period amounted to 1151 litres per hectare, or about 14 bushels per imperial acre.

by the flowers being green, and by the edges of the seed or grain being rough; it is also more branching in its growth. It is certainly more productive, but the grain is of inferior quality, and better suited for cattle-food than for use as a bread-corn.

The "Notch-seeded Buckwheat" is rarely cultivated; it is an inferior species, with larger leaves, and wide thin edges to its seeds.

Our information respecting the diseases incidental to the crop, or the injuries it sustains from the attacks of insects, is very deficient; and its *chemistry* has received less attention than has been bestowed on most of our other "Farm Crops."

The proportion of grain to straw is nearly equal, or about 45 of the former to 55 of the latter in the 100 parts.

The grain contains about 12 to 15 per cent. of water. Horsford found 14.19 per cent of water, and 7.94 of nitrogen compounds. Its average composition is thus given:—

Nitrogen compounds,.....	8.58
Compounds destitute of nitrogen, as starch,.....	51.91
" " " " fibre, &c.,.....	23.12
Ash (mineral matter),.....	2.20
Water,.....	14.19
	<hr/> 100.00

The ash in the grain is from 2 to 2.5 per cent.; and, according to Bichon¹ is composed as follows:—

Potash,.....	8.74
Soda,.....	20.10
Lime,.....	6.66
Magnesia,.....	10.38
Oxide of Iron,.....	1.05
Phosphoric acid,.....	50.07
Sulphuric acid,.....	2.16
Silica,.....	.69
	<hr/> 99.85

The straw contains from 3 to 4 per cent. of inorganic matter, and about the same proportion of water as the grain. Burger gives its nitrogen compounds at from 2 to 2.5 per

¹ *Revue Scient. et Ind.*, tom. xxiv. p. 71.

cent., which would show that it has a considerable feeding value. In its green state, cut as fodder, it is stated by Einhof and Crome to consist of—

Water,.....	82.5
Starch,.....	4.7
Cellulose,.....	10.0
Nitrogen compounds,.....	.2
Extractive matter (?),.....	2.6
	<hr/> 100.0

The straw has been analyzed by Sprengel, and is thus given:¹—

Potash,	10.36
Lime,.....	21.98
Magnesia,	40.84
Alumina (?),	.81
Silica,.....	4.37
Oxide of Iron,.....	.47
Oxide of Manganese,.....	1.00
Sulphuric acid,	6.77
Phosphoric acid,	9.00
Chloride of Sodium,	4.90
	<hr/> 100.00

Although the proportion of nitrogen compounds in the grain is smaller than in the cereals generally, thus rendering buckwheat inferior to them as a bread-corn, still the much larger produce of the crop to the acre on the poorer description of soils, makes it very valuable even for food purposes to the inhabitants of such countries, as the aggregate amount of flesh-forming principles obtained per acre by a crop of this grain would be far in excess of that produced by either of the cereal crops. To horses, and to cattle generally, it may be given with advantage, either alone or mixed with other food. Poultry of all kinds eat it greedily, and no food makes them so productive as this grain does; while a small patch planted in the neighbourhood of the homestead will, during the time of flowering, furnish a rich treat to the bees and keep them from straying in search of food.

¹ *Annales Agricoles de Rouille*, tom. viii. p. 212.

THE BEAN CROP.

WE now pass on to another order of plants, differing widely in its agricultural character from that which contains our ordinary bread-corn, and certainly ranking next to it in its important bearing upon the human economy. This order is the LEGUMINOSÆ, and the members which we have now to take into consideration, as "crops cultivated for their seeds," are beans and peas. Later in the series we shall have several other members before us as "forage crops," which will then be fully described.

Beans have been known and used as an article of food well-nigh as long as our records of the past serve us. In the Scriptures¹ we find mention made of them as having been offered, with other grains, to David, when fleeing to the wilderness to escape from his son Absalom. And, again, in one of the early sieges of Jerusalem, described in Ezekiel,² we find them included amongst other articles of food then in common use. No reference, however, is made anywhere to the harvesting of beans, though frequent allusions are made to the other grain crops; which fact, combined with the unsuitability of Palestine generally to the requirements of the plant, has led to the opinion that, in all probability, its cultivation was limited to the strong alluvial soils of the valley of the Nile, whence it was carried as corn to Canaan, in exchange for the flocks and fruits of that pastoral country.

All our evidence tends to confirm the belief in its eastern origin, though our information respecting it is

¹ 2 Sam. xvii. 28, 1023 B.C.

² Ezek. iv. 9, 595 B.C.

not sufficient to enable us to point to its native country. It is usually stated as Persia. De Candolle is of opinion that it is a native of the borders of the Caspian Sea. This, however, has not been confirmed by any of the recent Russian naturalists and travellers in those regions, neither has any wild plant been as yet found.

Although, in some of the early Greek writers—Homer, for instance—beans are spoken of as being known as articles of food, it is in the pages of the later Roman historians that we find the important place they then occupied in their agriculture, and the care and attention they received in their fields. Apart from their value on the farm, superstition endowed them in those days with supernatural qualities, and gave them an exclusive value for certain ceremonies and special occasions. According to Pliny, cakes made of the meal of beans were used as votive offerings in certain of the Pagan rites and ceremonies. Although so used, the grand priests of the Romans, termed "*Flamines*," carefully abstained from them, under the belief that the souls of the departed resided in them. From this superstition they were always accounted proper to be used at funeral ceremonies. Another reason given for this abstinence from their use was the supposition that letters and characters of an ominous nature, indicating heaviness and signs of death, were marked on the flowers. The Egyptian priests, however, went further, and even denounced it as a crime to look at beans, judging the very sight of them to be unclean. A passage also occurs in Lucian, to the effect "that to eat beans and to eat our father's head were equal crimes." Phillips has collected a number of curious and interesting facts relative to the bean: amongst others, that the modern practice of "blackballing" any obnoxious candidate was derived from the ancients, who used white and black beans in taking the votes of the people, and for the

election of their magistrates. A white bean signified "absolution," and a black one "condemnation."

Ovid gives a lively description of the ceremonies of the *Lemuralia* and *Parentalia*, wherein beans appear to have had a mysterious value attached to them as a portion of the ceremony. The master of the family had to throw black beans over his head, still repeating the words, "I redeem myself and my family by these beans." Abstinence from beans was strictly enjoined by Pythagoras, one of whose precepts is *χναμῶν ἀπεχεσθαι*—*abstinere a fabis*. This precept of Pythagoras has been variously interpreted, owing to the word he uses for beans bearing another and very different interpretation. Clemens Alexandrinus grounds the prohibition against beans on their alleged quality of rendering women barren; and this is confirmed by Theophrastus, who asserts that some other plants have the same property. Cicero suggests another reason for this enjoined abstinence, namely, that beans are great enemies to tranquillity of mind. Hence Amphiarivus is said to have abstained from beans even before Pythagoras, that he might enjoy a clearer divination from dreams.

There is no doubt that beans, consumed by themselves, or with but a sparing admixture of other food-materials, would be very likely, especially with those of sedentary habits or occupations, so to disturb the natural functions of the body as to produce many of those mysterious sensations which have been by the ancients attributed to them. Chemistry has accounted for and dispelled many such illusions. In this case we see (page 241) that beans contain a far larger proportion of nitrogen compounds than that which experience has shown to be best adapted to the requirements of the human economy; consequently, any large surplus, such as beans contain, could not be consumed for any time without deranging some of the

functions of the body, by which the mental impressions must always more or less be influenced. Shakspeare tells us—

“We are not ourselves, when nature, being oppressed,
Commands the mind to suffer with the body.”

Superstition attached sometimes good as well as unpleasant qualities to beans, inasmuch as the Roman husbandman was accustomed to carry with him a small bag of beans when he sowed his wheat or other corn, in the belief that its presence would insure success to his labours, and increase the produce of his crop.

Beans, as well as others of the leguminous plants, entered largely into the agriculture of the ancients. They are fully described, and directions and advice given for their cultivation, by all the Roman agricultural writers. In their general directions they recommend winter sowing; that the soil be strong; that it be in good heart, and well manured; and that the crop be carefully hoed and kept clean from noxious weeds. All these recommendations we acknowledge as correct, and are, of course, very desirous to see carried out. The importance attached by the Romans to the cultivation of this plant as an article of food—principally, it is true, for their labouring servants and slaves, and for their cattle—may be recognized in the fact of its having given rise to one of those honourable distinctions which have made the family of the Fabii remembered, while most other names of that period have passed entirely from history's page.¹

We have no very correct knowledge as to the period of the introduction of the bean into this country. By some it is stated to have occurred shortly after the invasion of Spain by the Moors, who introduced it there, whence it

¹ There were other noble names originating from this order of plants—the Pisones, from *pisum*, the pea; the Ciceros, *cicer*, chick-pea; the Lentuli, *lentulus*, lentil, &c.

passed into France, and then across the Channel to our shores. More probably, however, it was introduced directly by the Romans at an earlier period, whose practice it was to follow up the stride of their victorious legions through a conquered country, by the introduction of those arts and appliances which had conduced to their own prosperity and comfort at home—a noble policy, worthy of later civilization, which, however, we are only yet but imperfectly acquainted with. Our early writers mostly speak of beans (*pulse*) as entering into the agriculture of their respective periods; but it is only of late years that their full value has been recognized either agriculturally as a rotation crop on the farm, or chemically as an article of food for ourselves and our cattle.

The bean belongs to the natural order LEGUMINOSÆ, and is termed by the botanist *FABA VULGARIS*. There is only one species, though long cultivation has generated a well-marked division between those cultivated in fields and those cultivated in gardens, which has induced some writers to separate them into two different species (*F. vulgaris arvensis* and *F. vulgaris hortensis*); while the aptitude of a few of the varieties to grow equally well in the open field or in the garden has given rise to the classification of a third species (*F. vulgaris arvensis vel hortensis*), which has been adopted by Lawson and others. The name *leguminous* has been, according to Varro, applied to this order of plants because they were removed from the ground by being pulled, not cut as the other crops—“*legumina quæ velluntur e terrâ non subsecantur. Unde et legumina appellata quia ita leguntur.*” The generic name of the plant *Faba*, Paxton, following Isodorus, tells us, is derived from the Greek word φαγῶ, to eat.

The first and the last divisions are those which come before us as farm crops, as they are indiscriminately

grown in the fields of the southern half of the country; in the northern portions the climate limits the field cultivation to those varieties which are comprised in the first division, the others being only suitable for the sheltered culture of the gardens. The following are the varieties generally met with in cultivation:—

Common Scotch or *Horse Bean* is the ordinary field-bean of the northern districts, while the *Tick Bean* is that which is principally grown in the south. This variety is very hardy, and, in good seasons, very prolific. The stem is stout, from 3 to 5 feet in length, carrying its pods down to its middle—the pods containing usually three, but sometimes four and even five seeds. The seed is from one-half to five-eighths of an inch long, by three-eighths in breadth (*fig. 1*), generally slightly and rather irregularly compressed and wrinkled on the sides, and frequently a little hollowed or flattened at the end; of a whitish or lightish-brown colour, occasionally interspersed with darker blotches, particularly towards the extremities; colour of the eye, black. If exposed too long in the field, or heated in the stack, they become much darker in appearance. Their weight ranges from 60 to 65 lbs. per bushel: the average yield may be taken at four quarters to the acre. This variety is suitable for good, strong, well-drained clay or alluvial soils: on soils containing much vegetable matter it runs too much to straw, and on light soils it loses its vigour of growth, and diminishes in size and produce. It is well adapted for feeding purposes, and not unpalatable when made into breadstuffs. In grinding, 100 parts yield 85 to 86 parts meal, and 14 to 15 parts of husk. (*Haxton.*)

Tick.—There are several varieties known by this name—the Common Tick, Harrow Ticks, Flat Ticks, Essex Ticks, French Ticks, &c., differing only from the common by being grown in different soils and under different

circumstances. This is the common field or horse bean of the south, and is there in as general estimation as the foregoing variety is in the north. It is much better

1. Horse Bean.
2. Tick Bean.
3. Winter Bean.
4. Heligoland.
5. Early Mazagan.

6. Common Long-pod.
7. Auld's Long-pod.
8. Green Long-pod.
9. Hangdown Long-pod.

10. Johnston's Long-pod.
11. White Blossom Bean.
12. Red Blossom Bean.
13. Broad Windsor.

suited for cultivation in a lighter class of soils, and is a more prolific variety, with a shorter straw, from 3 to 4 feet in height; pods smaller and containing smaller-sized seed, which is plumper and more cylindrical in shape,

and rounder at the extremities (*fig. 2*). The proportion per cent. of husk to meal—15·873 to 84·127—is a little higher than in the Scotch beans—due, probably, to its inferior size. The Harrow Ticks are, again, smaller than the Common, and are equally good croppers upon even lighter soils.

Winter Bean is a very hardy and prolific variety, which is rapidly increasing in favour with the farmers of the south, and has been introduced successfully into Scotland, whose average winter climate is not likely to be too severe for it. It was introduced into this country about 1825, and offers the great advantage of being sown in the autumn, about October, and being ready for harvest at the end of July—thus obviating the difficulties and contingencies generally attendant upon this crop, owing to the earliness of the seed-time (in February), and the late period of the harvest. Another strong recommendation in its favour arises from its general freedom from the attacks of the *Aphis*, which so frequently destroy our bean crops. In seasons when the spring-sown beans of entire districts have been affected, it has been noticed that the Winter Beans, even on the same farm, have been free from them. In appearance this variety is fully as vigorous as the others; the straw is from 3 to 4 feet high; well-podded; seed small (*fig. 3*); very plump and heavy; weighs from 65 to 70 lbs. per bushel; colour, the same as the Tick Bean, but distinguished from it by a dark-greenish spot on the short side, a little below the termination of the small, very black eye. The average proportion of husk to meal is—husk, 16·2; meal, 83·8.

Heligoland.—This is a very prolific, early, and hardy variety, suited for the higher class of soils in late districts. It is shorter in the straw than the preceding varieties, averaging 3 to 3½ feet, and carries a large number (fre-

quently from thirty to fifty) of smallish, straight, cylindrical-shaped pods, containing three or four seeds in each. The seeds are small; of a darkish-brown colour; of an oblong, rounded shape (*fig. 4*); plump, and well-filled, making a superior and heavy sample. Under favourable conditions the yield is very satisfactory—4 to 6 qrs. to the acre; and the weight per bushel from 66 to 70 lbs. The average percentage proportion of husk and meal are—husk, 15·91; meal, 84·09.

Mazagan.—This is one of the intermediate varieties common to both field and garden cultivation. In the south it grows well on the farm, whereas in the north it is confined to the garden. It is an early and very prolific variety, and is more suitable for good soils of medium texture than either for the heavier or lighter class of soils, particularly if of inferior character. It has a long, somewhat slender stem, about 4 to 5 feet high, with longish, rather narrow pods, containing from four to five seeds each. The seeds are larger and flatter than the ordinary field-beans, and of a much lighter colour (*fig. 5*). As its name would import, it is supposed to have been introduced into this country from the Portuguese settlement on the coast of Africa, but has been improved by cultivation in this country. It is well adapted for grinding, the relative proportions of husk and meal being—husk, 14·05; meal, 85·95 per cent.

Annfield.—A variety partaking very much of the characters of the *Mazagan*. It is inferior to it, however, in earliness, and also produce, unless grown under very favourable conditions. The stem is slight, from 4 to 5 feet high; pods $3\frac{1}{2}$ to 4 inches long, and containing three or four seeds of a largish size, with flattened sides, and generally tapered to a small roundish point.

Pigeon (*F. vulgaris pisiformis*).—This is the smallest of all our beans, both in its habit of growth and also in its

seeds, which are used as substitutes for peas in feeding pigeons, for which it is generally cultivated. It is an early and prolific variety; and on the Continent, where it is grown far more extensively than in this country, it is selected for cultivation on the lighter description of soils.

Long-podded.—Under this general title there are many varieties, known by different epithets, due either to some distinctive character in themselves, or merely to the name of the person who first introduced them into cultivation; as Auld's Long-pod (*fig. 7*), Child's Long-pod, Green Long-pod (*fig. 8*), Hangdown Long-pod (*fig. 9*), Johnston's Long-pod (*fig. 10*), Large Long-pod, White Blossom Long-pod (*fig. 11*), &c. These varieties, although quite suitable for field cultivation, are usually only grown within reach of good markets, to which they are sent as vegetable produce. They are generally of vigorous growth, with stout tall stems, carrying longer pods than the ordinary field varieties, and producing flatter and much larger seeds. The colour of the seeds is of a greenish-white, or of a cream colour, becoming gradually darker as they ripen. The husk is thinner, and the proportion of meal they contain is always higher than the common kinds, averaging 87 to 88 per cent. of meal to 12 to 13 per cent. of husk.

Windsor.—This variety is, like the foregoing, known by several different names, arising from the difference in colour of the flowers, and also from the persons who first introduced them. There are Green, Red, and White Windsors (*figs. 12 and 13*), all delicate plants, and suited rather for market-gardening purposes than for the farm. The last is the sort more commonly grown, as it possesses the peculiar habit of ripening very unequally, thus continuing the vegetable supply from day to day for some little time. They are all very prolific, owing probably to the high quality of soils in which they are usually grown.

The seeds are flat-sided, with dark black marks at the end, and contain on the average about the same proportions of meal and husk as the Long-pod varieties.

The bean plant delights in strong soils; indeed, those soils which are best adapted for wheat are equally suited for the cultivation of beans, in like manner as the lighter class of soils on which barley thrives are those most congenial to the growth of the turnip. Although it may be grown successfully on the strongest clay soils, as those of the London, the wealden, the oolite, and the lias, still a freer description of soil, such as the clay loams (clays containing sand), is that best suited to its habits of growth, and in this class of soils we see its cultivation carried on to the greatest perfection.

A good bean soil should have a certain amount of tenacity or staple to give it the requisite firmness; it should be deep, so as to admit freely the downward passage of the roots in search of food, and it should be free from any surplus water beyond that which such soils always naturally contain. These are the principal *physical* conditions for a good bean soil. The first is natural to the soil, and in fact determines its suitability; the second can in such a class of soils be always secured by subsoiling and additional tillage; and the last generally requires the application of

drainage, which, if properly carried out, effectually relieves the land from that excess of moisture which always acts prejudicially to our "Farm Crops."

The *chemical* conditions of the soil for beans are very different from those required by wheat (see page 89); instead of the silica required by that plant, we find beans need a large supply of lime (page 240). This difference in the constituents of the two plants has induced a classification of our principal crops according to the prevailing chemical features of their conditions; hence the cereals and grasses generally are termed "silicious crops;" the leguminous, as beans, clover, vetches, &c., are termed "calcareous crops;" and the fallow and root crops, as turnips, cabbage, potatoes, &c., are termed "potash crops." Consequently, we find that lime, although necessary in small proportions to all fertile soils, is an important ingredient in all soils in which beans or any other leguminous plant is to be grown; and if they do not naturally contain it, it must be added to them from time to time in the usual manner.

On light soils, such as are usually farmed on the Norfolk (four-course) system, we see beans occasionally grown—the Winter Bean, for instance, occupying one-half of the clover brake. The plant, however, never has the same vigorous growth that it possesses in more congenial soils; and although the quality of the sample is generally very good, the yield is very unsatisfactory. Neither are the returns so satisfactory on the strong humous soils of Lincolnshire, the fen-lands of Huntingdonshire, and Cambridgeshire. On these, however, the growth of the plant is too vigorous, the stems and leaves are too luxuriant, the organic portions of the food have been obtained and elaborated too quickly, while the sap of the plant is so largely diluted with water, that it has not been able to build up the stem sufficiently strong to enable it to stand against the action of the weather, wind, and rain, or to

furnish those materials required for the formation of its seed. The crop, though magnificent while growing, is generally deficient in the barn. In all cases, whether the soil be strong, medium, or light, it is most important that it be in good condition—we need never be afraid of giving too much manure to our bean land. The Roman farmers were well aware of this, and they recommended either that the land should be well dunged—Columella¹ speaks of 24 loads to the *jugerum*, equal to about 36 loads per acre, or if that were not convenient, that the land should be fallowed the year previous to the bean crop, in order that it might have plenty of food. Virgil, who evidently was an excellent practical farmer, recommends that the seed before sowing be steeped in a solution of nitre, and *amurca*, (the lees of the oil press) “so that the fruit may grow larger in the deceitful pods.”² The advantage of this practice is strongly advocated by Columella, who says “that he found the fruit of seed thus prepared less subject to be hurt by the weevil.” This practice of preparing seed previous to sowing, appears to have been very general in Roman agriculture. As has been already observed (p. 24), we cannot admit its manurial value beyond the amount of actual fertilizing matter it attached to the seed; or its value as a preservative against disease or the attacks of insects beyond its power of freeing the seeds from the spores of the one or the eggs of the other that might adhere to them. In this case, the insect named the weevil attacks the grain only when in the store, and therefore could not be influenced by any preparation of the seed used, though the seed might be to a small extent assisted by it in the earlier stage of its growth.

Farmyard dung is the manure usually applied to the

¹ Columella, lib. ii. c. x.

² “Semina vidi multos medicare serentes,
Et nitro prius, et nigro perfundere amurcā,
Grandior ut fœtus siliquis fallacibus esset.”—*Geor.* i. 193.

bean land, and this may be either spread on the stubble of the preceding crop, and ploughed in at the time, or left until the time of sowing, when it is distributed, and either ploughed in, in the usual way, or laid in the furrows and covered up by splitting the ridges, if the beans are to be sown on the ridge. This latter mode is that usually followed in the north, and possesses great advantages over sowing on the flat, which is the usual practice in the south; the crop can be hoed earlier and more regularly during its growth, which, indeed, gives to the bean crop all the advantages of a fallow crop in the rotation. As we shall have to describe the method of preparing ridges, and of depositing the manure in them, in the next Part, when we discuss the cultivation of the "Turnip," we will not attempt it now. All we would observe is, that before sowing is attempted, whether on the flat or on the ridge, it is important that the land be thoroughly cleaned. This part of the operation is generally, on such soils, far more effectually and economically performed in the autumn than in the spring, and should be commenced as soon as possible after the land intended for beans is cleared of its crop. The manure may then be ploughed in, and the land left with a good deep winter furrow. If this has been properly attended to, a double turn of the scarifier on well-drained soils, will generally give a sufficient seed-bed for sowing on the flat, without bringing the plough on the field at all; and, indeed, for ridge-sowing the scarifier may always advantageously precede the ploughs, as the soil by being moved becomes drier and more friable, and the process of ridging is far more satisfactorily executed. In the selection of the seed, the same care should be taken that it is *sound, fully matured, and true to its variety*, as has before been recommended in regard to the cereals.

The particular variety sown will be determined by the

soil, the climate, and the markets of the district. In the north, the Scotch Horse Bean is that universally sown; while in the south, the Ticks, Heligoland, Mazagan, and the Winter Bean are those most commonly met with. In both the north and the south, beans are now admitted to a regular place in the different rotations followed. On the heaviest class of soils, the strong clays, they alternate with wheat, either with or without a fallow, every third year. The old-accustomed open fallow is now rapidly disappearing, as thorough draining and the use of improved implements make their way into those districts; and a green crop—rape, swedes, or mangold—takes its place. This practice (open fallowing) is, however, still followed on the strong clays of Essex and the heavy vale soils of Bucks; here the land is fallowed for wheat, and the bean crop follows. On the strong lias soils of Gloucestershire, the bean crop succeeds to the fallow, and wheat is taken at the end of the course.

When the four-course system is followed, the soils are usually of a light class, and, so far, not those in which the bean thrives best. Here it is that the winter variety is of such value, as it enables the farmer to vary his crop, by sowing half the land that would, in the usual method, be in clover, with beans. His rotation is thus strictly adhered to, while he lessens the chances of his land being clover-sick, by taking a crop at intervals of eight instead of four years. In Suffolk, Norfolk, Bedfordshire, and Hertfordshire, this practice of adding beans to their rotation, rendering their clover returns more certain, is carried out very successfully, and is rapidly advancing in the good opinion of the farmers. In those parts of the country where the five and six course systems prevail, the soils are generally of a stouter character, and better adapted for the cultivation of beans. There we find that beans are usually placed between two straw crops—following wheat, and preceding

oats, for instance. In this case, they are always well manured, sown widely apart, and kept well cleaned, and thus act entirely as a fallow crop in the rotation, as the mineral requirements of the beans differ greatly from those of the cereals; while, at the same time, it leaves a large amount of organic matter (leaves and roots) on the land. On some of the strong loams of Warwickshire and the Midland Counties, the beans are taken between two crops of wheat. On the rich alluvial soils of Nottinghamshire, Lincolnshire, and Yorkshire, bordering the Humber and its tributary rivers, beans usually follow oats; and on the strong soils of Bedfordshire and neighbouring counties, the same practice exists, the beans being succeeded by wheat.

In the farming of the north, beans are considered a good preparation for wheat, and consequently we find them generally preceding the wheat crop, or in some cases following it, as the season, markets, or other circumstances of the farm, may render most convenient. In the Lothians, where the soils suitable to bean cultivation are farmed on the six-course system, we generally see beans occupying the fifth place in the rotation, following the oat and preceding the wheat crop. In all cases, this practice of treating beans as a fallow crop, by placing it between two straw crops, manuring it, and keeping it perfectly clean from weeds, is to be recommended as most philosophical, and as likely, in the long run, to be the most successful and remunerative. In the lax farming of some parts of the south, beans are taken after seeds; sometimes, if the season be favourable, a good crop is obtained; but it would very rarely prove a profitable one if its produce were compared with the probable returns of the cereal crop which it had displaced.

The two principal kinds of beans—Winter and Spring—and their respective periods of sowing—offer great inducements for extending their cultivation, by introducing

them more generally into the rotation of districts where at present they are but little known. The period of sowing depends, of course, upon the variety selected. The early part of October is probably the best time for sowing the Winter bean, as by that time the stubbles of the preceding crop have been ploughed and well cleaned. This latter operation should be always carefully attended to in regard to the bean land, whether intended for winter or spring sowing, as the land can never be so efficiently cleared of weeds, if they are left untouched until the spring.

For spring sowing, February is the best time; they are, however, frequently sown during the month of March, and in favourable seasons have produced good crops. It is always advisable to take advantage of the first opportunity the weather affords after the middle of February, and get them in as early as possible, as the bean plant requires from six to seven months to complete its growth; and if the period of sowing is delayed, the harvest operations are necessarily kept back at a period of the year when each day's delay renders the season less adapted for the purpose, and the stooks are frequently injured by being so long exposed to the weather before they can safely be carted off the field. Some comparative experiments were carried out by Arthur Young, in respect to the relative produce of beans, sown at various times, and under the same conditions as to soil, climate, &c., which gave the following results:—

Sown in November,	the produce	= 4·
„ December,	„ „	= 3·42
„ January,	„ „	= 4·42
„ February,	„ „	= 4·49
„ March,	„ „	= 4·
„ April,	„ „	= 2·1
„ May,	„ „	= 1·42

If the land is well drained, and the principal rainfall has

been before Christmas, scarifying pretty deeply will frequently give a sufficient depth of tilth, and enable the crop to be sown, either on the flat or on the ridge, without ploughing it all. If, however, the manure has to be applied, or if the soil is not sufficiently open and divided, and it be found necessary to send in the ploughs, the work should be done across the furrows of the autumn ploughing, and then the crop be sown in lines across this last ploughing, and, of course, parallel to the line of the first or autumn ploughing.

The quantity of seed per acre should be regulated by the description of bean sown. For Winter beans, the quantity of seed is usually from $1\frac{1}{2}$ to 2 bushels; while of those varieties sown in the spring, from 2 to 4 bushels are required. In some places, especially in the Lothians, a proportion of peas or of vetches is mixed with the seed beans and sown together. The erect stem of the bean gives support to the climbing stem of the pea or vetch, either of which can readily be separated by riddling when the crop is thrashed out. When peas or vetches are grown for seed, this offers some advantages, as the quality of the sample is generally superior to that grown in the ordinary way; but if the beans are really a good crop, they would give a better yield without any such additions, which take from the soil exactly the same ingredients which the beans require for their growth. The Winter Bean are much smaller in size than the spring varieties; consequently, a greater number are contained in the bushel; while the period at which the former are sown gives them a power of tillering far beyond that which the latter possess. These, indeed, vary much in size—the Mazagan, for instance, being twice the size of the Common Tick or the Heligoland; in measuring out the seed, this should be borne in mind, as a larger quantity per acre will be required of the large-sized varieties than of the small ones, in order to secure an equal plant over the field. When the particular variety

for sowing has been determined upon, the same care should be bestowed upon the selection of the seed as has been recommended in regard to the wheat and other corn crops (p. 19.)

It is equally important for the reasons there given, that the seed be fully *developed* and *matured*, *true to its sort*, and *free from injury or disease*; as, upon the condition of the parent seed, the health and vigour of the young plant mainly depends. The same advice, too, in regard to the advantages of changing the seed, holds good with the bean, as, indeed, it does with all our other cultivated crops. In the Lothians, where beans are largely grown, the farmers prefer to get their seed from the rich carse districts of Falkirk and Stirling; while the produce of the Lothian farms is considered an equally good change for the bean soils of the alluvial tracts mentioned. Steeping is never practised with beans, as, although the plant has many enemies to contend with during its period of growth, they arise chiefly from the attacks of insects, and not from those fungoid diseases which have been described in treating of wheat. In Roman agriculture, however, it was strongly recommended to immerse the seeds, previous to sowing, in a certain manurial compound, for the purpose of increasing their fertility; and also to follow the practice of the Greeks, who "asserted that the seed which is steeped in capon's blood is not hurt by destructive weeds; that if infused in water a day or two before sowing, it will spring the sooner; and if sprinkled with a little nitre before being cooked as food, it will boil all the better for it."¹ The value of the first portion of the recommendation must be limited to the mere weight of the fertilizing substances added to the seed; while the advantages of infusing the seed in water previous to sowing, would probably be far

¹ Palladius, lib. xiii. tit. i.

greater in the soils of a dry country like Italy, than in those of a humid climate like our own.

The three methods of depositing seed already discussed—broadcast, drilling, and dibbling—are each met with in different parts of the country. Of these three, the first is clearly the worst, and less adapted to beans than to the cereal crops, as although you may get on to a field to broadcast before it is fit for drilling, and get over more ground in a day; still it is impossible to keep the broadcasted crop clean when it comes up, and few plants suffer more in their early stages from weeds than the bean does. Where, however, the seed is to be sown broadcast, the surface should not be touched after the cross ploughing in spring, but the seed sown on the furrow slices, and then covered with the harrows in the usual way, and a light rolling given if the surface is left too rough.

In *drilling* on the flat, the general drill of the farm may be used, merely changing the grain feed-spindle for one suitable for the larger sized bean seed, and arranging the cog-wheels according to the quantity desired to be deposited. The same drill will also serve for sowing on the ridge. In this case great care should be taken that the land be ridged up in parallel lines equidistant from each other, or the work will be irregular. For both purposes, however, it is necessary that the mechanical construction of the machine should admit of the coulter and spouts being set to any given width desired, as beans are always sown at greater distances apart than the cereal crops. The common drills, with fixed coulters, &c., of course cannot be used for this or any of the root or fallow crops on the farm; and a bean-barrow, or some other form of machine, must be obtained. Where the drill used is not suitable for sowing large seeds and at wide distances, the beans are in some places sown with the bean-barrow, which deposits them at equal distances along the lines of the last ploughing. In order to

secure the desired distance between the rows, every alternate furrow is missed; this, with a 9-inch furrow, would give an interval of 18 inches; by missing two furrows, and only sowing in the third, the interval would be increased to three times the width of the furrow-slice, whatever that might be. To keep the seed-barrow constantly going, all the furrows (two or three, as the case may be) must be drawn at the same time, the necessary number of ploughs following each other, and the sower closing up the rear, and depositing the seed immediately behind the last plough: the harrows then follow and complete the work.

The practice of *dibbling* is far more common with beans than with any other crop, owing probably to the character of the soils and the early period of the year at which they are planted rendering the ordinary tillage processes of machine sowing more difficult and dilatory, and also to the greater facility of manipulation offered by the larger size of the seeds to be deposited. In some places the mode of dibbling the seed is performed in a very primitive manner—the thumb and the finger of the operator being all the tools required; sometimes a small stick or dibble is used, and the seed dropped in the hole. On the bean soils of the eastern counties, the work is frequently seen being done by the joint labour of men and children: the man to make the holes, which he does with two long dibble-rods (sometimes fixed together at the desired width), walking backwards, and followed by two children, who deposit the seed in the holes. Cold fingers and careless hands, however, cause negligent work, and have led to the introduction of various mechanical substitutes, which do the work far better, in every respect, than it can be done by hands, and enable the labourer to make better use of his physical as well as mental powers than he formerly did; while the children, no longer needed in the field for work so unfitted for them, are left to enjoy

the advantages of the schools which are now happily placed within the reach of well-nigh the whole of our rural population. We have already described the method of dibbling in treating of wheat sowing; for beans the hand-dibbles are more suitable, and the one figured, p. 30, Newberry's, is perhaps the simplest and cheapest in construction, and as efficient as any other form of implement in use. In the eastern counties, Bentall's seed-depositor is a simple and inexpensive form of hand-machine—another arrangement known as Crawford's hand-dibble is also highly spoken of by those who have used it.¹ Either of these may be worked singly, or two or three together set in a frame and moved by a common handle, so as to employ the full power of the labourer using them. Dibbling is usually piece-work, from 5s. to 6s. per acre being the average price paid.

In some places we find the work paid for at so much per bushel of seed deposited. This is clearly a very faulty and short-sighted mode of payment, as it places the interest of the labourer in direct antagonism to that of his employer. The object of the latter is to have a given quantity of his seed carefully and equally distributed over his field; whereas the object of the former is to get through as much seed as possible in the shortest time, and thus receive a larger payment for his work. The result too frequently observed, when the plants come up, is that fewer holes have been made and more seed deposited in them; while, in many cases, portions of the intended seed have not been sown at all, but either thrown aside or carried away, if the labourer be a dishonest fellow. This mode of payment exists in Buckinghamshire and the neighbouring counties, where 1s. 6d. per bushel is the average price paid. *In no department*

¹ These are both fully described, and working drawings and details given, in the article "Sowing Machines," in the *Cyclop. of Agric.*

of industry is it good policy, or even just, when it can be avoided, to place the interest of the employed in antagonism to that of the employer. It offers temptation to the good and naturally honest man; and, in the long run, it insures the ruin of the doubtful and the bad. Least of all ought we thus to tempt the agricultural labourer, whose moral perceptions are generally weak from want of development and cultivation in early youth, and whose moral principles are sadly undermined by the daily struggle he has to undergo with the ordinary circumstances of his calling, in order to obtain a bare sufficiency for the support of himself and his family.

The only difference to be observed in sowing beans, is, that they should be deposited in the soil at a greater depth than that of the cereal crops. About two inches is the depth recommended for the spring varieties, and an additional inch for those sown in the autumn. The process of germination in the bean is the same as that described (p. 21) in reference to wheat—a certain amount of moisture, of temperature, and the absence of light, are the conditions required, and these are secured by planting the seed at a proper depth in a suitable soil. The young plant is somewhat longer than wheat in making its appearance above ground; and as its “plumule,” or young stem, is larger, and its mode of growth somewhat different, it meets with more resistance from the surface soil, which frequently, if heavy rains have fallen after the seed was deposited, has got battered down and formed a sort of crust. Therefore, under ordinary circumstances, it is recommended, directly any appearance of the plant at the surface has been noticed, to send the light seed-harrows on the land, and give it a turn up and down the furrows, and across if necessary, so as to loosen the surface and allow the young plant more readily to force its way through. This may generally be done in from

ten days to a fortnight after sowing. A dry day should be selected for the purpose; and it had better not be attempted at all, unless the surface is sufficiently free from wet. When the beans are sown on the ridge, a curved-shaped set of harrows is required for the work.

When the young plant is fairly above the surface, it grows pretty fast; the stem rapidly increases in height and in substance, and leaves of a pale green, or rather glaucous tint, make their appearance in quick succession. The flowering commences at the axils of the lower leaves, and follows with the growth of the plant up to the top, the stem continuing its growth until the process of reproduction (maturing its seeds) is completed.

In order that full advantage should be taken of beans, as a fallow crop between two straw crops, the first opportunity should be taken after the plant is well up, to commence the operation of hoeing; and this should be repeated as often as the crop requires, or as circumstances will permit, until the plants get too high to allow the hoe to pass between the rows without injury. Where the drills are more than 18 inches wide, the first and second hoeings may readily be done with the horse-hoe: any subsequent cleaning is usually better done by the hand, as the plants by that time are too far advanced to admit the passage of the horse between them. When they are sown in lines at distances less than 18 inches apart, they require to be hand-hoed from the beginning; and this must be repeated two or three or more times, as the state of the field requires. The price paid for hand-hoeing is from 3s. to 6s. per acre. About 5s., however, may be taken as an average price.

A great difference of opinion appears to exist as to the best distances at which beans should be planted between the rows or drills. Some advocate a great width, so as to give the plant the fullest exposure to the action of the air

and the sun, and thus enable it, with its numerous large leaves, to appropriate as much organic food from the atmosphere as possible, and increase its productive powers. To effect this, they recommend that something like the Lois-Weedon practice, which has been already described (p. 41), should be carried out, and the beans sown either in single rows or two or three rows together, at very wide intervals—from 3 to 6 feet—or, at all events, equal to the width occupied by the rows of beans, the vacant spaces being either left bare or else occupied by some other fallow crop which possesses a more lowly habit of growth—carrots, turnips, or mangold, for instance—so that the plants of the primary crop, the beans, should be as free from contact with each other and as fully exposed as possible, and placed in full possession of the upper stratum of the atmosphere of the field.¹ To carry out this principle properly, only two rows of beans should be placed together, with intervals between each pair of rows, all over the field. Then each row has one side fully exposed. If more than two rows are tried, the centre rows are no better off than if they had been planted in the customary way.

Where beans are looked upon and treated as a fallow crop, it is customary to drill them at the same distances as the other fallowing crops. In the north this distance is usually 27 inches, which is ample for all the operations of horse-hoeing husbandry to be efficiently carried out. It has, however, been remarked by some of the leading agriculturists, that by sowing at closer distances the growth of weeds is very much checked, less hoeing required, and that the produce is rather increased than diminished. At one of the monthly meetings of the Highland Society,² the “Cultivation of the Bean Crop” was discussed; and

¹ Full details of the results of this practice are given in the *Roy. Agri. Soc. Jour.*, vol. xiv. p. 425, and also in vol. xi. p. 427.

² The paper is given in full in the *High. Soc. Trans.* for July, 1859, p. 22.

Mr. G. Hope, Fenton-Barns, one of the first of the Lothian farmers, gave the result of his experiments, with the comparative advantages of sowing in drills, at distances of 8, 16, and 27 inches respectively. The quantity of seed sown was at the rate of 3 bushels per acre—vetches having been mixed with the beans at the rate of one of vetches to four of beans. A portion of the field was laid up in *ridges* 27 inches apart, and sown in the usual way. A second portion was sown *on the flat*, with Garrett's drill, at 16-inch distances, and the third portion of the field was sown in drills at 8-inch distances apart; the same quantity of seed being sown in each portion. During their growth the 8-inch and 16-inch drills always appeared to be more vigorous than those sown at 27 inches; and although the latter received more labour, in the shape of hoeing at harvest-time, the surface presented the appearance of a mass of weeds, while hardly a green speck was to be seen on the portions of the field occupied by either of the other parts of the crop. Mr. Hope gives us the relative cost of tillage of the three portions under trial, and also their yield.

The 8-inch drills were not horse-hoed at all, but were carefully hand-hoed, and the high weeds at a later period pulled up.

The 16-inch drills were horse-hoed very efficiently with Garrett's horse-hoe, and not touched afterwards.

The 27-inch drills (on the ridge) were harrowed down and rolled just before the beans began to appear above the ground, the other lots being only harrowed at that time. They were then horse-hoed when fairly above the ground, and twice afterwards. They were also all carefully hand-hoed once, and a second time along the ends of the drills, and as far up as the workers could conveniently get for the vetches. The items of cost for each portion are as follows:—

The 8-inch drills—	s.	d.
Sowing, per acre,.....	1	2
Hand-hoeing and weeding,.....	3	6
	<u>4</u>	<u>8</u>
The 16-inch drills—		
Sowing, per acre,.....	1	2
Horse-hoeing,.....	1	2
	<u>2</u>	<u>4</u>
The 27-inch drills—		
Drawing drills and covering (ridging), per acre,	4	0
Sowing,.....	0	4
Rolling,.....	0	6
Hoeing (hand),.....	3	8
Horse-hoeing three times,.....	3	6
	<u>12</u>	<u>0</u>

The three portions ripened equally, and were harvested at the same time. They were stacked, and threshed out separately, when the produce of the portion drilled at 16 inches was found to exceed that drilled at 8 inches by 3 bushels per acre; while the latter exceeded the portion sown at 27 inches by 4 bushels per acre—the straw, also, of the narrowest weighed one-fifteenth more than that of the widest drills. In the preparation of the land for the succeeding crop of wheat an additional expense of 8s. per acre was incurred in cleaning the portion of the field occupied by the 27-inch drills—thus making the tillage expenses of the three trial portions 20s., 2s. 4d., and 4s. 8d. per acre respectively.

When we consider the nature and habit of growth of the bean, and the early period at which it is sown, we can readily detect the principles involved in Mr Hope's experiments, and understand why the medium width was the most productive. The bean is a plant of erect growth, carrying its leaves chiefly at the head or uppermost part of the stem, the lower part being comparatively bare. In the early stage of its growth the horse-hoe readily keeps the surface free from weeds, and their

growth is afterwards kept down by the bushy tops of the beans overhanging the spaces between the rows, and thus closing them in from the action of the air and the sunshine. In the drills at 27 inches, the width was greater than the most vigorous plants could cover up in the growth; and although the greater width enabled the crop to be hoed oftener, and up to a later period of its growth, than the others, still there is ample time, before the crop is ready for harvesting, for weeds to spring up, which they do the more abundantly from the high condition which we always endeavour to bring our bean soils to. Then, again, the same amount of seed-grain was sown on the wide as on the medium drills; consequently, although the distance between the rows was greater, the distance between the plants in the drill or row was proportionably less; and therefore, practically, the plants in the 27-inch drills really had but little advantage in regard to the space allotted to each individual plant; while they laboured under the disadvantage of having to contend against a host of enemies in the shape of vigorous, hungry weeds. How far the produce might have been affected by a proportionate reduction in the amount of seed sown in the 27-inch drills from that sown in the 16-inch drills—say, in round numbers, two bushels instead of three—we cannot say. The experiments, however, are quite sufficient to show that, even for tillage reasons alone, the medium width is preferable to either the extremely narrow drills, which are seen so often in certain districts of the south, or the wide ridges, the common practice of the north.¹ After the beans begin to flower it is not safe to

¹ In planting or sowing, it is always desirable that distances should be regulated, as far as possible, by the standard of measure recognized by the law or the custom of the district. The measurement of surface is computed by the acre, rood, and rod, pole, or perch, this latter consisting of 198 linear inches. Consequently, if the drills or rows be placed at regular distances of some divisional part of this length—say, 18 inches apart—we should have just 11 drills in each rod, and could then readily calculate the exact acreage under

attempt to hoe them any more, and they are then usually left to take their chances in the field. In the north, and some other districts where they are sown on wide ridges, it is customary to finish the cultivation by slightly moulding them up with a drill-plough, drawn by a single horse up between the rows. This, especially on soft, rich soils, is a sound practice: it has all the good effect of a hoeing, while, at the same time, it affords a better support for the bean-stalks by inducing an increased development of rootlets from the base of the stem of the plant.

Beans, during their growth, are not nearly so liable to the attacks, either of disease or of insects, as our corn crops. The injury, however, which they do receive from one of the insects infesting them is generally far more detrimental to them than the attacks of either of the insect enemies to our corn crops which we have hitherto had to describe. This is what is commonly known by the name of "blight," caused by a small, dark-coloured fly—the "Black Dolphin," or "Collier," as it is generally called—which attacks the plant about, or shortly after, the time of flowering, and inflicts such injuries as effectually to destroy the plant, unless its ravages are checked by natural or artificial causes. These we shall have an opportunity of recurring to when we describe this part of the subject, after we have discussed the final process of cultivation—that of harvesting the crop.

Here we meet with a wide discrepancy between the practices which prevail in the north and in the south, especially in respect to the proper period at which the crop should be cut. In the north the straw is looked upon as a valuable fodder substance, and as forming a

crop, by merely measuring the length of the drills, and thus obtaining the number of square rods, 160 of which go to the acre. For field piece-work, as hoeing, harvesting, &c., this is a very convenient practice; therefore, we would rather recommend 18-inch drills for beans than 16 inches, the width adopted in the experiment referred to.

valuable portion of the bean crop; consequently, in order to secure this in its best condition, it is the practice to cut as soon as any indications of maturity are noticed—in many cases, indeed, while the straw is quite green, and before the seed has attained its maximum state of development as a feeding substance. In the south the fodder value of the straw seems to be totally unheeded, as the cutting is usually deferred until the beans are dead ripe and the stems denuded of leaves, blackened by exposure after the circulation has ceased, and so dry as to be not only unpalatable to cattle, but indigestible, like ligneous tissue, when forced upon them in the straw-yard in winter, where it is usually trodden down as litter and formed into dung. Probably we should find the most advantageous period for cutting,—taking both straw and seed into consideration,—to exist between these two extreme practices, and to decide upon commencing harvest operations as soon as the stems and leaves have acquired a brown or blackish patchy appearance, indications that a change is taking place in their structure and functions, and that the process of maturity has commenced. At this time the pod will be found to open more readily to the pressure of the thumb, and the beans or seed to have acquired a black colour at the *hilum*, or eye, and to be more easily detached from their bed.

Beans are more commonly cut with a sickle or hook than by either of the other methods already described. Both the scythe and the reaping-machine make excellent work, especially where the drills have been sown pretty close together. About the same amount of work can be done in the day as with the wheat crop: the price paid per acre is, however, generally less, as it forms the last of the harvest operations, and labour is more abundant. After cutting, if the weather be wet or if the

straw be greenish, they are frequently left lying on the ground for a day or two; or they may be tied up in sheaves, and stooked in the usual way. When grown mixed with peas or vetches, the latter furnish the material for the bands; when grown by themselves, it is always desirable to provide bands of straw, ready twisted for use in the field. Any wet day during harvest is employed for this work, which can be done by women or children; and rye or oat straw is the best for the purpose. The sheaves should never exceed 10 to 12 inches in diameter, and the stooks should consist of six sheaves rather than the number recommended for the cereal crops.

Owing to the herbaceous character of the straw, and the late period of the season, they require to be left longer out in the field—from ten days to even three or four weeks, according to the season and the district. If they are stacked before they are properly dried the straw is apt to become mouldy and unfit for fodder, and the seed acquires a dark colour, and is lessened in market value. In all cases, however, it is better to err on the safe side—to leave them a day or two longer than necessary in the field than to cart them a day or two too soon. In stacking it is generally advisable to build the stacks somewhat smaller than the corn stacks, or, at all events, to secure ventilation by means either of a “boss” or hollow chimney, as described at p. 59. In regard to shape and proportions of the stack, the data there given are equally applicable to this crop. Owing to the habit of the bean to carry seed-pods low down on its stem, it is impossible, in stacking, to secure them all within the stack, a certain number always making their appearance on the outside. These should be thrashed off the stack at once with a long rod or beater, and collected on a rick cloth or tarpaulin as they fall.

Beans should not be kept longer in the stack than necessary, as it is desirable to make use of the straw as soon after harvest as possible. If used as fodder, it is softer and more palatable; and if too dry and fit only for litter purposes, it has longer to ferment and decompose in the cattle-yards. Beans are thrashed out either by the flail or the thrashing machine. Where vetches or peas are mixed with them, care must be taken to arrange the riddles or screens accordingly.

The late period at which beans are ready for cutting, and the length of time they require to remain out in the field before they are fit to be stacked, interfere very much in some seasons with the progress of work on the farm, and inconveniently delay the finish of the operations of harvest. Neither can the bean crop be calculated upon so safely as our corn crops. It is generally more influenced by climatal vicissitudes; and although less subject to disease, and, as far as we at present know, to the attacks of fewer insects, the injuries it does sustain when it is attacked are far more serious, frequently, indeed, resulting in the entire destruction of the crop. To meet these two objectionable points, and to get the maximum effect from the crop, without the risks, inconvenience, and expense of harvesting, it has been recommended to adopt the Belgian mode of cutting them green, and using them in that state as food; or better still, to feed them off on the land by sheep, in the same way as vetches. To carry out this practice properly, a particular description of hurdle should be used (*see diagram*), in which the bars are placed vertically, instead of horizontally, with a stay at the back, which enables the hurdle to be readily moved back and fixed in an inclined position, so that the sheep can consume the quantity allotted to them without treading down and injuring the rest. This form of hurdle is equally serviceable for feeding off vetches, mustard, or any other erect

growing-green crop. Whether for cutting and carting off the field, according to the Belgian plan, or feeding on the ground as now recommended, it is desirable that the plant

should have arrived at a certain state of growth, as near maturity as possible to allow time to get over the whole crop before the beans get too old for such mode of consumption. By either of these methods a far larger amount of food is obtained from the crop than under the ordinary treatment. The entire plant, stem as well as seed, is rendered available and consumed—the risks and expenses of harvesting are saved—the field cleared early enough for the ordinary autumn cultivation, and left, if the crop has been *fed* off, in a richly manured condition, well adapted, from its highly nitrogenized constituents, for the succeeding crop of wheat.

The *diseases* to which the bean plant is liable, do not appear to have excited much notice up to the present time. As the crop, however, advances in our estimation, and becomes a more regular member of our rotations, our attention will be drawn to them, and they will no doubt receive more consideration, both from us as cultivators and from the men of science, who are ever ready to assist us where our knowledge fails. In the early stages of the growth of the plant

it is liable to be attacked by a parasitic fungus, similar in appearance to "mildew," which shows itself generally after cold and wet weather, especially if accompanied by sudden variations of temperature. This is always to be feared more on cold, undrained soils, than even on the strong tenacious clays if they be drained. If the plant is not very badly attacked, which is soon seen by the state of the leaves and stem, the better plan is to cut the crop at once, and give it to the cattle as green fodder, and then to plough up the land as speedily as possible for another crop; or it may be advisable, if the season is somewhat advanced, or if the disease is very bad, so as to render it unfit for use, to run the roller (ribbed, if you have one) over the crop, and then plough it all in as a green manure, which of course would greatly benefit the succeeding crop.

In 1851, a peculiar disease, of a pustular character, was observed affecting the pods of the bean. At first it appeared to confine itself to the surface of the pods, where it assumed the form of a rough black scab. In some cases, however, it penetrated through the pods, and then came in contact with the seeds inclosed in them, which were speedily inoculated with the disease, became spotted and indented, and had their general growth arrested, while the cotyledons themselves continued to be developed,

one of them being variously lobed and overlapping the other; or, if a perforation had taken place in the integument (skin), one of the lobes of the margin projected

through the aperture. Sometimes the substance of the cotyledon is unaffected, but occasionally a pustule similar to those on the pods is observable beneath the discoloured spots.

A full description of this disease, and of the different forms it assumes, is given in the *Gardeners' Chronicle* for 1851, from which it would appear that the disease is by no means uncommon, but is rarely noticed unless it assumes an aggravated form, so as to affect the seed in the manner shown in the diagram. In this case, many of the seeds, which are not deformed by the irregular indented spots, are covered with well-defined brown spots, like those seen in the first instance on the diseased pods, or so common upon the leaves of many plants, insomuch that the sample when matured, can only be sold at a very inferior price. The disease appears to be caused principally by extreme alternations of dry and wet weather, acting upon the organism of the plant growing in a richly manured soil.

In a recent number of the *Agricultural Gazette*,¹ an account is given by the Rev. M. J. Berkeley, of another form of fungoid disease, lately noticed attacking the bean crop, which we will give in his own words:—"We have lately made some remarks upon the disease which has been so prevalent among winter beans. We have since had an opportunity of examining it more minutely, and extending our observations to the same disease as occurring on spring-sown beans, in which it assumes, in general, a milder form, though occasionally taking such firm possession of the plant as to induce rapid decay, especially where the crop is thick, and consequently the haulm is not easily dried after heavy rains or dews. In either case it commences with a red, tolerably defined spot, which is pale in the centre. These spots

¹ *Agri. Gazette*, 1859, p. 677.

often remain of a small size, though occasionally spreading far and wide, especially when occurring on the stem. Though, however, the red spots remain of small size, and therefore comparatively innocuous, the disease does not always cease entirely. Other spots of a brown tinge occur, irregular in outline, but extending in concentric rings, so as frequently to leave slight traces behind, and involving in their course the smaller patches. Though the growth is evidently concentric, the strictest search does not detect any fungoid growth, as might at first be suspected. If the brown patch extends to the stem, decay rapidly ensues. This is not, however, always the case; but though the crop looks miserable, the fruit may still be perfected, though not without exhibiting here and there traces of the disease in the shape of irregular brown spots affecting the subjacent tissues. The disease described in the *Gardeners' Chronicle* for 1851, is probably of a similar nature. Supposing the disease to be arrested by weather unfavourable to its growth, another enemy now steps in, completing the exhaustion of the plant. We have now before us specimens, in which not only are the leaves covered with the red and brown blotches, but in which a third set of spots occurs, snuff-coloured in the centre, and white or pale in the circumference, the central mass consisting of perfectly smooth, sub-globose, brown, stemless spores. These are in fact due to the *Uredo Fabæ* (De C). When possessed by the three kinds of blotches at once, the crop wears a very wretched aspect, and the prospect of the farmer is by no means encouraging. It is well, however, that proper precaution should be exercised before the crop is utterly condemned. We have this year seen a crop of winter beans which seemed in an utterly hopeless state, and which were accordingly destined one fixed day to be ploughed in. Happily, however, the farmer, who is very intelligent, thought that there were signs of the disease

yielding, and he determined to let the crop stand a little longer. His neighbours all believed that he was losing time; but a few days showed that he was perfectly right; and the result is, that he has an abundant crop, the beans in general being large and well coloured, with a small admixture of blotched or speckled individuals. An ordinary cultivator would undoubtedly have followed the example of others. *This is but one amongst hundreds of examples which prove the necessity of close observation in agricultural and horticultural pursuits, where it is too often utterly neglected.*"

The *insect* enemies to the bean crop, and their mode of attack, are far better known to us than the diseases to which it is liable. No sooner is the seed-bean placed in the ground, and the process of germination fairly commenced, than a "millepede," or false wireworm (*see fig. p. 74*), seeks it out, and commences its operations by eating into the substance of the bean, and thus either destroying the seed at once, or so injuring it as to render it capable of producing only a sickly and debilitated offspring, which either falls before the first frost that visits the surface, or lingers on a little longer, to become the prey of disease, or of other insects that visit the plant at a later period of its growth. The "millepedes" generally met with thus attacking the seed, are the *Iulus pulchellus*, and the *Polydesmus complanatus*. Those plants which thrive, and are fortunate enough to escape uninjured by them, are liable, as soon as they appear above the ground, to be attacked by the "Bean Weevils," the *Sitona lineata* and the *Otiorhynchus picipes*. These are in appearance like very minute beetles, of a dark ochreous colour, very much resembling the soil, in which they take refuge during the night, or whenever they are disturbed during the day time, so that, unless detected while at work on the plant itself, it is impossible to discover them. They commence their attacks with the

day-light, and speedily demonstrate their powers of mischief by nibbling off the leaves of the very young plants and thus destroying them; or if the plants are more advanced, by notching them deeply all round, and thus more or less injuring the plants by limiting their feeding powers. This curious condition of the leaves of beans has often been noticed in the garden as well as the field, and birds generally have had the credit of causing it. Now, however, we know to whom to attribute it, though it requires some adroitness to catch the culprits at work, as the slightest motion, or even the shadow of the approaching observer cast by the sun over the plant, is sufficient to warn them, and cause them to fall off to the ground. They generally make their appearance in March, and are most vigorous in their attacks during April, so that the earlier we get our seed in, and the more advanced our crop is at the period of their visit, the better able will it be to resist their attacks. Broadcasting soot or lime, or a mixture of both, early in the morning when the dew is on the plants, is the remedy recommended. Although it does not destroy the weevils, it saves the beans materially from their attacks.

As the plant grows up it has frequently to encounter a more dreaded enemy, the *Aphis Fabæ*—Bean Aphis or “Black Dolphin” or “Collier Fly,” as it is usually called. This minute insect makes its appearance on the uppermost part of the plant, and owing to its enormous powers of reproduction, which Köllar tells us is at the rate of 729,000,000 in one season if the weather be suitable, it rapidly takes possession of the head of the plant, and covers the leaves and stem, gradually descending downwards, until all appearance of colour has disappeared, and nothing is seen but a dark shiny and sticky mass, consisting of winged flies, each of which is supposed to derive its nourishment from the sap of the plant. If this is allowed to con-

tinue unnoticed by the farmer, it rapidly destroys the whole plant, and the crop is entirely lost. If, however, he has watched his fields, and noticed the commencement of the

1. Top of plant infected by *Aphis Fabae*. 2. Winged Aphis (male), magnified. 3. Winged Aphis, natural size. 4. Female Aphis (black colour, no wings).

attack upon his beans, he can generally materially lessen the injury inflicted¹ by cutting off the heads of the infected plants, and either conveying them off the field in baskets and burning them, which is the most effectual way, or having them carefully destroyed by the foot on the place where they fall. Here the larvæ of the common lady-bird do us good service by feeding on these destructive flies, as do also some ichneumons and maggots of other insects.

The botanist tells us that bees frequently are serviceable to vegetation, by carrying the pollen of the male flowers to the ovaries of the female flowers in certain plants, and thus rendering them fertile. In this plant—the bean—he is, however, no friend to the farmer, as

¹ If this be done immediately the insects appear, it is possible no loss of produce whatever may be sustained; for it was an old practice, described and recommended by Sir J. Sinclair in his *Code of Agri.* (p. 340), to cut off the tops of the healthy plant as soon as the flowers begin to decay, in order to swell out the pods and increase their contents.

he has been detected puncturing the base of the flower, for the purpose of more readily getting at its contents, which his bulk prevented him from arriving at in the ordinary way. This, in some seasons, is very destructive to the crop, as the flower, thus injured, is rendered partially or entirely abortive, no pod is produced, and a proportionably lessened yield is the consequence. Two species of humble-bees have been caught in the act, “*flagrante delicto*”—the *Bombus terrestris* and the *B. lucorum*. Curtis tells us that they form their nests in old

1. *Bombus lucorum* (Wood Humble-Bee). 2 and 3. Apertures in calyx of flower, punctured by proboscis of insect. 4. *Bombus terrestris* (Earth Humble-Bee).

loose walls, at roots of trees, &c., live through the winter, and resort to the willows when in flower. They, too, fortunately for us, have their enemies, which check their powers of injuring our crops. The butcher-birds destroy vast numbers of them; while the maggots of certain flies and moths, the *Volucella inanis* and the *Ilithya colonella*, not only destroy them, but eat up their store of honey also.

About the same period of flowering, another class of insects, the *Bruchidæ*—“bugs or beetles”—commence

their operations by laying their eggs in the flowers; the maggots, as soon as born, eating into and feeding on the ripe seed until the beetle is hatched in the spring, when it forces itself out of the cell through the aperture cut by the maggot. These beetles appear to confine themselves to the seeds of pod-bearing plants, and inflict serious injury on stored leguminous seeds of all kinds, though

1 and 2. *Bruchus granarius* (Bean Grain-beetle); natural size and magnified. 3. Infested bean split open, with oval cell (a). 4 and 5. Maggot, natural size and magnified; changing to 6 and 7. Pupæ; natural size and magnified. 8. Horse-bean injured by beetle (b), sown and vegetating. 9 and 10. *Bruchus Pisi* (Pea-Beetle); natural size and magnified. 11. Seed-pea injured by beetle.

generally speaking, they do not destroy the germ, so that infected seeds when sown germinate, but from their injured state they are liable to produce not only sickly plants, but also to propagate the cause of their own injury. To prevent this as far as possible, it is recommended to steep the suspected seed in brine, or in hot water for a minute or so, before sowing. There are two members of this family attacking the bean crop, with which we are well

acquainted, the *Bruchus granarius* and *B. flavimanus*, and these are kept in check by the larvæ of certain parasitic flies, which feed upon their bodies, and thus destroy them. The late-sown crops are more liable to be attacked than the early, and chalky districts are said to be favourable to their increase, from such soils probably producing wild flowers (*weeds*), which supply the beetles with food, and thus aid in propagating their race. When the seed is badly infected, as is frequently seen in foreign beans, they are unfit to be used as food—fatal cases have even occurred from giving them to horses in this state.

The mole-cricket, *Gryllotalpa vulgaris*, is very destructive in some parts of the country to the bean plant. On the Continent, in Germany, and the south of France, they commit sad ravages in the crops, burrowing in the ground like the mole, and coming out to commit their depredations in the dark. In those places where they abound, Curtis recommends that holes should be dug, in September, 2 to 3 feet deep, and about a foot wide, which should be filled with horse-dung, and covered slightly over with soil, to which, on the first appearance of frost, all the mole-crickets will resort, and can easily be destroyed. They are as prolific as they are destructive, but happily they are also very ferocious; and being omnivorous, prey upon each other, the female frequently devouring nine-tenths of her own offspring; besides which the farmer's *real friend*, the "mole," is very partial to them, and disposes of great numbers, in which good work he is actively assisted by the rooks and other strong-billed birds.

The high feeding value which has always been assigned to beans, long before we had any idea of chemistry at all, gave the crop a claim upon the attention of chemists, as soon as they commenced to investigate the constitution of our soils and the plants we cultivate in them. The consequence is, that well-nigh every variety in cultivation, either at

home or abroad, has been investigated and analyzed, either by our own or continental chemists, so that their composition and their soil requirements are now well known to us. The proportion of straw or stem to seed or grain is on the average about 3 to 2; and the average percentage of ash (inorganic matter) in each may be taken at from 2·5 to 3 per cent. in the seed—the smaller varieties containing the largest proportion,—and from 5 to 7 per cent. in the straw. The following analyses, by Messrs. Way and Ogston, give us the percentage composition of their mineral or inorganic matter:¹—

	Seed.	Straw.
Silica,	·03	3·86
Phosphoric acid,.....	31·87	7·35
Sulphuric acid,.....	4·50	3·21
Carbonic acid,.....	1·94	22·73
Lime,	8·65	21·29
Magnesia,.....	6·55	4·88
Peroxide of Iron,.....	·36	·90
Potash,.....	42·13	21·26
Soda,	·90	4·56
Chloride of Sodium,.....	1·90	9·05
Chloride of Potassium,.....	·34	·90
	100·00	99·99

These results are the mean of six analyses of beans in ordinary cultivation—the Heligoland and Mazagan varieties—and of four analyses of the bean straw, by which we also find that the average proportion of water in the bean is about 14 per cent., and in the straw about 10 per cent. Assuming, therefore, that a fair crop of beans would produce 32 bushels, weighing 66 lbs. per bushel, we should find from the foregoing figures that it had removed from the soil something like the following amount of mineral constituents, which must be restored to the soil in some shape or another, if we wish to sustain its normal fertility or condition:—

¹ *Roy. Agri. Soc. Jour.*, vol. ix. p. 152.

In the beans,..... 64 lbs. }
 In the straw,..... 182 ,, } 246 lbs.; or of—

	In the Seed.	In the Straw.	In all.
	lbs.	lbs.	lbs.
Silica,.....	...	7	7
Phosphoric acid,.....	20	13	33
Sulphuric acid,.....	3	7½	10½
Carbonic acid,.....	1¼	40	41¼
Lime,.....	5¾	38½	44¼
Magnesia,.....	4	9	13
Peroxide of Iron,.....	¼	1½	1¾
Potash,.....	28	38½	66½
Soda,.....	½	8½	9
Chloride of Sodium,.....	1	17	18
Chloride of Potassium,.....	¼	1½	1¾
	64	182	246

The organic composition of the bean has also been well worked out by our chemists; and we now readily understand how it has acquired its high reputation as a feeding substance.

Einhof and Braconnot have given its proximate composition as follows:—

Water,.....	15·5
Husk,.....	16·2
Meal,.....	68·3
	<u>100·0</u>

The meal being composed of—

Starch,.....	69
Legumine,.....	19
Gum, sugar, &c.,.....	12

in the 100 parts.

Fresenius gives the following as the average composition of the Common Bean (*Faba vulgaris*), deduced from the analyses of Horsford, Krockner, and Braconnot:—

Legumine,.....	23·3
Starch,.....	36·0
Fatty matter,	2·0
Grape-sugar,.....	2·0
Woody fibre,.....	10·0
Pectic acid,.....	4·0
Gum,.....	4·5
Water,.....	14·8
Ash—mineral matter,	3·4
	<u>100·0</u>

animal life, every process of respiration is carried on at the expense and consumption of some of the non-nitrogenous portions of its food, and every process of motion is equally carried on at the expense of the nitrogenous portions of it. Consequently, the harder the work and the more constant the motion, the larger the consumption of these constituents of the food, and the greater the necessity to replace them, in order to sustain the normal condition of the animal body. In working horses we see the good effect of the mixture of a proportion of beans with their oats, especially if the work be very heavy—coach-work and hunting, for instance—or the animal be old, and its power of assimilation consequently reduced. Indeed, horses seem instinctively to recognize the restorative value of beans to their exhausted powers, by the eagerness with which they welcome the mixture in their regular food, and the manner in which they pick them out from the other grain. To prevent this, and to insure their proper mastication, it is always advisable to split them, or, better still, to crush them, before mixing with the oats and chaff.

Bean-meal, too, enters very beneficially into human consumption, when mixed with other substances, so as to secure the necessary balance between the two classes of food-materials already described. It is frequently added in the proportion of one-tenth to one-twentieth part to wheat-flour in bread-making, which it greatly improves. In the north, especially by the working classes, it is consumed in much larger proportions, both in their panary compounds (cakes, bannocks, &c.), and in their soups and broths. Everywhere, where the animal frame is called upon to undergo severe exertion, beans, or some other leguminous seed, may be used beneficially and economically to replace the consequent wear and tear, and

to keep the body in health and condition. Darwin tells us that in the mines of South America, the labourers, whose work is perhaps the most severe to which the force of man is applied—consisting of carrying loads of 180 lbs. to 200 lbs. up steep ladders to the surface, from a depth of 450 to 500 feet—are fed entirely upon coarse bread and beans. They would rather confine themselves to bread alone; but their masters found that their strength failed upon that diet, and their work regularly decreased, so that they enforce the mixture of beans, in certain proportions, in their daily amount of food.

Although the feeding value assigned to beans has been checked and confirmed by several of our leading chemists, that of *bean-straw* appears to have been entirely disregarded by them; as, so far as we know, the only published analysis of its *organic* composition is that contained in Mr. Horsfall's paper on the "Management of Dairy Cattle," in the *Royal Agricultural Society's Journal*, vol. xvii. p. 263. This analysis,¹ however, is manifestly so inaccurate, and consequently so liable to mislead, that Dr. Voelcker kindly undertook to investigate its composition for me, and thus furnish a more correct (or, at all events, another) standard by which we could estimate its real feeding value. The result of his analysis shows a wide difference in the constituents, and reduces materially the amount of nutritive matter assigned to it in Mr. Horsfall's paper. Its composition is thus given:—

¹ Moisture,.....	14·47
Albuminous matter,.....	16·38
Oil or fatty matter,	2·23
Woody fibre,	25·84
Starch, gum, &c.,	31·63
Mineral matters,.....	9·45
	<hr/>
	100·00

Water,.....	19.40	
Compounds containing nitrogen—albumen,.....	3.36	
Compounds not containing nitrogen—oil and fat.....	1.02	
" " gum and digestible fibre,...	6.93	
" " woody fibre (indigestible),	65.58	
Mineral matter, soluble,.....	2.31	
" insoluble,.....	1.40	3.71
		<hr/> 100.00

These proportions of valuable compounds, however, are quite sufficient to enable us to recognize the superior feeding value of bean-straw as compared with the straw of other seed-bearing crops (p. 162), and to show the importance of harvesting our beans at the proper period, so as to secure the full feeding value of the straw as well as of the seed.

THE PEA CROP.

THE next member of the order LEGUMINOSÆ that we cultivate for its seeds is the PEA, which, however, is met with in our "Farm Crops" to a far more limited extent than the bean. It is generally supposed to be a native of southern climates, and was well known both to the Greeks and Romans, frequent mention being made of it in the works of the old writers on rural subjects. Dr. Lindley considers that the Common Gray Pea, still found growing wild in Greece and other parts of the Levant, is the origin of our Common Pea, and of all the highly domesticated varieties belonging to it. In this country it has been known and cultivated for centuries past. Most of our early writers have some mention of it, either as a garden vegetable, or as being grown as a field crop, in the vicinity of large towns, where a ready market could be obtained for it in its green state. Lydgate, a writer in the time of Henry VI., speaks of peas being hawked about in the streets of London. Indeed, before the introduction of the potato, they appear to have entered more largely into general consumption as an article of food than at the present time. Horticulture was then more advanced in Holland than in our own country, as Fuller tells us that in the time of Elizabeth it was the custom to obtain the best varieties from Holland, "as fit dainties for ladies—they came so far and cost so dear."

The pea is a far more delicate plant than the bean,

more particular in its choice of soils, and less able to bear the changes of a variable climate. This, since the universal introduction of root crops into our rotations, has no doubt tended very much to lessen its cultivation, even in those districts where the climate is not unfavourable to its growth. At present we rarely find peas entering into the regular rotations of the farm, except in certain districts, where the soil and climate are favourable to their growth. Their cultivation elsewhere is generally for special purposes, either as a change from other cropping, or as a green market crop, where proximity to a large population insures a ready and remunerative sale. In Scotland, their position as a field crop is shown by the statistics for 1857, where the acreage under cultivation in beans is returned at 39,186, while the acreage in peas is only 3687. These proportions would probably be equally applicable to England.

The pea is classed as a leguminous plant, and is termed by the botanists *Pisum sativum*, or Cultivated Pea. Although its botanical characters admit of only one species, still there are so many varieties in cultivation, with certain well-marked and persistent characteristics, that, for practical purposes, they may be classified under two heads, viz., *Pisum sativum arvense*, which includes all those varieties suitable for cultivation in the field, and *Pisum sativum hortense* which comprises those varieties suitable for garden cultivation. They are commonly distinguished by the flowers—the former being coloured, the latter simply white. Of both of these there are a great number of varieties cultivated. The garden varieties receive numerous additions every year, and are known by an equal variety of names. These, however, we shall have no further occasion to allude to.

The field peas in ordinary cultivation have generally purple-coloured flowers, the seed being either white, dun,

gray, or speckled. Of these the following are the favourite varieties:—

Common Gray.—This is the variety most commonly grown. In the south it is met with as a distinct field crop; but in the north it is usually grown with beans, for which purpose it is well adapted, as, being a late variety, it comes to maturity at about the same time. It is very prolific: on rich soils it becomes too bulky in the straw; but on dry soils, even if the climate be moist, it produces a good return. The pod is semi-cylindrical, long, and well filled, and contains from five to eight peas or seeds. Towards the time of ripening but little difference is observable in the straw; but when thrashed out, three distinctly-marked varieties appear—one spotted, with a bluish-green ground, one light blue, and one bluish-coloured green, without spots. When grown with beans, which keep the stems off the ground, the return is frequently very large. Under ordinary circumstances it is a good cropper, and the haulm or straw makes excellent fodder for all descriptions of stock.

Hastings Gray is a late variety, but earlier than the last. The stem is longer and more slender than the Common Gray. Its pods are long, cylindrical, and well filled, the seeds being compressed at the side. It is suitable for light soils in districts which are too late for the Common Gray, where its yield is always more satisfactory.

Warwick Gray is the earliest of the gray varieties, or indeed of any of the field peas in cultivation. It is also known by the name of the Banbury or Nimble Hog Pea. In Scotland it was sown on the 29th March, and harvested on the 20th July. In the south it has been sown the first week in April, and cut in the last week in June. It usually comes to maturity three weeks earlier than the Hastings Gray, and from four to five weeks earlier than the Common Gray, and therefore is well adapted for late

districts. The stem is generally short—from 2 to 3 feet; the pods small, straight, and cylindrical, containing from three to five seeds, which are small, round, or slightly compressed, with small purple-coloured speckles.

Rounceval Gray, Giant, or Dutch Pea.—This is the latest and the largest of our field peas, and also the most vigorous in its growth, the straw frequently attaining a length of from 8 to 10 feet, and rarely less than 6 feet. The pods are generally in pairs, broad, and rather flat-sided, and contain five or six seeds, which are a good deal flattened and wrinkled, of a dun-brown colour, with small black eyes. It is less hardy than the foregoing, and is more suitable for the climate of the south than of the north of this country.

Partridge is known also by the names of the Gray Maple and Marlborough Pea. It is an early variety, taking place next to the Warwick, and is very generally esteemed as the best variety for cultivation in late districts, as it combines the properties of being very early, prolific, and of excellent quality. It is a vigorous grower, with a succulent stem about 4 feet high; leaves large and broad; and bearing broad, well-filled pods, containing from five to seven seeds, roundish in form, of a medium size, and of a yellowish-brown speckled colour, with light-coloured eyes. In the north this pea is usually grown with the earlier varieties of field beans, as the Annfield, Heligoland, or Mazagan.

Purple-podded or Australian.—This variety appears at present to be but little known in cultivation, yet Mr. Lawson and others, who have tried it, report most highly in its favour, and consider that it possesses properties which entitle it to our consideration, as especially suitable to late districts. It is remarkably prolific, earlier even than the Partridge, with stems growing from 5 to 6 feet high, carrying fleshy pods of a dark purple colour, containing five or

six seeds of an average size, slightly and irregularly compressed, and of a light dunnish colour—always making an excellent sample. The colour of the pods is not permanent: sometimes they are met with green, in which case they are, however, readily distinguishable from those of ordinary peas by their thick and fleshy nature.

Winter.—This is more generally met with on the Continent than in this country: here, however, especially in the south, its cultivation is increasing. It is very hardy, and stands the severest winters without injury, coming to harvest much earlier than the spring varieties. If this, however, is sown in the spring, then it becomes a late pea, and remains out after the others are harvested. It grows to the height of 3 to 4 feet. The pods are small, cylindrical, and straight, containing from four to six peas of a dark colour, and smaller than any of the other varieties of peas. It is the *pois gris d'hiver* of the French.

The pea, like the bean, delights in soils of a calcareous character, and is classed with it as one of our lime plants, or plants into whose composition lime enters in large proportions. The soils most suitable for peas are those of a light loamy or marly character, rather partaking of the characters of our best barley soils than of those which we are accustomed to call wheat and bean soils. The necessary conditions in the soil for peas cultivation are, that it be perfectly free from stagnant water, and yet of sufficient depth to retain its natural moisture,—that it contain a sufficient proportion of lime,—and that it be in good heart and tillage condition; and if these points cannot be secured, the chances of a good return are considerably diminished. These characters we generally find in the soils of the secondary formations—the cretaceous, oolitic, and new red sandstone series; while the soils proceeding from the more recent tertiary formations, as the alluvial deposits and the clays of the London basin, and the soils

of the earlier primary, as the carboniferous and silurian series, are not, either from their composition or from the surface area they occupy in this country, so suitable for this crop. In the secondary series, too, we find many soils equally unsuitable to it—for instance, the weald and gault clays of the cretaceous, the Bradford and lias clays of the oolite; while the new red sandstone, though rich in marls, is in some places so destitute of lime as to form very poor soils, and to need the addition of it artificially before the cultivation of peas can be attempted with any prospect of success.

Not only will the pea grow on a lighter class of soil than the bean, but it will grow also on shallower soils, as, although its habit of growth is the same, the plant itself is of more delicate character, and its tap-root contents itself with a less depth of soil than that which the bean requires for its development. Neither the strong clay soils nor those of a humous character—such as the fen-lands, bogs, &c.—are suitable for peas. The former will frequently carry a good crop, especially in a dry, warm climate. At the same time, they would be more suitable for beans, and would

produce a better crop; while the latter, if rendered suitable, by claying or marling, for tillage cultivation,

would be likely to induce too luxuriant a growth of stem, and to reduce the power of the plant to perfect its seeds. In such soils, however, peas may be grown advantageously mixed with beans—the bean stem affording the necessary support to the pea, keeping it off the ground, and giving it access to the air and the sun, and the mixed crop yielding a greater return than if beans had alone been sown. This is a favourite practice in many districts, as it is said not only to increase the yield, but also to reduce the chances of loss from blight, which appears to be less injurious in its attacks than when either plant is sown alone—the beans retaining their vigour and producing a crop should the “green aphid” attack the peas; while the peas remain uninjured when the “black aphid” (p. 235) is destroying the beans. In many seasons the entire crops of large districts have been destroyed by the visitation of these insects. In 1854 the bean crop in the south suffered severely from the “black aphid;” and in 1858 the pea crop throughout a wide range of country was similarly injured by its green congener. In Scotland peas are rarely sown by themselves: neither the soils nor the climate are so suitable for their cultivation as in the south. In some of the warmer districts, and on the rubbly soils of the disintegrated trap rocks, too thin in many cases for beans, peas are cultivated successfully, and give very good returns.

As has been before remarked, peas, in ordinary farming, seldom enter into the regular rotations. Where they do, they ought always to occupy that place which has been assigned to beans, as a member of the leguminous order of plants. This can be very well arranged, where it is desired, as peas may be grown successfully on a class of soils which are not the best suited for beans. On the light soils farmed on the four-course system, it is very desirable to alternate some other leguminous crop with the clover, so

that clover may be taken at eight years' interval, instead of every fourth year. In this case peas would, on most soils, be a more suitable crop than beans, and might with advantage be substituted for them as a change, with either the whole or a portion of the clover land, as already described. On the stronger descriptions of soils, where longer rotations are practised, it is always desirable to place peas between two straw crops, and to treat them as a fallow crop. If sown after a root crop, as is sometimes the case, the straw is too luxuriant, and the yield is proportionably diminished. In Scotland, on suitable soils, they are taken instead of potatoes or beans, and generally precede wheat; but more commonly they are mixed with the bean crop, and then take place in the regular rotation. Peas, however, are not equal to beans as a fallowing crop; for although, chemically speaking, they are the same in their effects on the soil, their habit of growth is so different as to render it well nigh impossible to keep the land clean, and in a proper condition for the succeeding crop. If a system of autumnal cultivation be properly carried out, and the land well cleaned before the winter commences, but little more is generally required to be done to it before seed-time in the early spring. Then the horse-hoe should be actively employed as long as the plants will admit of it, after which their trailing growth is generally sufficient to keep down the annual weeds, and to leave the surface tolerably free from them at harvest-time. In the pea-growing districts of the south, a more negligent mode of farming is generally met with. The weeds of the past year are commonly allowed to seed after harvest, and are ploughed in with the light furrow slice of the district. In the spring the peas are got in—sometimes in narrow drills, at others broadcast—too early to admit of anything like a good cleaning, and, indeed, before the seeds have germinated. A single hoeing is at most all that is given to

them, and they are left to take their chances of success—to struggle for food with the indigenous occupants of the soil, until harvest, when a stunted crop and poor yield show the impolicy of the system, and the field is left more foul and impoverished than it was before.

The selection of the seed requires the same attention as has been recommended for the crops already described. When from any cause old seed is used, it is a good practice to steep it for about twenty-four hours in plain water, in order to induce a regular sprouting. The process of pickling the seed previous to sowing, however, is never practised. The quantity sown is from 2 to 3 bushels an acre when drilled, and about double the quantity when sown broadcast. The period of sowing is materially determined by the sort of pea to be sown, the later varieties requiring to be sown earlier than those which come to maturity in a shorter time. As a rule, it is advisable to get the crop sown as early as the state and condition of the land will permit, as it has been noticed that the forward plants are less subject to mildew than those of backward growth. From the first week in February to the last week in March is the best time for getting the crop sown; and at this time of the year it is always good policy to wait a few days, rather than to go on the land before it is in a suitable condition to receive the seed. The winter variety is of course sown earlier—in October, or the first week in November; and the quick-growing varieties, such as the Warwick Gray, or Nimble Hog Pea, are frequently grown successfully, especially in moist seasons, when the sowing has been delayed until the middle of April.

The preparation of the land has already been discussed in reference to other crops, and the same general rules or principles hold good with all our cultivated plants, viz., that the soil be tilled as deep as possible; that its particles

be in a state of minute division, finely pulverized; and that it contains all the food-substances that the growing crop requires. If these conditions are not secured, your crop is diminished accordingly. Some plants, it is true, owing to the difference of their root development, do not require the same depth of soil as others do; for instance, the barley does not require the same as the wheat (see p. 212), nor the pea as the bean. For all crops, however, it is desirable, though for some it is more necessary than for others.

In growing peas, where the value of the straw for fodder purposes enters into consideration, manures more rich in organic matter may be used than where they are grown merely for their seed. Farmyard manure, if applied directly to the crop, generally produces a too luxuriant growth of straw; while Peruvian guano, in the proportion of from 3 to 5 cwts. per acre, according to the condition of the field, is in most soils sufficient to secure a good crop of both straw and seed. Where farmyard manure is used, the addition of superphosphate of lime—about 2 to 3 cwts. to the acre—is followed by the best results; or even lime itself may be used. In this latter case it is desirable to plough the lime in with the winter furrow, and to apply the dung in a well rotted state at the time of sowing in the spring; or, better still, to reverse the operation, by ploughing in the fresh manure with the winter furrow, and applying the lime previous to sowing in the spring. The action of the lime would thus be more energetic and effective in a soil charged with rich organic matter. In all cases it must be remembered that *lime* is a *necessary* ingredient in soils where peas and beans are to be grown. Gypsum (sulphate of lime) is a very good form to apply it in, if it can be obtained at a suitable price, as the pea requires both lime and sulphuric acid (see analysis, p. 261) to complete its processes of growth. It has been affirmed that

gypsum has a tendency to make the peas *boil hard*. This common impression among pea-growers, however, should be dispelled, since the results of analysis (Dr. Voelcker's) would appear to show that the difference in cooking between peas must originate in other causes than that referred to. Two varieties of peas—the one noted as *hard* boilers, and the other for their property of boiling *soft*, and both being suitable for table use—were submitted to analysis, and Dr. Voelcker found that the proportion of sulphate of lime was practically the same in both.

The mode of sowing is either by broadcast, drilling, or dibbling. The former is still largely practised in the pea-growing districts, while the latter method is not seen followed to the same extent as with beans. Broadcasting cannot be admitted under any conditions. Even if the land is carefully cleaned before sowing, the weeds in such soils are sure to spring up and check the growth of the plant, by which the whole object of the fallow crop is destroyed, and a large outlay for labour again required before the land is fit for the succeeding crop. Drilling, at distances from 18 to 24 inches between the rows, gives the plant a more regular and equal distribution of space to grow in, while it affords an opportunity of keeping the weeds down by hoeing, until the plants cover over the intervening spaces, and check their further growth. When they have arrived at this point of their existence, no further attention is required, and they must take their chances of success or failure, as the weather and disease may favour or check their increase and maturity. By drilling, also, you can more readily regulate the depth at which the seed is deposited in the soil. This should be about 2 inches, as mice and birds, pigeons especially, commit sad devastation if the seed is within reach of the surface. The flowering takes place irregularly, as with the bean, the lower and more matured part of the stem bearing its flowers before

the upper portion, which continues its growth even after pods are formed below. The crop is ready for harvesting generally in about six to eight weeks after the period of flowering has commenced. The right time for cutting is determined by the lower pods being properly matured and yielding readily to the pressure of the thumb. Those on the upper part are then sufficiently advanced to ripen while lying in the field; while the last-formed pods, at the extreme end of the plant, if they yield no seed, add considerably to the nutritive value of the straw for feeding purposes.

The cutting is usually performed with a sickle or hook—in some places the scythe is used; but if the crop be heavy, or much laid on the ground, the scythe is very apt to cut through the pods, and leave a larger proportion of the seed on the ground than when the hook is used. Where peas have been sown with beans, the scythe may be used with advantage. In the north good work is made with a tool called a “peas-make,” made of an old scythe blade fixed in a short handle, a hooked or curved stick in the left hand holding the stems while being severed, and collecting them when cut. In the south a large hook is used, and the trailing stems are collected with an old worn-out hook, in the same manner. When cut they are generally loosely rolled up in small bundles, or wads, and left lying in rows on the field. These require to be carefully turned every, or every other, day, until they are fit for carrying, which of course must be determined by the condition they are in at the time. The price paid for cutting varies with the crop and the season. It may, however, be taken at about half that which is being paid for wheat (reaping), as the rows are wider apart and no binding is required. Care should be taken not to cart the crop until it is sufficiently dry for stacking, as, owing to the soft nature of the straw, it sinks down very close, and,

if not in proper condition, it either heats or gets mildewed, and both the straw and the seed are greatly deteriorated in value. It is always desirable to stack peas on staddles, or on a raised frame of some sort, and also to insert a boss, or secure some other means of ventilation through the mass of the stack, as described at page 59. The sooner peas can be thrashed out the better; for if they are kept too long in the stack the straw becomes very dry and brittle, breaks up into small pieces when thrashed, and a great proportion rendered unfit for cattle, except in establishments where steaming arrangements exist, and it can be mixed and steamed with the other food. Few crops vary more in their yield than peas: 32 to 40 bushels to the acre may be taken as a fair average crop, on a suitable soil. Some seasons the ordinary returns are not half this quantity; while instances are recorded of a produce of 84 bushels per acre from the Partridge variety in a wet season, and of 62 bushels per acre from the Common Gray Pea, grown on a strong clay soil in the neighbourhood of Cupar-Fife.

The pea suffers from the attack of the same parasitic fungus that injures the beans at an earlier period of their growth. In this case, too, the same treatment is recommended—to cut them down at once, and use them as a forage crop. If they are very badly diseased, it is not advisable to give them to the cattle; but if not too far advanced in growth, it is better to run the roller over them, and then to plough them in as a green manure, and get another crop sown on the ground as soon as possible.

The *insects* that attack the pea crop are fully as numerous as those described as being injurious to beans; while there are one or two others which are peculiar to it, and in certain seasons inflict great injuries on it. No sooner are the peas placed in the ground than they are eagerly sought for by the snake-millepedes, which, in wet seasons

more particularly, destroy a large proportion of the seed. The plants that have escaped the attacks of these insects have to encounter another, directly they appear above the ground, where they are immediately visited by the weevils—*Sitona crinita*, the spotted pea-weevil, *S. lineata*, the striped pea-weevil, and the *Otiorhynchus picipes*. These are all well-known enemies to the pea, which they prefer to the bean, or any other leguminous plant, devouring the entire leaves of the young plant,

1 and 2. *Sitona crinita*, natural size and magnified. 4 and 5. *S. lineata*, natural size and magnified. 3. Leaf notched by Weevils.

and thus effectually destroying it, or injuring it by nibbling and notching, if more fully grown. The “striped weevil,” however, is the one most commonly met with in our fields. Many remedies have been suggested. That recommended in reference to beans is the most practicable and effectual, viz., to send the light seed harrows over the field early in the morning, when the dew is on the plants, so that the soil may adhere to the leaves, which will at once stop their work, as they never venture on a soiled or dirty leaf. Broadcasting soot or lime, or any finely pulverized substance, when the leaves are moist, would have the same effect.

When the plant has attained a moderate growth, you

may frequently see, on closely observing the leaves, little faded patches, with a minute brown speck in their centres. On examination with a good glass, these are seen to be the pupæ of a small fly, the *Phytomyza nigricornis*, the same as that which infests the turnip leaves, the larvæ feeding on the "parenchyma," or fleshy part of the leaf, and sadly injuring it and interfering with its functions. As their growth advances too, just at the time of flowering, they are liable to be attacked by the *Aphis pisi*, "pea-aphis," or "green dolphin," as it is sometimes called, to distinguish it from the aphis infesting the bean plant. These commit, in some seasons, great ravages in the crop, and although not generally so serious in their results as the attacks of the "bean-aphis," still the effects, on the whole, are equally felt, as, owing to the trailing habit of the pea, the same treatment there recommended cannot be administered, and the plant has to sustain the full brunt of their attacks. As soon as the pods are formed, they become suitable receptacles for the maggots of certain little flies.

1. Caterpillar on pea, which it has eaten out. 2. Caterpillar, magnified.
3 and 4. Moth (*Tortrix pisana*), natural size and magnified.

Then the caterpillars of a moth (*Tortrix pisana*) live upon the young green seeds (peas) in the pod, rendering them "maggotty" at harvest-time, and injuring the whole sample. These worm-eaten peas, when thrashed out, are infested by the *Tinea sarcitella* (the white-

shouldered woollen moth), which finishes the work of destruction already commenced. Stored peas suffer equally with beans from the grain-beetle (*Bruchus granarius*), and the pea-beetle (*B. pisi*), (see figs. 9, 10, p. 237), which conduct their attacks in the manner already described. Their transformations, from the egg to the perfect beetle, are carried on so silently and securely that it is only by the comparative lightness of the grain, or by the appearance of the beetle, that any idea of the mischief that has been inflicted can exist. Curtis recommends that the seed peas be kept until the second year, when all the beetles will have deserted them; or they may be immersed in boiling water for *one* minute, which will destroy the insect without injuring the vitality of the seed. These destructive beetles are happily kept in check by certain ichneumon flies—the *Sigalphus pallipes* and *Chremylus rubiginosus*—which prey upon the bodies of those and other members of the family Bruchidæ. Light chalky soils appear to be most subject to the attacks of this destructive family, probably owing to the weeds indigenous to such soils favouring its powers of increase.

The *Chemistry* of the pea crop has been well worked out. The high estimation in which peas have been so long held, both as a garden vegetable and as a valuable article of food, in their stems as well as seeds, for all descriptions of animals, has secured to them the attention of the leading chemists, abroad as well as at home, whose investigations have made known to us the composition of their organic as well as inorganic constituents. The proportions of grain to straw, of course, vary with the circumstances under which they have been grown—as soil, climate, variety, &c. Johnston gives them at 1 to 2·08; Schwerz, at 27 to 73; and De Gasparin at 1 to 3·5. The average may be taken at 3 to 7, or 30 of grain and 70 of straw in the 100 parts. The ash or inorganic matter in the seed averages about

3 per cent., in the straw about 5 per cent., and in the pod about 7 per cent.

The composition of the inorganic (mineral) matter may be taken as follows:—

	Grain. ¹	Straw. ²
Potash,.....	36·05	11·78
Soda,	7·42	6·55
Lime,.....	5·29	40·34
Magnesia,.....	8·46	8·30
Oxide of Iron,.....	·99	1·03
Phosphoric acid,.....	33·29	8·26
Sulphuric acid,.....	4·36	6·76
Silica,.....	·51	10·66
Chloride of Sodium,.....	3·13	6·32
	99·50	100·00

These analyses show us the large proportion of lime which the pea requires to enable it to carry out its processes of growth and reproduction; and if this lime be not naturally present in the soil, or be added to it in the shape of manure, as phosphate or sulphate of lime (gypsum), or in the shape of amendments, as marling, liming, or chalking, the cultivation of peas cannot be successfully carried on. At the same time, they show that the crop requires large supplies also of potash and phosphoric acid, which can only be obtained in a soil in a high state of cultivation; and if these points are not secured, the crop must be proportionably diminished. The ingredients removed from the soil by a crop of peas are the same as those removed by the bean crop, though the total quantities are somewhat less, as the straw of the bean contains a higher proportion of mineral substances than that of the pea. For all practical purposes, however, the tabulated quantities given at p. 240 will serve for both crops.

The organic analyses of peas and of pea straw at once indicate their high feeding properties, and thus confirm

¹ The mean of several analyses.

² Hertwig.

with wheat-flour, for bread-making; and a white variety, round and plump in shape, is largely cultivated for use for culinary purposes. It is essential that these should be good *boilers*,¹ so as to “melt,” as it is termed, readily, and assume a semi-fluid or plastic condition. In Scotland peasemeal is very generally consumed, by the rural population especially, either mixed with oat, barley, or sometimes wheat meal, in the form of bannocks or cakes, or else as an ingredient in the broth that forms part of their daily food. For cattle-feeding, peas are equally valuable as beans. To pigs they are frequently given whole, though it is much more advantageous to give them in the shape of meal, mixed with some other kind of food richer in fat-forming materials, as peas or beans given alone are apt to give a firmness and hardness to the flesh, which for food-purposes is not desirable.

The straw has not been subject to such a rigid investigation as the seed; indeed, our knowledge of the action of particular feeding substances upon the economy of the lower animals is too imperfect to render the rigid investigation of substances supplied only to them so necessary as when they enter also into the food of ourselves. The analyses, however, of Sprengel, Hertwig, and Boussingault, make us sufficiently acquainted with its composition to recognize at once its great value for all fodder purposes. Its average composition is thus given:—

Nitrogen compounds (flesh-formers),.....	12·55
Compounds not containing nitrogen,.....	47·52
Compounds suitable to support respiration, and to lay on fat,	21·93
Water,.....	12·00
Ash (mineral matter, suitable to the formation of bones, cartilage, &c.),	6·00
	<hr/> 100·00

The correctness of these several analyses is confirmed

¹ It is said that the addition of a small proportion of soda to the water in which they are boiled, will cause the “bad boilers” to become soft. This would tend to point to the “legumine,” rather than the sulphate of lime, being the cause of difference in the boiling properties of peas.

by those of Liebig, who reduced the several *proximate* organic compounds to their *ultimate* elements, which he found to exist in the following proportions:¹—

	In the Seed.	In the Straw.
Carbon,	46·5	45·8
Hydrogen,	6·2	5·0
Oxygen,	40·0	35·6
Nitrogen,	4·2	2·3
Ash,	3·1	11·3
	100·0	100·0

At the same time, without questioning their correctness, we find that these results give a higher value to the pea-straw of the Continent than our own possesses, by which, of course, we must be guided in fixing its comparative value as a feeding substance.

It has been quite recently the subject of a careful investigation by Dr. Voelcker, who gives its organic composition as follows:—

• Water,	16·02
Compounds containing nitrogen—albumen,	8·86
Compounds not containing nitrogen—oil and fat,	2·34
" " " gum, and digestible fibre,	25·06
" " " indigestible fibre,	42·79
Ash (mineral matter),	4·93
	100·00

These results, though somewhat less favourable than the preceding, clearly show us that pea-straw is far more valuable for fodder purposes than the straw of any of our other cultivated crops.

• In these ultimate analyses, the substances were previously dried at a temperature of 110 centig.=250° Fah., by which all their water was driven off, and the relative proportions of constituents consequently increased.

THE TURNIP CROP.

WE now have to consider a very different class of our "Farm Crops," that class which comprises those usually known as "root and fallow crops." Of these, turnips naturally in this country take the precedence, being the keystone of our improved system of farming—the crop by whose success or failure the welfare of the whole rotation is mainly influenced.

Hooker tells us that the turnip is one of the plants indigenous to this country, and is not uncommonly met with in waste places, at the sides of roads, &c. When it was first introduced into cultivation in this country is not very distinctly known, as, doubtless, it was cultivated to a greater or lesser extent in the gardens of the religious houses from the time of the Romans, to whom, it is most probable, we are indebted for a knowledge of its value, as well as for several other of our culinary herbs. As long back as we have any distinct records of agriculture to refer to, we find information respecting this plant. The Romans, and even before them the Grecian authors—Hesiod and Theophrastus especially—have given us full details of the value placed upon turnips by the farmers of their day, and also of the methods recommended and adopted for their successful cultivation. Columella speaks chiefly of two sorts grown in his time—the *rapa* and the *napus*. Palladius confirms the statement of Columella, and, remarking on the two varieties, gives it as his experience that the difference is due to cultivation and the soil, and that by due care they

may be either preserved separate or changed into each other. Pliny mentions three distinct species, of which he gives a detailed description. He speaks strongly in their praise, and says they were accounted as the third in value of the cultivated crops, the vine and corn being ranked before them. They each describe the character of soils best suited for the cultivation of both sorts—the one delighting in a lighter class of soils than the other; and they all agree in strongly recommending that the land be well broken up by repeated stirrings until a fine tilth be obtained, and that it be well manured. The diligent farmer, says Pliny, ploughs four times for his *rapa* and five times for his *napus*, and never forgets his dung. He also tells that in his time many of the roots on a well-cultivated farm would weigh upwards of 40 lbs. each.¹ The quantity of seed to be sown is given at about 4 lbs per acre, and directions are not forgotten to thin them at a certain stage of their growth, so that those left, which should always be the strongest and most vigorous plants, should have more air and room for increase. Our enemy “the fly” appears to have been well known to them, as they all speak of the injuries it caused to their crops, and offer remedies or palliatives to its attacks. Columella says he successfully used to collect the dust from his chambers and the soot from his chimneys, and steep his seeds in this, mixed with a small quantity of water. Palladius used to content himself with strewing a mixture of soot and ashes in the drills at the time of sowing. Our turnip-fly is probably the same insect that is referred to by the Roman authors as attacking their crops, and our most approved remedy is to place the seed in the soil under those conditions most likely to insure a speedy and

¹ This is an extraordinary weight, even in our own country; while on the Continent, especially in the warm climate of Italy, the turnip of the present day dwindles down to a size far below that ordinarily met with in our crops.

vigorous growth, so as to carry the young plant as quickly as possible out of the reach of its enemy. This, we consider, is accomplished by securing a fine tilth for the seed-bed, and by depositing at the same time with the seed a certain quantity of readily available manure, either in a solid or a liquid form. This is our advanced practice, and now only to be met with in practice on our best cultivated farms; and yet the practice was known to and commonly adopted by the Roman farmers 2000 years ago.

The great weakness of Roman agriculture was the superstition attached to every operation. While turnip-sowing the husbandmen were accustomed to pray that the crop might prosper and increase both for themselves and their neighbours; and we find, consequently, that no restrictions were placed against the practice, too common in some districts in our own times, of persons pulling them while growing in the fields. In the cultivation of the turnip, and in its general use on the farm, especially as a feeding substance for the cattle during the winter, the ancient farmers were quite as well versed as the modern; and indeed that improved system—turnip husbandry—which so contributed to the progress and material welfare of the country at the close of the last and commencement of the present century, appears, in the time of Columella, to have been commonly practised in the Roman provinces in Italy and Gaul.

In our own country we have reason to believe turnips were cultivated in the gardens of the religious establishments from the earliest periods of our history. They are mentioned by several of our early authors—by Googe,¹ in 1586; by Gerarde,² in 1597; by Parkinson, in 1629; but, as no allusion is made to their field culture, and as different names are applied in describing them,

¹ *Whole Art of Husbandrie*, by Barnaby Googe. A.D. 1586.

² *The Herball, or General Historie of Plantes*, by John Gerarde. A.D. 1597.

it is somewhat uncertain whether the "rape" or the "turnip" is the plant alluded to. Be that as it may, with the authors already quoted, we are distinctly informed by the great botanist Ray, in 1686, that at that date they were grown everywhere, in the fields as well as the gardens, for the sake of their roots. Lisle, in his *Observations on Husbandry*, at the beginning of the eighteenth century, speaks of them as being in field cultivation; but the first and principal improvement in their mode of treatment appears to be due to Lord Charles Townshend, of Rainham, in Norfolk, in 1730, whose successful system of cultivation gave them a status as a crop which they did not possess before. In a recent number of the *Quarterly*,¹ in a clever and interesting article on the progress of British agriculture, the subject is thus alluded to:—"A new source of agricultural wealth was discovered in turnips, which, as their important qualities became known, excited in many of their early cultivators much of the same sort of enthusiasm as they did in Lord Monboddo, who, on returning home from the circuit, went to look at a field of them by candle-light. Turnips gradually replaced the old fallows, filled the cattle mangers with food in winter, and, when fed off on the light soils by sheep, consolidated while they manured them, and prepared the way for corn crops on wastes that had hitherto only carried rabbits or geese."

About this period Jethro Tull published his first work on *Horse-hoeing Husbandry*, a system peculiarly applicable to turnip cultivation, and which no doubt aided very much in its success, as we find that they had acquired a regular place in the rotations of Norfolk long before they were known in other parts of the kingdom. Yet it must be admitted that we are indebted to the farmers of the north for the successful development of turnip husbandry, and

¹ *Quarterly Review*, No. 210.

for the advanced condition which it exhibits at the present day, as their cultivation was first established, and their treatment made generally known, in Roxburgh, Berwick, and Northumberland, by the enlightened farm practice of Dawson, Pringle, and Culley. Before these well-known men had established the practice of turnip husbandry, it had been successfully achieved in Dumfriesshire by Craig of Arbigland, who drilled his turnips in 1745, and by Philip Howard of Corby, a great Cumberland proprietor, who followed the same practice in 1755—both of them taking their lesson from, and following the instructions given in Tull's book. Then came Pringle of Coldstream, and, a few years afterwards, Dawson, who, having spent some time in Norfolk, and seen the system there practised, went back to Roxburghshire, and carried it out successfully on his own farm. Its introduction, it appears, was marked by the general distrust with which farmers usually view any innovation on old customs that does not originate with one of their own class. Although they had had opportunities of seeing its manifest advantage, year after year, on the farm of Mr. Pringle, none seemed disposed to follow his example until Dawson came down and settled among them, when the very men who had so long neglected the lesson taught them by Pringle now gladly followed Dawson's example, because he was one of their own class—a rent-paying farmer. In the *Agriculture of Northumberland*—written for the Board of Agriculture by Messrs. Bailey and Culley—in speaking of this subject, they say “that at first his practice met with many opponents, and was ridiculed by the old, the ignorant, and the prejudiced; but his superior farming and crops soon gained converts, and the practice in a few years became general.” In Northumberland George Culley took it up, and gave it a character; and thus turnip husbandry by this new mode of treatment soon became firmly established in the

opinion of all as a most valuable and important addition to the productive resources of a farm. About this period, 1775–80, the Swedish turnip was introduced into Scotland, some seed having been sent over from Gottenberg, from which sprung the different varieties of Swedes we now cultivate, and probably, also, at a later period, the yellow and hybrid varieties, the produce of a cross between the original white turnip and the newly-introduced Swede. Brown, in his *Treatise on Rural Affairs*, observes “that the introduction of the improved turnip culture into the husbandry of Great Britain occasioned one of those revolutions in the rural art which are so constantly occurring among husbandmen. Before the introduction of this root it was not possible to cultivate light soils successfully, or to devise suitable rotations for cropping them with advantage. It was, likewise, a difficult task to support live stock through the winter and spring months; and as for feeding, and preparing cattle or sheep for market during these inclement seasons, the practice was hardly thought of, and still more rarely attempted, unless where a full stock of hay was provided, which only happened in very few instances. The benefits derived from it are of very great magnitude. Light soils, before useless, are now cultivated with facility and profit; abundance of food is provided for man and beast; the earth is turned to the uses for which it is physically calculated; and, by being suitably cleaned with this preparatory crop, a bed is provided for grass and other seeds, wherein they flourish and prosper with greater vigour than after any other preparation.”

Since these times we have taken a great step in the mechanical treatment of the soil. Formerly, turnip cultivation was confined to one particular class of soils—those of a light, sandy character; but now—thanks to our system of thorough-draining, and to our various mechanical aids in pulverizing the soil—there are but few soils in the

country that do not carry turnips, or, at all events, that would not do so were they properly treated. In England, unfortunately, all agricultural estimates are mere matters of guess-work; in Scotland, until lately, an admirable system of statistics enabled us to speak more positively, and really to know what we were about on our farms. On looking for the turnip acreage in the last returns published (1857), we find that the total area under rotation tillage was 3,556,572 acres; of this no less than 476,691 $\frac{3}{4}$ were occupied by turnips; which, if we take the average rotation at six years, would show that fully three-fourths of the tillage soils of Scotland are, under the improved treatment there practised, suitable for turnip cultivation.

The turnip belongs to an order of plants widely differing from those we have already discussed—an order which, however, furnishes to agriculture a class of plants well-nigh equal in number and in importance to either of the others. The name "*Cruciferae*" has been given to the "*order*," from the cruciform shape of its flowers; and the "*genus*" which comprises the plants we have chiefly to take into consideration is termed by the botanists "*Brassica*." Among the numerous "*species*" belonging to this genus the agriculturist is only interested in about five, to which all the *varieties* of turnip, rape, coleseed, cabbage, &c., are apparently referable. These are as follows:—

1. BRASSICA OLERACEA—Cultivated Cabbage.
2. BRASSICA RAPA—Rough-leaved Summer Rape—Turnip.
3. BRASSICA CAMPESTRIS—Smooth-leaved Summer Rape—Swede Turnip—Colza.
4. BRASSICA NAPUS—Winter Rape—Coleseed.
5. BRASSICA CAULO-RAPE—Kohl-rabi.

Dr. Lindley, in speaking of the division of species, says, "How far the various divisions are really to be regarded as distinct species, we are not called upon to determine. They all breed freely together if in each other's neigh-

bourhood, and therefore demand the most scrupulous care on the part of the seedsman, that no two varieties are allowed to flower near each other. If that happens, hybrids are immediately produced, and purity of race becomes impossible. It is also to be borne in mind, that the smaller the patches of any 'Brassica' in flower, the greater the chance of its being spoiled by insects, which frequent it after leaving neighbouring fields, containing other species of 'Brassica' also in flower."

Our subject now is Turnips, and consequently we have only to refer to two out of the five divisions—the ordinary turnip bearing the same relation to the rough-leaved Rape (*Brassica rapa*) as the Swedish turnip (*ruta бага*) does to the smooth-leaved Rape (*B. campestris*). They appear to be only varieties of their respective stocks induced by cultivation—the originals being marked by their more erect habit of growth, and by their small, fusi-

Fig. 1.

form, and fibrous roots; while the more lowly and spreading growth of the turnip, and its largely developed globular root (napiform), at once mark the changes resulting from a long and careful cultivation.

The Swedes are usually known by the colour of the top of the bulbs, such as purple, green, or purplish-green. Of each of these there are several varieties in cultivation. Lawson¹ enumerates and describes five of the purple, three of the green, and six of the purplish-green top Swedes.

Common Purple-top or *Lothian* variety (fig. 1) is that in general cultivation in the north, and is the stock from which most of the others have

¹ *Synopsis of Vegetable Products, &c.* Edinburgh, 1851.

originated. It is very hardy, little apt to seed, and a good cropper under good treatment and on good deep soils. As its tendency is to strike deep into the ground, it frequently appears to be less of a crop on the field than it really is. It may be distinguished by its more oblong shape; its colour is a dull purplish at the upper part, and yellowish underneath.

Skirving's Purple-top Swede is a well-known variety, and was introduced into cultivation in 1837-8. Since then,

Fig. 2.

an "improved" variety (*fig. 2*) has been brought out by Mr. Skirving, which possesses all the good characteristics of size and solidity of texture of the other, while it is a

good cropper, comes early to maturity, and keeps well when properly stored. The root is of an oblong shape, grows higher out of the ground than the old sorts, and consequently is better adapted for growing on shallow soils. This habit of growth, however, renders it more readily injured by frost when left standing during the winter. It is also very apt to taper considerably towards the neck, and to run to seed during the autumn, especially if the seed be not of the best description.

Matson's Purple-top is an excellent variety, largely grown in the southern and midland counties. The bulbs are full, firm in texture, and more spherical in form than the foregoing—the leaves growing out of the crown without any tapering at the neck. Sheep and cattle generally are very fond of this variety.

The *Common Green-top* (fig. 3) is the oldest variety of

Fig. 3.

the Swedish turnips in cultivation. It has of late years fallen into comparative disrepute, owing to the greater attention that has been paid to the purple-top varieties. Where, however, care has been bestowed on its cultivation, it has proved as productive, as hardy, and to be possessed of the same keeping and feeding qualities as the more favoured varieties. The colour of the upper part of the bulb is a dull green with yellow below. The skin is rough, and gives a coarse appearance to the turnip, which, in general, is less symmetrical in appearance than the purple-top varieties.

The *Fettercairn Globe*, green and purple tops, are both excellent varieties, possessing size, symmetry of shape, and all the qualities of a good turnip. They are highly esteemed in certain districts, and are especially suitable for good

loamy soils, where their produce and keeping properties are generally satisfactory.

Laing's Improved Purple-top (fig. 4), differs widely from the other varieties of Swedes, in having large, entire, cabbage-like leaves, which, by their spreading horizontal habit of growth, speedily cover the soil between the drills, prevent evaporation from the surface, and materially check

Fig. 4.

the growth of weeds. It is rather a slow grower, and appears to be better adapted for the climate of the south than of the north, where the earlier winter checks its growth. It is very hardy, of a fine globular shape, no neck, and rarely exhibits any tendency to run to seed in autumn; indeed, in the spring it is usually a fortnight later than the other varieties in commencing this process.

In the *Cyclopedia of Agriculture*, Mr. Haxton furnishes the results of an experimental trial of the productive qualities of the several varieties of Swedes, all grown under

exactly the same conditions, in a good, easy-working, black trap soil, and manured with sixteen double cart-loads of well-rotted compost, and in addition from 4 to 5 bushels of bone-dust strewed in the drills above the manure. The growth was satisfactory throughout, and the roots were lifted at the end of October, a portion of each lot measured, and the produce carefully weighed, giving the following results:—

Names of Varieties.	Weight per Acre.			
	tons.	cwts.	qrs.	lbs.
Common Purple-top Swede,.....	22	11	2	24
Skirving's Improved „	19	5	0	1
Fettercairn Purple-top „	18	7	1	8
Laing's „ „	14	0	1	5
Common Green-top „	21	12	0	16
Fettercairn „ „	14	16	1	8
Green-top White „	14	8	3	18
Purple-top „ „	16	13	1	13

Of the common turnip the number of varieties is far greater. Lawson enumerates and describes no less than forty-six. These may all be divided into the round or globe-shaped (*depressa*), or those approaching the tankard form (*oblonga*), and are generally distinguished by the colour of the tops of the bulbs, which are either purple, yellow, green, or white. Of the purple-top varieties, the

Common, or "Purple-top" Aberdeen, is an old and deservedly esteemed variety, very hardy, with comparatively short spreading leaves of a darkish colour, growing clean out of bulb. The bulb is globular, of medium size, dark purple above and deep yellow below the ground, with small tap-root.

The *Berwickshire* and *Skirving's* improved purple-top yellows are also excellent varieties.

The *Aberdeen "green-top" yellow*, in the size and shape of its bulb, resembles the purple-top, and is a valuable sort for winter keep, as it is able to stand the vicissitudes of the winter climate with less injury than most others. On

good land in good condition it gives large returns, otherwise it is not a very productive variety. If for winter keep, it is desirable not to sow it too early, so that it may

Fig. 5.

be in a growing condition up to the time the frosts set in; under any case, however, it is said to be less subject to mildew than the purple-top varieties.

Gibb's improved green-top yellow, *Gordon's* yellow, *Hood's* imperial yellow, and *Pollexfen's* yellow bullock, are all valuable sub-varieties of the green-top turnips, introduced into cultivation by the gentlemen whose names they respectively bear.

The "yellow-top" varieties are rarely met with in cultivation to any great extent. Although they are generally quick growers, they are less productive and less hardy than other varieties.

The *yellow globe* is one of the best varieties for field culture, with bulbs of a medium size, globular, and growing deep in the soil; leaves small and spreading.

Altringham yellow, *Jones' yellow*, *yellow Preston*, and *Chivas' orange jelly*, are favourite varieties in different districts.

The white varieties in cultivation are very numerous. Of these—

The *common white globe* (*fig. 6*) is that most generally grown, and is an excellent description of root for early consumption. The bulb is globular, skin smooth, and perfectly

Fig. 6.

white; moderately large head, neck fine and small, and tap-root small. The shape varies, with the care bestowed in selecting the seed-roots, from an almost perfect sphere to a sphere flattened more or less at one or both ends. On rich soils this variety has a tendency to develop itself to a great size, to become woolly in texture, diminished in feeding value, and to exhibit a tendency to rot and deteriorate in the field, especially if they be flat at the top, and the weather be wet and

changeable. It is, therefore, desirable on such soils, to leave them pretty close together in the drills—say 9 or 10 inches apart. This gives fully as large a return per acre, by the increased number of smaller roots being more nutritive and less liable to injury than the large ones. They are generally ready for use about the end of Sep-

tember or beginning of October, and will carry the stock on until the yellow varieties have completed their growth.

The *white Norfolk*, or white round turnip, is a large, irregular-shaped, soft variety. It is more depressed at the top than the foregoing, and more disposed to deteriorate at the time of maturity. Like that, it is a heavy cropper, and requires to be fed off early in the season.

The *Pomeranian* is an improved variety of the white globe. The shape is globular, less liable to depression at the top, and consequently to injury from wet or weather. The skin is fine and white, leaves smooth, and of a darker green colour, with whitish nerves.

The *Stone Globe* is one of the hardiest of the white globe turnips. It grows deeper in the soil, has a stronger and coarser skin, and is better able generally to resist the effects of weather. In the south, if sown late, it stands through the winter, and furnishes excellent and valuable keep for the ewes at lambing time.

The *Stubble*, or *Autumn Turnip*, offers the advantage of arriving at maturity sooner than any other variety, and thus may be sown in early districts after the fields are cleared of the straw crops. From its rapid growth, it is soft in texture, and low comparatively in nutritive value, and requires to be fed off before the winter frosts commence. It is a useful variety, however, to assist the keep where the fly has taken the earlier sown varieties, or to fill up blanks in the field where the first sowing may have partially failed.

The *Tankard* varieties (*oblonga*) are generally less valuable than the globe (*depressa*). They naturally possess a larger amount of surface, are more exposed above the ground, and are in proportion more liable to injuries, both natural and artificial. They are all early in their maturity. Their yield is frequently large, and their quality equal to the globe; and they require to be consumed

before the frosts set in, as they are soon injured. The favourite varieties are the White Tankard (*fig. 1*); the

Fig. 1.

Fig. 2.

Fig. 3.

Green-top White (*fig. 2*); and the Laurencekirk (*fig. 3*); and the Long Cambridgeshire Yellow.

The *Norfolk Bell Turnip* is a favourite variety of the Tankard. It is grown chiefly in the eastern and midland counties, and possesses the same qualities, being early, productive, and tender, with an increasing development of the lower half of the bulb, whence its name.

Besides the foregoing varieties of the Swedish and the common turnips, we have another class of intermediate or *Hybrid* turnips, which possesses certain of the qualities of the two parents, and is every year becoming of more value to the farmer. Although a distinct cross between the

Swede and the turnip, it partakes far more of the character of the latter, as the leaves are rough and of a vivid green (not smooth and glaucous, like the Swede), and the roots are similar in shape, though firmer in texture.

Dale's Hybrid was introduced into cultivation in 1822–3, by Mr. Dale, an intelligent Mid-Lothian farmer, who, having received from a Berwickshire friend (James Sherriff, Bastleridge), a small portion of the seed of a new hybrid variety of turnip, sowed it, and by repeated selection and careful impregnation of the produce, at length obtained this highly esteemed variety, the distinguishing characteristics of which are—strong and luxuriant foliage, well-developed roots, oblong shape, sometimes varying towards spherical, of a lightish yellow colour, with a bright green top, small neck, and small tap-root.

Compared with the ordinary varieties in cultivation, it is found to arrive sooner at maturity, and consequently admits of being sown later in the season; while, at the same time, it is equally hardy, and will stand well through our ordinary winters, or keep sound and fresh if stored away before the frosts have touched it. It grows well out of the ground, which renders it somewhat more sensitive to frost than the deep-growing sorts, and is well adapted for folding sheep upon, as it requires but little picking after them; it is also, for the same reason, well suited for shallow or strong clay soils, being easily lifted. Great care is required in the selection of seed, as of late years, owing to neglect, arising in a great measure from the increased demand, both the size and shape of the bulb have shown a tendency to deteriorate.

The other principal hybrid varieties are known as the *New Purple-top Hybrid*, the *Lawton Hybrid*, the *Woolton Hybrid*, *Red-top White*—all of which, more or less, partake of the characters already described.

In regard to the relative productiveness of the common,

yellow, and hybrid varieties, Mr. Haxton also gives us the following valuable tabulated results.¹ The specified varieties "were sown on medium black soft land, situated on 'trap,' and were manured with farmyard dung, and treated precisely in the same manner in every respect."

Varieties.	Weight per Acre.			
	tons.	cwts.	qrs.	lbs.
Aberdeen Green-top Yellow,.....	16	16	3	22
Hood's Imperial Green-top Yellow,.....	18	2	1	17
Gordon's Green-top,.....	19	2	2	5
Dale's Hybrid Yellow,	17	17	3	21
Laurencekirk Tankard Green-top Yellow,.....	22	2	0	2
Common Purple-top Yellow,.....	20	12	1	16
Berwickshire „ „	19	7	1	8
Common White Globe,.....	27	13	0	6
White Stone Globe,	29	19	3	25
White Round,.....	25	7	2	25
White Tankard,.....	25	16	0	11
Green-top Globe,	20	19	3	5
Green-top Tankard,	21	3	2	0
Green-top Round,.....	16	7	0	22
Red-top Globe,.....	20	19	8	5
Red Round,.....	21	3	2	0
Red Tankard,.....	21	3	2	0
Woolton Hybrid,	21	17	0	9

The soils best suited for the cultivation of turnips are unquestionably those of a free-working, loamy character, in which the most suitable conditions, *chemical* as well as *mechanical*, for the growth of the plant, are met with. In the lightest description of soils, those proceeding from the silicious beds of the several sandstone formations, the *mechanical* condition, so far as the division of the particles is concerned, is met with to the greatest extent; and in the heaviest description of soils, those proceeding from the clay beds of the argillaceous formations, the *chemical* conditions exist in the most favourable proportions. Between

¹ These results must only be taken for what they are really worth, as the soil in which they were *all* grown was no doubt much better adapted to one or more varieties than to the others, whose produce in a more congenial soil might have quite reversed the figures now given.

these two extremes we have a wide range of soils, possessing, in necessarily varying proportions, the two desired conditions. To assign to these their proper relative values in the cultivation of the crop would be impossible, without a knowledge of the climatal conditions of the district in which it was to be carried on; as in a locality where either the rainfall was great, or the humidity of the air constant—as on some portions of the western coast, for instance—the mechanical texture of the soil would be of higher relative importance than its chemical constituents; whereas, in a naturally dry district (the midland or eastern counties) a far larger proportion of clay would, from its powers of absorbing and retaining moisture, improve the texture and capabilities of the turnip soils. There is no doubt that within the last few years the range of turnip soils has been largely increased in this country, by the aid of thorough draining, and the improved mechanical contrivances which our skilful and enterprising agricultural engineers and implement makers have placed at our command. Those, however, possessing in themselves the natural suitabilities for the crop, are always the most free from disturbing effects of weather, &c., economical to work, and most certain in their returns. The *essentials of a turnip soil* are that it be deep, free from stagnant water, susceptible of minute division, and sufficiently tenacious to absorb and retain moisture sufficient for the wants of the plant, and that its general composition be such as to contain the mineral constituents necessary for its growth.

The first essential—the depth—is limited, in some cases, by natural causes; in many, however, it can be materially increased by draining, and by judiciously subsoiling, our newly-harnessed labourer—“steam”—giving us, at a cheap rate, any amount of power we please to take advantage of; and it is pretty certain that the older we grow, and the wiser we get, the more disposed we shall

be to add to our present area of cultivation by carrying our tillage operations deeper and deeper into the soil, and thus materially increase our producing capabilities. This has already been touched upon in regard to wheat (p. 38). The roots of a vigorous turnip may, in a suitable soil, frequently be traced to a depth of 2 to 3 feet. The benefits of thorough draining are now so universally acknowledged, and the mode of carrying it out so well understood, that no stagnant water need now be seen anywhere in our fields; while the judicious employment of the proper implements—and we have enough to meet every possible requirement of soil—at *the proper time*, will secure that fine division of the soil (tilth) so necessary for the successful cultivation of the plant. The necessary chemical conditions of the soil must be secured by the application of manurial substances; some soils, of course, are naturally more fertile than others, but all require certain additions, to compensate for the large amount of fertilizing substances (plant-food) which are abstracted from the field by each successive crop.

We shall at once recognize why these conditions are essential to the successful growth of the plant if we briefly follow it through its career in the field. In the month of May or June we place a small seed in the ground, and in October we expect that seed to have produced a fully-developed plant—in fact, in five short months, to have, through its peculiar vital powers, elaborated from the soil and the air an amount of organized substances equal in round numbers to 1,000,000 times its original weight, taking the weight of the seed at $\frac{1}{25}$ th of a grain, and that of the plant (bulb and top) at 6 lbs. This enormous increase can only be obtained through the effective agency of the root and the leaves; and if these are not placed by the cultivator under conditions favourable to their peculiar powers, they cannot exercise them in a healthy and vigorous manner,

and these results must be proportionably diminished. The functions and powers of the roots have been already described (p. 39). Let us now briefly inquire into those of the leaves of plants. In the economy of vegetation, we assign to the leaves the duty of obtaining and preparing for the plant the largest proportion of its entire substance—its organic constituents.¹ They have the power of absorbing carbonic acid from the atmosphere, decomposing it, fixing and appropriating the carbon, and setting free an equal volume of oxygen, which is returned to the air in order to sustain its power for the support of animal life. Leaves both absorb and give out watery vapour, according to the differing hygrometric conditions of the surrounding atmosphere, and their own requirements. They have also, according to Ville, the power of abstracting nitrogen from the air, and also, according to Draper, of giving out nitrogen to the air in variable proportion, and under certain conditions. The first point, which involves considerations of vast importance to agriculture, has been controverted by other chemists. At present the balance of evidence is against it; science, however, is progressive, and to-morrow may enable us to read characters which to-day are not within our range. Our acquaintance with physiological botany is still very imperfect; we know that carbonic acid is absorbed, and that oxygen is given out by the leaves; and we are fairly entitled to believe that the proportion of carbon thus retained is elaborated by the plant into those carbon compounds—starch, gum, sugar, wax, oils, cellulose, &c., which form so large a portion of all our plants; but here our knowledge fails us, for we are in ignorance of the manner in which these complicated arrangements are effected.

The turnip, therefore, through the agency of its roots

¹ The turnip, for instance, contains about 1 per cent. of *inorganic* and 99 per cent. of organic matter. See analysis, p. 232.

and leaves, is expected to abstract from the soil and the atmosphere, and elaborate into forms of substances suitable for animal food, an amount of matter equal to 1,000,000 times its own original weight. To enable it to achieve this end successfully the cultivator is expected to have previously secured for it all the conditions which experience and theory have shown to be necessary for its healthy and vigorous development. It is necessary that the soil should be deep enough to allow its branching rootlets full range in search of food; that it should be in a state of minute division, so as to present, in each particle, the largest possible amount of surface to the fertilizing action of the air and moisture, always in contact with them, and thus add at once to the feeding surface and food materials of the plant; that no stagnant water should exist, which always sours and chills the soil, and is opposed to cultivation, but that the soil should contain moisture sufficient for the healthy development of the plant, a point materially influenced by the foregoing conditions of depth and fineness of division of its particles; and lastly, that all the food materials which the plant requires to complete its full growth should be present in the soil in sufficient quantities, and in an immediately available condition, as the plant being a quick grower is, of necessity, a quick feeder. The differences that we so frequently see in the turnip crops in the same districts, where the same climatal influences and insect visitations occur, are generally attributable to the more or less perfect observance of these necessary conditions. They are simple in themselves, involving no difficulties in their comprehension or execution; if it is good policy to cultivate turnips at all, it surely is the best policy to take advantage of every circumstance which will enable us to do so with the greatest chances of success, and thus produce the largest and most remunerative returns.

The proper place of the turnip crop in the rotation is very clearly defined. By common consent it is everywhere placed between two straw crops. The preceding crop is usually harvested at a sufficiently early period in the autumn to allow of the land being ploughed up and thoroughly cleaned before the winter sets in, and the turnip crop, whether carted off or fed on the land, is cleared away, and the land ploughed up, in time for the succeeding straw crop, whether winter-sown wheat or spring-sown barley or oats. In the Norfolk four-course system of farming the lighter soils, so commonly called "turnip soils," the turnip crop is taken after the wheat, and is succeeded by barley; as on such soils it is customary to consume the turnips on the field, for the double purpose of manuring the surface soil and of consolidating it after the deep stirring it had in preparing for the crop. In the five, six, and seven course systems it is invariably placed in the same position, the straw crops between which it is grown differing with the nature of the soil, the climate, the markets, and the general labour arrangements of the farm. It is essentially a fallowing and manuring crop, its cultivation admitting of the weed-growth being checked and the land kept clean. Its requirements from the soil differ materially from those of the straw crops (as may be readily seen by comparing their respective analyses), while, from the nature and habits of the crop itself, it abstracts from the atmosphere a large amount of those nitrogenized substances which, we have reason to believe, are so beneficially applied to the growth of the succeeding cereal plants. In humous soils, containing a large amount of organic matter, which, in general, are not favourable to the growth of cereal crops, turnips in most cases are successfully cultivated, though the bulb is less in proportion to the top, and less firm in its texture than in those grown on other soils. Here, where oats are frequently the only cereal crops cap-

able of being grown, the turnip cannot, of course, be so readily placed between two straw crops; its cultivation, however, can be so arranged as to place it between two crops belonging to different orders, and having different food requirements from the soils, and different habits of growth to itself. This is best secured by taking turnips after oats and following them by beans. The deep and careful tillage the root crop receives, the cleaning opportunities it affords, and the large quantity of rich nitrogenous manure it leaves behind, are all excellent preparatives, which rarely fail to tell beneficially upon the succeeding bean crop. In all cases, and *with all crops*, it should be remembered *as a rule* that the longer interval we can arrange between their cultivation on the same soil, the greater the chances of freedom from disease and insect ravages. Therefore, we should always bear in mind the desirability of substituting, whenever we can, other crops having the same economic uses and value, but different habits and growth requirements. The importance of this *rule* is as marked in regard to turnips as to any other crop, as will be seen presently when we come to discuss the diseases to which the plant is liable. Fortunately, we have at hand a good substitute for turnips in the shape of mangold, which possesses equal value to the farmer, and indeed offers many advantages for sharing with the latter one-half of the root-acreage of our farms. If this plan were generally carried out, it would act beneficially on both crops, as it would at once double the length of time (interval) between the recurrence of the same crop on the same field, and thus materially lessen the chances of injury, whether from disease, insect attacks, or climatal influences. At the same time, the labour arrangements of the farm would be rather relieved and benefited by it, as the mangold crop is got in earlier than the turnip; and although stored away in the same manner and at an earlier period,

it rather improves by keeping, and is fit for feeding after the turnips are all consumed.

No matter what place the turnip crop occupies in the rotation, it is always the one to which the largest amount of manure is applied, as by the proper selection and quantity of that, the success of the crop is greatly influenced; and upon the success of this crop the general welfare of the farm is mainly dependent. If the root crop be good, a large head of stock can be kept, and a large quantity of manure made for the next year's use. If the crop fails, the stock must be diminished or kept on purchased food, and the manure is either less in quantity or made necessarily at a higher cost. The *principles* that should govern the application of manures are still very imperfectly understood by us, and until agricultural education is more advanced, and the farmer is better acquainted with the nature of the plants he cultivates, and of the soil and the atmosphere in which they grow, there will always be difficulties in the way of establishing anything like general intelligible rules for our guidance, and the present random system must remain. Chemistry, however, has done this much for us, which we can practically apply with advantage: it has made us acquainted with the nature and amount of ingredients which our different growing crops abstract from the soil; and we may therefore fairly infer that, if these are again returned to the soil in the shape of manures, we shall at all events sustain its normal degree of fertility. This probably, for the present, is the safest and simplest guide we can take in deciding upon the description and quantity of the manure we should apply to our fields. The calculations are easily made by those who prefer accurate figures to guess-work in their farm estimates; and if the quantities given to the land are in excess of the quantities abstracted from it, the farm is likely to be kept up in good condition.

In replacing the mineral ingredients abstracted from the field by the growing crops, there are only two or three out of the nine which they have made use of, about which we need concern ourselves, as the remainder are those of which the mass of the soil is commonly made up. Of these the potash and phosphoric acid are the most important, as all our "Farm Crops" draw largely upon both for their requirements, while they rarely are met with in our soils except in very minute proportions. If we look at the analysis of the turnip (p. 328) we see that the proportion of potash it abstracts from the soil is about three times that of the phosphoric acid; and yet we are inclined to consider that "superphosphate," rarely containing a particle of potash, is the most judicious application, whether for supplying the wants of the growing crop or of replacing in the soil the substances it takes from it. *Now, it should be distinctly understood that fertility in a soil is not governed so much by the maximum as by the minimum proportions of its constituents.* If out of the nine substances the plant requires for its growth, eight of them be largely in excess of its wants, and one be in a less proportion than the crop requires, *its returns will be determined altogether by the producing power of the minimum, and not in the least affected by that of the other substances in excess.* It is true that plants have, like animals, a great power of suiting themselves to the conditions under which they are placed, and of substituting, to a limited extent, one food material for another—for instance, soda for potash, magnesia for lime; but this variation does not affect the above *rule*, neither do the plants, under these forced conditions, carry on their processes in such a vigorous and healthy manner. In the use of all artificial manures these points should not be forgotten, and a due proportion in all the composing ingredients be secured.

By common consent, good farmyard manure is looked upon as the best type of all our manurial applications, and justly so, because it contains within itself *all* the substances which plants require, and in the right proportions. Not only does good farmyard manure contain all the inorganic (mineral) substances the crop requires, but also the organic, which are equally essential to its growth, but which plants can and do, to the greatest extent, obtain from another source—the atmosphere. It has been already stated (p. 285) that plants cannot appropriate the nitrogen necessary for their most important organic compounds directly from the atmosphere, but derive it from the ammonia always found in the air in minute and variable proportions. To secure this necessary ingredient to the growing crop, in proportions suited to its now (by long cultivation) largely-increased requirements, it is always desirable to secure a due supply of it or its constituents in the manurial compounds we apply to the soil. Experience has shown, and science has confirmed, that different plants (orders) require different proportions of nitrogen in carrying out their natural processes, and also that they have different capacities for appropriating it from the atmosphere. It has, therefore, been found in practice desirable—with a view, of course, to obtain the largest results—to supplement this difference in wants and capacity to obtain, by giving these nitrogenized compounds in the manure in accordance with the requirements of the crop to which they are applied. The *leaf-surface of the plant* is a good general guide in this case, its capacity to obtain ammonia from the atmosphere being mainly influenced by the amount of breathing surface exposed—while our knowledge that a higher proportion of nitrogen is required for the perfection of the *seed* than of any other portion of the plant, would show us that crops “cultivated for their seeds” need it more than those cultivated for other purposes.

Wheat and turnips may be taken as good instances in point. Wheat (a seed-bearing crop) has a minimum amount of leaf-surface, and requires a large amount of nitrogen compounds in its grain produce; turnips (an herbaceous crop) have a maximum amount of leaf-surface, and a proportionate feeding capacity, while their nitrogen requirements are very small. We therefore infer that nitrogenized manures are more necessary to the one than to the other; and we consequently recommend "Peruvian guano" as most effective for wheat, and "superphosphate" for the turnip crop.¹

The valuable experiments of Messrs. Lawes and Gilbert, and of Dr. Voelcker, in reference to manurial applications, show us how satisfactorily practice confirms the theory of the present case. Each year we have the details of numerous experiments with different manures to different crops, but chiefly to turnips, placed before us, and we see as great a variation in the results. Now, this constant variation, which so materially reduces their general value, is due to the impossibility of securing in each case the same conditions of soil, climate, and season—each of which largely affects the action of any manurial substance used. We often hear of a manure being followed by the best results in one place and being a total failure in another, while the most successful application in the latter was placed low on the trial scale in the former place. Yet both may be equally suitable for the conditions under which they were applied—the difference in their results proving how disastrous they may be if applied indiscriminately, without a proper knowledge of the conditions inseparable from their successful application. We must not, therefore, place too much reliance on the results of these various trials, especially when made in a different district, as regards climate and soil, from our own; neither

¹ *Roy. Agr. Soc. Jour.*, vol. xviii. p. 491.

can we be sure that the results obtained last season will be followed by the same in the next. They all have their value nevertheless, and in a series of years may admit of certain *average* results being drawn, which, in a practical art so liable to modifying influences as agriculture, are always information of importance to those who follow it. The method of taking the money value of each substance as the *standard* of comparison in the trials is, after all, the best way for the present of practically testing their relative values, though somewhat opposed to the philosophy of scientific farming.

Let us, then, not follow blindly the practices of others, and imagine that because a manure has been successful elsewhere it necessarily will be with us, but, *as a matter of economy*, strive to make ourselves acquainted with the requirements of our crops, with the nature and composition of manures and of our soils, and with the conditions under which the three can be most favourably brought together; and we may rely upon it, we shall be amply repaid by the satisfaction which increased knowledge ever gives, and by the more material returns resulting from success in our operations.

The preparation of the soil for the turnip crop is a matter of great importance, and should be carefully attended to. The requirements of the plant in regard to the soil have been discussed, and we have now to make our arrangements for securing them. When the preceding straw crop is cleared off, the stubble is left more or less free from weeds, annual and perennial. These mostly have seeded before the corn crop was ready for cutting, and in the operations of harvesting have had their seeds knocked out and scattered over the surface. If these are left unnoticed, and covered in by the ploughs, either at once or at a later period of the season, they will remain in the soil uninjured for a long time, ready to germinate

and reproduce their kind directly they are placed under suitable conditions. On light soils, where the furrow is generally very shallow, this occurs with the ensuing spring, and the field generally becomes dirtier than it was before: on other soils the next ploughing that is given brings them close to the surface again, above which they speedily show themselves. It is, therefore, most important to commence our preparations immediately the field is free from the straw crop, by inducing as far as possible the germination of the seeds of the annuals, and by thoroughly clearing it of the roots of the perennials met with in the soil, before we think of sending in the plough for giving it the winter furrow. If the annuals are in excess, one of the best implements for this work is "Bentall's broad-share," which, with a moderate amount of power, shaves off the surface—say half an inch deep—effectually arresting further growth, and covering up the seeds sufficiently to induce their germination directly they can absorb moisture, either from a shower of rain or even the heavy dews usual at that period of the season. The field may then be left until the labour arrangements of the farm or weather indications render it desirable to resume the cleaning process, when the soil will have to be stirred to a greater extent, either by a powerful "grubber" or "cultivator," or the plough, in order to loosen and get hold of the roots of the perennials, which in some cases—the common couch-grass (*Triticum repens*), for instance—require great care, so that no portion even may be left behind. Where the "grubber" or "cultivator" is used, the roller and the harrows are generally sufficient to break up the moved soil and collect the rubbish; where it has been advisable to use the plough, the grubber should be sent across the line of ploughing, so as to thoroughly break up the furrow-slice and bring the roots, &c., to the surface, where a turn with the harrows

will collect them and finish the work.¹ In all cases the weeds, &c., should be carefully collected at once and burned on the field: they are never worth the trouble of carting away; and too frequently, when thrown down in the yards or mixed up in a "compost," they are again (under the name of manure) carried uninjured on to the land.

When we have satisfied ourselves that the field has been thoroughly cleaned, and have decided upon the distribution of the home-made manure of the farm, we may finish our autumn preparations, either by at once sending the ploughs into the field or by previously carting on the quantity of dung allotted to the intended crop, spreading it, and then covering it in with a good deep winter furrow. If this work has been successfully performed, the land will require but little or no preparation in the spring. In order to secure as deep and as fine a tilth as possible, it is customary to cross-plough the land in the spring, immediately before sowing-time, whether it be intended to grow the turnips on the ridge or on the flat. For ridging it is no doubt advisable, as it would be very rare indeed to meet with any field, save perhaps on light humous soils, where ridging could be satisfactorily effected upon the winter furrow. On the stronger class of soils, especially in late districts, it frequently happens that, if cross-ploughed in spring, the finely-weathered surface of the winter is buried, and wet, cloddy slices turned up. A good practice has therefore been introduced of leaving the mass of the soil untouched, and merely running a light-tined grubber through the surface, and then taking advantage of the fine tilth thus produced to secure a good seed-bed for the crop, which is sown with or without artificial manure, as the case may be. In this case care must have been taken

¹ The amount of work to be done in the day in these several operations, and in those following, as ridging, sowing, and hand-hoeing, &c., may all be readily calculated by the rule given at p. 27.

thoroughly to clean the land in the autumn, and also, at the same time, to plough in the quantity of farm dung allotted to the field, which would exert a good mechanical effect on such soils (strong) by keeping them more open to the influence of the winter's frosts. This practice is better suited for sowing on the flat than on the ridge, as the dung would stop anything like neat work in the spring. If, from any circumstances, the land has not been properly cleaned in the autumn, it must be attended to in the spring: it is always far better to delay the period of sowing for a week or two than to sow on a dirty or badly-prepared seed-bed.

When it is intended to sow the crop on the ridge, and the land has been properly cleaned, and reduced, by ploughing, rolling, and harrowing, to the proper state, the double mould-board plough is sent into the field, and the land laid up in ridges at the desired distances apart—usually 24 to 27 inches:¹ the latter is that generally followed in the Lothians and other well-farmed districts in the north, as allowing ample room for the growth of the plants, and for the use of the horse-hoe in keeping the surface clean. As soon as three or four ridges are drawn, the carts should begin to distribute the farmyard manure intended for the crop, the horse walking down the centre furrow, and the wheels occupying that on either side without disturbing the ridges. The dung is dragged out from the tail of the cart in heaps of a given size and at given distances (calculated according to the number of loads per acre), and at once divided equally, and spread out at the bottom of the three furrows by labourers who follow up the cart for the purpose. As soon as the three rows are finished a second plough should be sent in to split the first set of ridges, and thus cover up the manure at the bottom of the furrows, and form the crown of the ridge immedi-

¹ See general note in respect to distances apart at p. 224.

ately over it. The work of preparation for the seed is then complete.

One great defect in our farming is the little regard that is usually paid to the *economy*—the proper distribution—of *labour*. We know what a material item of success that is in our factories, and yet it is rarely understood or even thought about on our farms. This operation of ridging, simple though it be, is not a bad test of its application. We have four parts of the machinery to arrange so that they shall all gear into and harmonize with each other, and we must recollect that in mechanics the *real strength* of a machine or body is only equal to its *weakest* part. We have here one part of the labour employed at the steading in loading the manure; another employed between the homestead and the field in carting the manure; labour employed in the field in preparing it for the reception of the manure, and in finishing it up afterwards; and, lastly, labour employed in distributing the manure equally on the ground. Now, unless this has been well considered beforehand, and a relative amount of strength assigned to each part, the machinery will not harmonize, and the work *must cost more money than it ought to do*. If we take the field as our starting-point, it is readily known what quantity of land can be laid up in ridges at given widths in a given time; and we can as readily calculate what labour will be required to spread manure in the intervals, or furrows, formed. The number of carts required would be, of course, determined by the distance between the homestead and the field; and the labour at the homestead in filling would be determined by the number of carts at work, or rather the space of time between the loads. The object to be sought for is that every one (parts of the machinery) should be continuously employed, and in doing the work for which they are suited. The hardest work is filling, and should be done by the stoutest hands;

boys can lead carts as well as men; lads or women can distribute the manure; and the best ploughman on the farm should draw out, or, at all events, finish off the ridging, which gives him a good opportunity of showing his skill and workmanlike capabilities.

The usual time for sowing Swede turnips is from the middle of May to the middle of June. The common turnips are usually got in as soon as convenient, after the Swedes are finished. In the south both varieties are sown two or three weeks later than in the north, as long experience has shown that the early-sown crops are more liable to be injured by "mildew" than those not so far advanced in their growth; and this disease, which appears to result from an insufficient supply of moisture to the plant, always prevails more in districts where the soils and climate are dry than where they possess the humidity natural to the north. The quantity of seed sown varies from 2 lbs. to 7 lbs. per acre. It is always greatly in excess of what is required to furnish the number of plants that are eventually left for the crop, and consequently wasted, if we could rely upon each seed germinating and producing a plant. If this could be secured we should find, according to Stephens,¹ that about $1\frac{3}{4}$ oz. of seed would furnish plants sufficient for an acre of ground. This weight is only about $\frac{1}{16}$ th of 2 lbs., the quantity usually thought necessary in the north; and $\frac{1}{4}$ th of 7 lbs., which in many places in the south the farmer is accustomed to use. We know, however, that practically this cannot be accomplished, and that, in order to secure a crop, we must sow a certain quantity of seed, more or less, in excess of that necessary to produce the number of plants we intend to leave to the acre, in order to allow for the great deficiency occasioned chiefly by imperfect germination of the seed, and the injuries inflicted by insects on those which

¹ *Book of the Farm*, vol. ii. p. 73.

have germinated. Some farmers are content to submit to these risks and losses without seeking to know their causes, and thus be in a position to guard against their recurrence—their only remedy being an increase in the quantity of seed, which, to a certain extent, may diminish the chance of loss. Others, again, who seek to know “the reason why”¹—and happily this class increases every year—believe that the losses sustained by the seed not sprouting can be materially lessened by securing good fresh seed; and that by taking proper measures in sowing, the risks from insect injuries are reduced to a, practically unfelt, minimum.

The necessity for care in the selection of turnip seed becomes each year more important, as we are made better acquainted with the enormous extent to which adulteration is carried on; sometimes with old inferior seed of the same sort, at others with useless rape seed, whose germinating qualities have been more or less destroyed; while, again, we have learned lately that “charlock” seed (*Sinapis arvensis*) has been publicly sold to a large extent for mixing with turnip seed, and thus inflicting an increased injury upon the unlucky purchasers. A low price for such seed is generally the inducement offered; but in farming, where faith in quality, and in *principles generally*, is so essential, it should always be remembered that *nothing bad can be really cheap*, and that it is far more economical at first, and profitable afterwards, to secure good seed without regard to the cost—to let quality be the first, and price the second consideration. In most other branches of industry, the purchased materials are kept more or less before the eye, where their qualities can be duly noted. In farming, the most important material of all—the seed—on which the future produce so largely depends, is at once buried, and

¹ *The Reason Why*, a popular and excellent exposition of common things in physical science, interesting to all classes of the rural community especially. Houlston & Wright, London.

its good or bad qualities placed in the soil, beyond the range of our senses, and under conditions affected by too many influences to admit of anything more than guess-work as to the causes of failure or successful growth. Any blanks that may occur in the drills should be filled up by the same plants raised in a separate seed-bed and carefully transplanted, or with cabbage plants obtained from the same source.

The chances of injury to the young plant from insect attacks, are greatly diminished by our improved system of cultivation, which secures a finely-divided seed-bed, and a supply of food in a state fit for assimilation by the young plant, directly it has thrown out its rootlets, and advanced its first pair of (cotyledon) leaves to the surface of the soil. Here its most dreaded enemy, "the fly," is watching for its appearance, and commences an attack which lasts until the plant throws out the second pair of leaves, when the attack diminishes, while the plant at the same time has become stronger and better able to withstand its effects. Therefore, the quicker we can induce the growth at this period, the less time the insect has for its attack, and the less the chance of injury from it. This has led to improved methods of sowing. Now it is the common practice in all well-farmed districts, to sow manure with the turnip seed from the same machine ("manure and seed drill"), the manure coulters preceding the seed coulters and depositing the manure at a certain depth, over which the finely-divided soil falls in a thin layer ready to receive the seed which is supplied by the following coulters, the roller travelling behind and closing up the drills in the usual manner. On the flat, the ordinary drill of the farm, with the manure box and delivery attached, may be used. On the ridge, it is necessary to have a separate machine for the purpose, which generally takes two drills at a time, and having small curved rollers attached,

finishes them off in one operation. In general, the practice of sowing on the ridge is preferable to sowing on the flat, as it enables the hoeing to be commenced much earlier, and the crop to get a better start and be kept cleaner than on the flat. In some soils, however, and in some districts, sowing on the flat is most advisable in order to retain the moisture in the soil, which, by the increased surface exposure of ridging, would be largely dissipated. On gravels, sandy and calcareous soils with dry absorbent subsoils, or in naturally dry districts, it is rarely advisable to ridge for root crops. On alluvial soils, marls, loams, and the stronger class of soils generally, or in moist climates, sowing on the ridge may be advantageously practised.

A sufficient degree of moisture in the soil is always one condition necessary for the germination and successful start of the turnip plant; and it is always better to wait a few days until this be secured, than to place the seed in a perfectly dry bed. To meet this not unfrequent occurrence, and at the same time to secure a supply of food to the young plant, a "liquid-manure drill" has been constructed, which deposits a supply of manure in a state of solution down one set of coulter-tubes, while another set supply the seed to be deposited in the moistened bed, which is immediately closed up by a small roller following and finishing off the work. The expense of this mode of sowing is certainly greater than the others, but that is of small importance if it secures a good plant at this ticklish period of its existence. For the purpose of applying manure either in a liquid or a solid form *with the seed*, "Peruvian guano" is probably the best of all applications, as it contains the three principal ingredients—phosphates, potash, and ammonia, which determine the value of all our fertilizing materials. For applying at other times, either with or without farmyard manure, the ingredient

ammonia is not considered to be so necessary to root as it undoubtedly is to our cereal crops; and, accordingly, phosphate of lime in a partially soluble condition, as "superphosphate," is generally used without the addition of either of the other more expensive substances. This is unquestionably wrong, as although the plant from its nature and habit of growth may obtain an unlimited amount of ammonia from the air, it is quite certain its root powers are limited in regard to potash, which only exists in the smallest proportions in the soil, and yet is essential to the development and healthy growth of the turnip (see *analysis*), and should in all cases be added, especially where no farm dung (which in itself contains it) has been used. The addition too of chloride of sodium (common salt), at the rate of 2 to 5 cwts. per acre, would in most cases be followed by increased returns, especially in the midland and other districts, too distant from the sea to admit of any sensible portion being carried over by the wind and the rain.¹ A glance at the analysis of the turnip (p. 328) will at once explain the policy of these additions to the phosphate of lime. *As a general rule*, applicable to all cases and to all artificial manures, it must be remembered *that efficiency is greatly influenced by their amount of division and distribution through the mass of soil which they are intended to benefit.* The more concentrated descriptions, as "guanos," "superphosphates," &c., should be well mixed with neutral substances, as sand, ashes, or even dry soil, previous to being applied; and then the more they are moved about and incorporated with the soil, the greater the chances the plants have of meeting with them, and the more immediate and beneficial are their effects.

After the sowing has been successfully accomplished,

¹ Salt has often been identified in the rain water during stormy weather at distances of 40 to 50 miles from the nearest point of the shore. An immense quantity, therefore, must fall on the surface of a country surrounded by sea, as this is.

and the plants have put forth their second pair of leaves, the horse-hoe should be sent in between the rows, and the spaces carefully cleared, and the cutting out or “bunching” in the drills proceeded with, as soon as the state of the soil and the weather will permit. This may be done by hand with a broad-bladed hoe, taking a cut of 9 inches, and then leaving about 3 inches in the drill untouched all along its length; or it may be done on the flat, by using the expanding horse-hoe (Garrett’s or Smith’s) across the drills, with its tines set at the above distances, so as to cut away spaces of 9 inches, and pass the plants on the intermediate spaces of 3 inches wide. On the ridge, too, a recently contrived machine (Garrett’s) effects the same purpose by travelling along the ridge, and cutting out the plants at given intervals by means of a set of knives, fixed spirally on a skeleton frame, to which a circular motion, at right angles to the line of draught, is communicated from the wheels of the machine.

By “bunching out” at an early period of their growth, the plants that are left to furnish the crop have greater exposure to air and light, assume a more vigorous growth, and in about a week’s time are ready for the next operation, that of “singling.” This is usually performed by adult labour, with a short-handled hoe, the superfluous plants being pushed from, rather than drawn to the labourer in the process, care being taken to leave the best plant for the crop. Too commonly, however, these two operations are done at the same time, and but little care bestowed upon them, whether by the regular labourer of the farm, or by strangers at “piecework.” The plants are cut away indiscriminately, and frequently the one that is left has been injured by the hoe, and never afterwards recovers from its effects. To guard against this constant source of injury to the crop, children have been employed to pull the surplus plants with their fingers, taking care that the

most vigorous is left uninjured in the drill. This is clearly work more suited to the child than to the adult; and with proper showing and moderate supervision, with the encouragement of an extra penny to the most careful workers it can generally be satisfactorily carried out, at a cost not exceeding that of the ordinary method, and with greater chances of a productive crop. Whether for "horse-hoeing," "bunching," or "singling" with the hoe or the hand, it is essential that the soil should be in a dry condition—a few days' delay is of far less importance than this important condition.

In fixing the distances at which the plants should be left in the drills, we have to consider the nature and condition of the soil, the habit of growth of the turnip, the distance between the rows, and the time at which it is sown. If we take 12 inches as our *average*, on good soils we should perhaps give a little more, and on the poorer class of soils a little less. Varieties with large spreading tops require more space than those with a more erect and confined habit of growth. Where the lateral spaces (between the rows) is less, the linear distance (in the rows) should be more; and lastly, a late-sown crop has not the same powers of development, and therefore needs less space, and can be safely left closer in the drill. All these points a *thinking farmer* settles for himself, and, according to the ever-varying circumstances of the case, gives his directions, even should they differ from the common practice of his district.

In the *Book of the Farm*, vol. i. p. 204, Mr. Stephens gives in a tabular form the number of turnips there should be on an acre at given distances between the drills, and between the plants in the drills, and of the weight of the crop at specified weights of each turnip. The table, which may afford us some assistance on the points in question, is given in next page.

Distance between the drills.	Distance between the plants.	Area of surface occupied by each plant.	Number of plants to the acre.	Weight of each turnip.	Weight of crop per acre.	
inches.	inches.	sq. ins.		lbs.	tons.	cwts.
27	9 for white turnips.	243	25,813	1	11	10½
				2	23	1
				3	34	11½
				4	46	2
				5	57	12½
				6	69	3
				7	80	13½
				8	92	4
27	10 for yellow turnips.	270	23,232	1	10	7
				2	20	14
				3	31	1
				4	41	8
				5	51	15
				6	62	2
				7	72	9
				8	82	16
27	11	297	21,120	1	9	8
				2	18	17½
				3	28	5
				4	37	14½
				5	47	2
				6	56	11½
				7	65	19
				8	75	8½
27	12 for Swedes.	324	19,360	1	8	12½
				2	17	0
				3	25	18½
				4	34	11
				5	43	3¾
				6	51	16½
				7	60	9½
				8	69	2

These figures show the importance of having the “singling” of the plants carefully attended to, as a very slight difference in the distances is followed by a great difference in the return; as, for instance, at 9-inch distances a crop of medium size roots, say 3 lbs. each, give a yield of 34½ tons per acre, whereas the same sized roots at 12-inch distances would only yield 26 tons. Again, too, it is seen what an immense difference the average weight of the bulbs makes to the gross of the crop, and how desirable it

is, that we should, by paying attention to the seed and general conditions of vegetation, secure bulbs of a good and regular size.

The after-growth of the crop receives no more assistance than that afforded by the hoe in keeping down the growth of the weeds, which should be attended to as long as the horse can travel through without injury to the plants, the spaces along the line of drill being kept clean by hand-hoeing. Later in the season, if the leaves continue flaccid, and "mildew" threatens, it is generally advantageous to give the soil a good stirring between the rows, for the purpose of enabling it to absorb moisture from the dews and night air, for the use of the languishing plant. Care must at this time be taken not to go so near the drills as to injure the bulbs, or so deep as to injure the roots, which ramify in every direction in search of food.

The various diseases and insect injuries incidental to the turnip plant, during the various stages of its growth, we will not refer to now, as they are fully described a little further on, but proceed at once to the last field operation, that of removing and storing, or otherwise disposing of them when their growth is completed. This usually takes place about the end of October or beginning of the next month. The common turnips, though sown the latest, are usually the first that are ready for use on the farm. This precocity of growth being combined with inferior keeping properties, usually cause them to be fed off on the land, or if removed to the homestead, to be consumed at once as they are brought in. They are rarely or never stored away for winter use. The other varieties—yellows, hybrids, and Swedes—are those which possess the best keeping qualities, and these have now to be disposed of according to the probable winter requirements of the farm. Here three principal considerations present

themselves—the sheep stock to be fed through the winter on the land—the head of cattle to be kept at the homestead—and the manure arrangements for the succeeding crops. It is clearly an unnecessary expenditure of labour to cart and store at the homestead more roots than will be required for the stock kept there, as the resulting manure has all to be carted back to the farm again; and it is clearly more economical, other circumstances being equal, to draw the store-supply from the fields nearest to the homestead, and to feed off those at the greatest distance, than to have to cart the roots from the most distant fields to the homestead, and to have to cart back in the spring an equivalent portion of manure.

When these points are settled, and the necessary labour arrangements made, the work should be commenced directly the weather is favourable, and proceeded with as rapidly as possible, in order to avoid the delay and chances of injury from frosts or rain, so common at this season of the year. The modes of effecting this operation vary greatly in different parts of the country. Some are directed throughout with great judgment and skill, while others again disregard all the principles of mechanics in the disposition of the labour, and of chemistry in the mode of storing the crop. In lifting and preparing turnips for carting, two different operations are required—that of removing the turnip from its bed, and that of “topping and tailing” it. If these are performed by the same individual, time is lost in constantly changing from one position to another; besides which, the two operations require a different quality of work—the “pulling” requiring a considerable amount of strength, the “topping and tailing” requiring less strength than careful work, so as not to injure the root. It therefore is advisable to separate them, to employ stout active men to go through the field, drawing the turnips, giving them a

shake to clear off the adhering soil, and then leaving them lying in the drill; and to employ women or lower-priced labour to follow, to "top and tail"¹ them, and place them in small heaps, ready for removal as soon as there are sufficient to keep the carts at work in taking them off the field. The quantity of work to be done in the day of course must depend upon the width of the rows and the weight of the crop; a good man, however, will generally pull as much as three or four women can top and tail in the same time.

Where it is intended to feed half the crop on the land and cart the other off, the better plan is to draw and leave two rows alternately over the field, as by this arrangement the crop is more equally divided, the turnips are consumed by the sheep with less injury from treading and soiling than when more rows are left together, and the manure is left better distributed on the surface, while the width cleared is quite sufficient for the cart to work through the crop without injuring the remaining portion. In the north and other districts, where the winters are severe, it is a common practice to protect them by partially earthing them up, by running the double mould-board ploughs through the drills. Where the drills, however, are only left two and two through the field, a "bout" of the common plough is generally all that is required to be done. Another practice exists, more common perhaps in the south than in the north, of storing the turnips to be consumed on the field in small-sized heaps of one or more cartloads, and then covering them lightly with straw, and a layer, about an inch thick, of soil. If well secured they will keep in good condition for a considerable time. After the roots are all carted off, the "shaws" should be at once spread over the field, and left a few days exposed to the action of

¹ An old or broken "hook" is commonly used for this purpose. It is, however, far better to have regular knives for this purpose, made sufficiently heavy to do the work, and blunt at the top, to prevent their being used, as the hooks too often are, to pick up the roots with, and thus save stooping.

the weather before they are ploughed in. Their manurial value may be calculated at about 5s. to 6s. per ton.

The root produce per acre, of course, is subject to great variations—20 tons of Swedes, 25 tons of yellow, and 30 tons of white turnips to the acre, would indicate good cultivation, and be received as satisfactory results. In some returns of turnip cultivation, published by the Lockerbie and the Morayshire Farmers' Societies, we find that the average weight per acre of turnips on thirty-seven farms, situated in the Upper and Middle Wards of Annandale, for the five years previous, was:—

	tons. cwt.s.	
Swedes,	21	19
Yellow,	23	4
Common,	27	13

And on twenty-five farms in Morayshire, the average of the year (1853), was:—

	tons. cwt.s.	
Swedes,	21	11½
Yellow,	18	2
Common,	22	13

The tops may be taken usually at from 20 to 25 per cent of the weight of the root crop.

In storing the root crop, the great object to be attained is to place them under such conditions that they shall not be injured by heating—which causes fermentation and decomposition—by frost, or by rain. There are various modes of effecting this, some preferable to others. These, however, will come better before us when we discuss the cultivation of another important root crop, “mangold-wurzel,” which in itself is more susceptible of injury than the turnip, while, at the same time, it has to be kept stored until the turnips are all consumed.

We have now, however, to consider the mode of raising seed, whether for home use, to improve or sustain a good stock, or for market purposes. The roots for this purpose

should be carefully selected, the following points being the most essential: *that they are true to the variety you wish to grow—that the bulb be uninjured, symmetrical in shape, whether globular or oblong, and free from lateral rootlets—that the head be well developed, and the neck small, and in the centre of the crown of the bulb—and that the tap-root be single, and finely drawn from the end.* This can be done as the turnips are being lifted, previous to “topping and tailing” them, a cart following to receive them as they are picked out. They are then taken to the place intended for them, which should have been previously well prepared and in good condition, and planted at distances of about 2 feet apart; or, if more convenient, they may be stored until February or March, and then set out at the given distances. In exposed places, or districts where winds prevail, the distances are diminished, in order to prevent the seed being flogged out by their action on the stems. Where the principal object sought is the improvement of the turnip, the details given at p. 330, in reference to the mode of determining the *real value* of a bulb, should receive due consideration.

The seed-stem is thrown out early in the spring; careful watching against depredation from small birds is required while the seed is maturing; the stems are then cut off with a sharp hook, so as to shake them as little as possible, and carted to the homestead for stacking and thrashing. Where the quantity is small and the weather fine, the seed is commonly thrashed out on the field, a large rick-cloth being spread to receive the produce. In order to secure the full reproductive powers of the seed thus grown, it is a good plan to mix it with three or four times its weight of an easily distinguishable variety—white or Swede, as the case may be—and sow it in the usual manner. Thus, 1 lb. of seed (Swedes) from carefully-selected bulbs, mixed with 4 lbs. of white turnip seed, will

be sufficient for two acres, the plants of the latter being cut out in the hoeing or singling, while the produce of the former (Swedes) may be allowed to stand as a crop for seed purposes the following year. If a little attention be given when the plants have arrived at maturity, to look the field over and draw out any faulty roots, the produce will generally sustain a good reputation for quality in the market. Turnip seed is looked upon rather as a speculative crop, subject to great variation in yield, from the effects of weather, wind, and other injuries, which, of course, if general, affect its market value also. The produce varies greatly according to the season and the variety grown; it may be taken at 20 to 30 bushels per acre.

The turnip is not subject to so many *diseases* as some others of our cultivated plants. Its greatest danger is from the attacks of insects, which visit it at every stage of its growth. Frequently on rich vegetable soils, or where a large proportion of organic manure has been used, we see the young plant exhibiting a very vigorous growth, with leaves of a rank, deep green colour, extremely large and succulent, indicative of an abnormal development of the top, and a proportionate weakness of the root and general vitality of the plant. Such plants are very liable, Mr. Berkeley tells us, to be attacked by a species of *Botrytis* (*B. parasitica*), nearly allied to the potato mould, and scarcely less injurious in its effects. The roots in those plants in which the parasite has effected a lodgment are very liable to decay, and a decomposition of the walls of the spiral vessels is frequently traceable for several inches, being 'always the sure forerunner of complete decay. In many cases, again, where the plants have been cultivated under ordinary conditions, and have sustained their ordinary growth under certain conditions of moisture and temperature, the surface of their leaves is covered more or less with a light mould, so as to give

them the peculiar glaucous hue of the "mildew," so perceptible even at a distance from the field. This condition of the plant is seen generally when vegetation has been arrested in consequence of continued drought, and is due to the presence of a species of "Oidium" upon the leaves, the growth of which is effectually checked by it, and in the end, as in the former case, unless the plant is speedily relieved by rain, and its powers restored, the roots as well as the tops perish, or are greatly deteriorated and of little value. This disease is far more commonly met with in the south than in the north, and appears to visit the more mature plants with greater severity than the younger ones. In many parts, therefore, where the soils or the climate predispose to this visitation, it is the custom to delay sowing, even the Swedes, until the end of June, so that the plant may not be too advanced in its growth at the period when the "mildew" may be expected to show itself. In all cases, however, whether in the north or the south, it is always desirable to keep the spaces between the rows well stirred and pulverized at the surface at this particular period (August and September), when the earth has acquired a high temperature, and but little rain can be looked for. This gives the surface a greater power of absorbing the moisture of the dew, and at the same time increases the capillary power of the soil to draw moisture upwards from the strata below. As long as the healthy plant can continue its regular functions of growth, there is no fear of mildew. If these are arrested for any time by the absence of sufficient moisture, disease and decomposition must ensue. In the *Agricultural Gazette* for 1853, p. 276, there is an account of a disease attacking the Swedes, the decay commencing apparently in the neck, immediately below the top, penetrating gradually to the centre, and ultimately cutting off all nutriment from the apex,

and so causing death. It is possible that this might have been a result of the "Oidium," the poison having been carried down to the root by the spiral vessels of the leaves, and that this changed effect of its attack may have been due to some constitutional weakness of the crop, aggravated probably by high cultivation.

There is another disease, however, which is still a *nexata questio* with scientific as well as with practical men; that is, the "fingers-and-toes," or "anbury," as it is generally and indiscriminately termed. This has been the subject of a vast amount of discussion and of writing by good practical men, and by some few scientific men, who seem generally to take different views on the subject, neither of them, however, being able to decide the question in a mutually satisfactory way. This is not surprising, as, indeed, it has never yet been investigated in the careful manner its importance to physiological botany deserves. The chemist appears, however, to have been appealed to with greater success than the botanist, as in 1852 the Highland Society drew up and issued a circular embodying a series of questions of a practical character, the replies to which were remitted to Drs. Anderson and Balfour to investigate and report upon, both in a chemical and botanical point of view.

The chemical portion was carefully worked out and reported on by Dr. Anderson in the following year.¹ After summing up the replies to the circular of queries, he says, "Such are the results of the inquiries made among some of the most skilful farmers in all parts of Scotland, results which, as it will be at once apparent, are of a very conflicting nature—much more so than could possibly have been anticipated. It appears, indeed, that not only do remarkable differences of opinion exist among different persons, but in some instances an individual reporter

¹ *Trans. High. Soc.*, 1853, p. 118.

informs us that he had arrived at certain definite conclusions, of which the experience of later years had led him to doubt the accuracy." He then proceeds to give what appear to be fair and legitimate inferences, from the consideration of all the facts, both theoretical and practical, which had been accumulated, and states that—

1st. It is unquestionable that the disease is not due to any *chemical* change in the *composition* of the soil. It is obvious, however, that its *physical* characters, though not the cause of the disease, influence, in some way or other, its development. Thus it is unequivocally made out that the disease occurs far more frequently and far more severely on light soils than on heavy, and that the stiffer clays seem to produce turnips in which it is rarely observed.

2d. The disease is not dependent on any chemical change having taken place in the plant itself, but the changes observed are a consequence of diseased action.

He continues his deductions by stating (3dly), that the most probable explanation of the disease is that which attributes it to the attacks of insects; (4thly), that it appears the disease may in most instances, though not in all, be prevented by the liberal use of lime, which must be applied one or two years previous to the turnip; and, lastly, that if this disease be really produced by the attacks of insects, whether lime may not produce its good effects by destroying them.

"Circumstances appear to have prevented Dr. Balfour making as extended and complete inquiries as the subject seemed to require," consequently no evidence is given, and the botanical part of the inquiry remains yet to be reported upon.

About the same time, however, the question was being investigated by the Professor of Botany at the Royal Agricultural College, who came to the conclu-

sion that the "anbury" and "fingers-and-toes," terms indiscriminately applied to express a disease frequent in turnips, and exhibited in the malformation of the root—were *distinct and different* affections—the one being a disease, and the other not so much a direct disease, in the strict meaning of the word, as a change effected by the circumstances of cultivation. He showed,¹ by careful experiments, that the tendency of cultivation, accompanied by a careful selection of seed and change of soil, is to produce *single* tap-roots; but that amongst a variety of seedlings, under the most favourable circumstances, there is always a disposition to revert to the original condition, and that this tendency is increased in proportion to adverse agricultural influences, as untimely sowing, poverty of soil, repetition of crops on the same ground, &c.

Wherever, therefore, a large proportion of branching roots occur, the *quality of the seed may be suspected*, especially if the soil be in good condition, and the same crop not have been taken in succession from it. These branching roots always have a greater propensity to run to seed than the single ones. For its prevention, care should be taken to obtain seed from carefully-selected roots, and not from a crop taken indiscriminately from the ground; that the roots should not be the produce of *late-sown seed*, which has an especial tendency to produce plants which run to seed rapidly without forming full-developed bulbs; and that the roots selected should have been raised and stored previously to being again planted for seed. This is of great importance, as by lifting and storing them, you check that exuberance of vegetation, which has a tendency to reduce plants to their original condition.

With our present imperfect acquaintance with vegetable physiology, especially in reference to our cultivated crops, it would ill become any one to speak in a dogmatic manner as

¹ *Roy. Agri. Soc. Jour.*, vol. xv.

to the exact causes of these two diseases, or as to the difference that exists between them. All that can be done safely is to sum up the reliable evidence we possess in reference to them, which would appear to show that they are perfectly *different in their origin, their mode of affecting the turnip, and their results*; that “fingers-and-toes,” well known to the vegetable pathologist as “*dactylorhiza*”¹—the intermediate condition between the natural (wild) and the artificial state—is in this case the result of degeneration

FORMS OF DISEASE IN TURNIPS.

1. “Fingers-and-toes” form of disease. 2. “Anbury” form of disease. 3. Grub found in excrescences of 2.

from cultivation to wildness, due to some of the causes given;² and that “anbury” is a distinct affection, due probably to the same causes as the “clubbing” in cabbages (which will be more fully considered hereafter), and readily

¹ From *δακτυλος*, a finger, and *ρίζα*, a root.

² In some experiments by Mr Lawes, carried out at Rothamstead some few years ago, we have evidence of the effect produced on turnips by the circumstances of cultivation, and of the readiness with which they revert to their

distinguishable by the different portions of the root affected, and by the presence of insects accompanying the progress of the disease. There is nothing in the evidence we have before us to lead us to infer that the two forms of disease could not exist in the same root; in some instances (*fig. 4*) such may have been the case, and thus have led to the many conflicting opinions that have been expressed on the subject. From the details of cultivation, obtained in reply to the Highland Society's circular, and from Dr. Anderson's valuable deductions, we would suggest that the amount of *available potash* in the soil may in some

Turnip affected by both forms of Disease,

way exert an influence on one or both forms of disease. It was found that it occurs far more frequently and far more severely on light than on heavy soils, and that on the stiff clays it is rarely observed; and again, that it may, in most original state if the circumstances which induced their abnormal condition be not constantly sustained.

Turnips of ordinary size were planted on a piece of *unmanured soil three years in succession*, the produce being reduced each year in weight to a considerable extent. In the fourth year the bulb had entirely disappeared, and the root had resumed its original wild state. The produce each year is thus given:—

	Weight per Acre.				Average weight of bulb in lbs.
	Tons.	cwts.	qrs.	lbs.	
1843	4	3	3	2	·52
1844	2	4	1	0	·36
1845	0	13	2	4	·11

instances, though not in all, be prevented by the liberal use of lime, which must be applied one or two years previously. We know from our ash analysis that turnips require for their healthy development a large proportion of potash, and if this is not obtainable, their health and growth are proportionably affected; and we also know that heavy and clay soils contain that salt in greater proportion than the lighter class of soils, on which the disease is the most frequent and the most severe. The action of lime on clay soils is twofold—it acts *mechanically*, by assisting in their disintegration, and it acts *chemically* by aiding their decomposition, and thus setting free the potash they may contain in an insoluble state, and consequently unavailable to the turnip plant. On the light turnip soils of Norfolk and Suffolk the disease is, however, far less often seen than on the heavier and richer soils of the north. The lime, which is recommended as the remedy here, is of but little value there, as there are no salts of potash locked up in their soil; but instead of lime, they find an equally effective remedy in marl,¹ which they apply largely to their fields, and thus keep their turnips free from disease. It is generally considered that the disease is more frequently met with now than in former years. If that be the case, it would confirm the suggestion we have advanced, as the great mass of manure now used in their cultivation is bones or “superphosphate,” containing phosphates in abundance, but *no potash at all*, though the plant requires (see p. 328) three times as much of that as it does of the phosphoric acid of the manure. In regard to that form of the disease which is properly termed “anbury,” this deficiency of potash would no doubt exert the strongest influence; in the mere “fingers-and-toes” its influence would be less, as this form of disease arises from

¹ Marl is a mixture of lime and clay in differing proportions: the marls of the lower chalk, which are used in the eastern counties, are all rich in potash.

a degenerate growth of the plant, favoured more or less by unsuitable food conditions in the soil in which it is grown.

Considering the number of *insect* enemies the turnip has to encounter in the field, it cannot be a matter of surprise if our crops have, during the progress of their growth, to submit to serious injuries from their attacks. Indeed, considering the little attention we pay to them, and the very little we really know about them, their habits, their reproduction, and their remedies, it should be rather a matter of surprise that we are able to secure at the end of the season those magnificent crops which, under the improved system of farming, have so largely added to our productive resources. As soon as the seeds are deposited in the soil the ants, always busy at that season, take possession of vast numbers of them, and carry them away; while those that are left germinate and in due time appear above the ground, where the "turnip-fly"—*Haltica nemorum*¹—in countless numbers, are on the look-out for them,

1 and 2. Insect (natural size and magnified). 3. Insect feeding. 4 and 5. Eggs of insect on under side of leaf. 6 and 7. Maggot advancing in growth. 8 and 9. Maggot full grown (natural size and magnified). 10 and 11. Pupa (natural size and magnified).

and speedily give evidence of their destructive capabilities. The first pair of (cotyledon) leaves are selected by them,

¹ This is a common misnomer—the insect is clearly a beetle, and not a fly.

and, according to the amount of injury these sustain, is the vigour and the life of the young plant determined. If it has power enough to throw out a second pair of leaves, it in general gets over the injury, as its growth at this period is very rapid, and it is better able to withstand the diminishing attack of its enemy. An allied species, slightly differing in appearance, the *H. concinna*, is also met with, attacking the young plant. At an early stage of their growth, the wireworms and "surface-grubs" (belonging to the genus *Mamestra*) frequently commit serious ravages by eating through the incipient root-stalks or bulbs, and thus either destroy the plant or check its after-development. As the growth advances, a member of the "weevil" family—*Ceutorhynchus contractus*—finds a supply of food in the leaves of the plant, which it commences to devour, and at the same time makes use of the root as a receptacle for its eggs, which, after having punctured the cuticle, are deposited therein. Some entomologists (Drs. Fleming and Calvert) tell us that the turnip suffers as much from this insect as from the "fly." No sooner has it passed through this stage of its career than another enemy appears, in the shape of the "black nigger"—*Athalia spinarum*—a voracious caterpillar of the "saw-fly" genus (*Tenthredinæ*)—which in some seasons speedily disposes of the entire leaves of entire crops. This last season (1859) its ravages were witnessed in a very marked degree. In its absence, the work of defoliation is always more or less attended to by the ordinary caterpillars of the cabbage and turnip butterflies—*Pontia brassicæ* and *P. rapæ*—which are to be seen every year in the gardens and fields of every part of the country, and always feeding on some portion of our cultivated plants. About the month of August, when the plants which have escaped injury from the foregoing insect attacks have well developed their tops, and assumed a vigorous appearance, the leaves ex-

hibit signs of injury, occasioned by a minute fly, of a pale slate colour, the *Phytomyza nigricornis*, or an equally small fly, of a pale green colour, called the *Drosophila flava*—"yellow turnip-leaf miner"—which lay their eggs

1. Blistered surface of leaf. 2 and 3. Maggot (natural size and magnified). 4 and 5. Pupæ (natural size and magnified). 6 and 7. The fly, *Drosophila flava* (natural size and magnified).

upon the leaves, the maggots when hatched burrowing and making galleries between the cuticles, living upon the fleshy part (parenchyma), and thus destroying its important functions in the processes of vegetable life. Later in the autumn the turnip plant-lice—*Aphis brassicæ* and *A. rapæ*—are met with, swarming on the leaves and abstracting their nourishment from them, and adding to the amount of injury they have already sustained.

This brief sketch of the better-known insect enemies the turnip has to encounter in its passage through life, must suffice here; full details of their natural history will be found in the interesting pages, already alluded to, of Curtis, Kirby and Spence, Köllar, and other writers on entomology. Their ravages are far greater, and the injuries they inflict far heavier, each year, than we usually, from our general want of observation, and indeed ignorance, of their existence or habits, believe; it is only when the attack of any one of them is very marked, as of the "black nigger" in the past season, that we find much notice bestowed on them, and

even then that frequently is limited to the district of their ravages. So far back as 1783, we find, in the *Philosophical Transactions of the Royal Society*, notices of the destructive visits of these caterpillars, extending over thousands of acres, which they entirely cleared off; and a few years later (1786), that the loss sustained by the ravages of the "fly" in the county of Devon alone, was estimated by Dr. Young at £100,000. At the present day, travel which way you will, everywhere the turnip fields give evidence, by their blanks and deficiencies, of some causes operating against the farmer's crops. What the deficiency throughout the country may be from their individual or combined ravages, could, in the present state of our statistical and other knowledge, only be guess-work. We have some data, however, in the recent statistical returns of Scotland, where, in 1857, we find the area under turnips to be 476,691 acres, while the entire produce amounted only to 6,690,109 tons, equal to about 14 tons per acre; whereas we may fairly estimate the productive capability of Scotland, with its good farming and congenial soil and climate, to average 20 tons to the acre, if the crops were not diminished by insect injuries. This would show a loss of from 25 to 30 per cent. of their entire crop. If this estimate is correct for the north, what must the loss be in the south, where the turnip cultivation is less attended to, and the soil and climate less congenial to turnips, and more congenial to insect growth? Happily for us, these destructive pests are always accompanied by certain parasitic insects, which live upon them and thus keep down their numbers; whilst pheasants, partridges, rooks, starlings, lapwings, and a host of smaller birds, live at certain seasons of the year entirely upon them.

As may be supposed, many remedies have been recommended from time to time for the purpose of preventing or lessening the injuries they commit. One simple remedy,

which in itself will materially lessen the chances of injury, is within every farmer's reach, viz., *to keep his fields free from weeds*, especially those of the same "genus" as his crop, upon nearly all of which his insect enemies find a subsistence. In regard to the "fly," it is clear that the great object is to carry the plant through its early stages as speedily as possible, and this is best attained by securing to it those conditions which we have already discussed, in regard to germination and early development of plant growth. The soil must be in fine tilth, moist enough to insure regular germination, and containing food immediately assimilable by the young plant. These conditions are readily attained by the various implements and manurial substances which are now at our command; and accordingly as they are observed or neglected, so do the chances of the plant increase or diminish. The remedies proposed consist chiefly of some method of dragging tarred or painted boards or nets over the drills, and thus catching the "fly" as it jumps off the plant at their approach; or of broadcasting some noxious substance over the field, which either destroys or drives away the enemy. One really efficient remedy is, however, all we require, and that would appear, from an account given last season to the Royal Agricultural Society¹ by Mr. Fisher Hobbs, a well-known and eminently practical agriculturist, to exist in the form of a mixture, very simple and inexpensive, both in its composition and mode of application.

The ingredients are: 1 bushel of white gas-ashes (*gas-lime*), fresh from the gas-house; 1 bushel of fresh lime from the kiln; 6 lbs. of sulphur and 10 lbs. of soot, well mixed together, and got to as fine a powder as possible, so that it may adhere to the young plant. These proportions are sufficient for 2 acres when drilled at 27 inches. It should be applied very early in the morning—*when*

¹ This is given *in extenso* in the *Agri. Gaz.* for 1859, p. 473.

the dew is on the leaf—a broadcast machine being the most expeditious way of distributing it; or it may be sprinkled with the hand carefully over the rows. If the “fly” continues troublesome, the process should be repeated. By this means, Mr. Fisher Hobbs says, 200 to 220 acres of turnips, Swedes, and rape, have been grown annually on his farms for eight or nine years past, without a rod of ground losing its plants. This, or some similar composition, would no doubt to a great extent protect the plants from the “black nigger” and other caterpillars; the safest way, however, is to have them picked off by the hand if not too numerous; or if the plants be young, this is done more effectually by young ducks, which should be kept moving along the rows, otherwise they are apt to eat the leaves also. The galls or excrescences seen so frequently on turnip bulbs, are due to the

1. Turnip injured by the “Turnip-gall Weevil.” 2. Excrescences or Galls.
3. Do. opened. 4. Grubs (natural size and magnified) found in them.
5. Weevil (*C. pleurostigma*), natural size and magnified.

attacks of the “turnip-gall weevil” (*Ceutorhynchus pleurostigma*); these each contain from one to three or four grubs, which feed upon the bulb, and then leave it in a suitable condition for the attacks of sundry other insects

—rove-beetles and the larvæ of dipterous flies—always ready to seize upon disorganized vegetable tissue, and assist its ultimate destruction.

Even when the turnips are planted out for seed, their dangers are not all over; as soon as they flower they are liable to be infested by the “turnip-flower aphis” (*A. floris-rapæ*), and also to the visits of the “green rose-chafer” (*Cetonia aurata*), which sometimes does great injury to the flowers by destroying the anthers, and thus rendering them abortive. This happens more frequently when the seed is being grown in a garden than in the field, especially if strawberry beds be near, in which this beetle breeds. After the flowering is past, and the seed-pods (siliques) formed, they are frequently found to be sadly injured by the “turnip-seed weevil” (*C. assimilis*), which

1 and 2. Weevil (natural size and magnified). 3 and 4. Maggot of Weevil (natural size and magnified). 5. Exit hole in seed-pod. 6. Form in soil. 7 and 8. Pupæ (natural size and magnified).

inhabits the flowers, and bores a hole in the incipient pods to lay its eggs in; the maggots then feed on the seeds until they are ready to change their state, when they eat their way out of the pod, and falling to the ground, bury themselves, and pass in due time into the state of pupæ, from which the perfect insect, “the weevil,” emerges in the spring.

The *chemistry* of the turnip has received the attention its importance to our system of agriculture demands; and

we have placed at our disposal reliable information upon every point of its composition and requirements. In a plant subject to such different modes of treatment as the turnip, its general composition and the relative proportion of its constituents are necessarily liable to great variations—the difference produced in it by a wet or dry season, by poor or rich soils, by slow or rapid growth induced by the absence or presence of stimulating manures, by far exceed that which is always, to a certain extent, found due to the influence of descent from different varieties. For this reason it is not possible to assign any fixed or determinate feeding value to this valuable root; all we should attempt is an estimate based upon our knowledge of its general composition, and upon the degree of development of the individual plant or crop. In an investigation involving such chances of difference as must ever exist in the composition of our root crops, the result of a solitary determination is of but little value, as it may represent a condition that may not occur elsewhere; it may be correct as regards the individual, but incorrect as regards the mass. In the systematic investigation by Messrs. Way and Ogston,¹ into the ash-analyses of turnips, we have the results of their examination of above 100 specimens, embracing all the ordinary varieties, and grown in well-nigh every variation of soil and climate. From these we can safely deduce *average results*, which probably would give us more reliable evidence as to the general composition and requirements of the crop, than we could, except at a great outlay of time and money, obtain from any special examination. In determining the proportion of water contained in the “bulbs” of thirty specimens of different varieties, it was found to vary from 86 to 92·77 per cent., giving an average of 90 per cent., and

¹ Full details of this important and interesting investigation are given in the *Roy. Agri. Soc. Jour.*, vol. viii. p. 134.

in the tops or "shaws" from 79 to 90 per cent., or a mean proportion of 85.5 per cent. This variation has a higher importance than at first meets the eye; it shows that the largest crops are not necessarily the most valuable, as the difference in weight per acre between two crops, may only be due to the larger proportion of water in the one than the other; and in this case the feeding value of the larger crop would be absolutely less than that of the smaller, as a proportion of its nutritive constituents would be consumed in raising the temperature of the extra quantity of water to the body heat of the animal, and thus contribute nothing to its increase. Indeed, it is possible, taking the two extremes, that a crop of 10 tons per acre may contain absolutely a greater amount of keep than another yielding double, or 20 tons per acre.

In the ash, or inorganic constituents, even a greater variation was met with; the proportions varying from .48 to 1.13 per cent. in the bulb, giving a mean of .73 per cent.; and from 1.19 to 2.64 per cent. in the tops, or an average of 1.84 per cent. Thus the average percentage composition of the turnip appears to be, in the bulb, 90 per cent. of water, .73 per cent. of inorganic matter, and 9.27 per cent. of solid organic matter—consisting chiefly of sugar, gum, pectine, nitrogen compounds (albumen), cellular tissue—*upon the proportions of which the real feeding value mainly depends.* In the tops the average composition per cent. is 85.5 of water, 1.84 of inorganic matter, and 12.66 of solid organic matter, consisting of the same substances, though in different proportions, as is shown in the following analyses. The composition of the inorganic portion (ash) of the plant is given at top of p. 328.

Basing our calculations on the foregoing mean proportions of inorganic matter in the turnips, and taking the average weight of the tops to be one-sixth that of the bulbs, we should find that a crop of roots weighing 20 tons

	Bulb. ¹	Top. ²	Whole Plant. ³
Potash,.....	34.1	15.21	28.65
Soda,.....	7.96	2.84	5.41
Lime,.....	9.93	28.49	23.27
Magnesia,.....	2.61	2.81	3.09
Oxide of Iron,.....	.46	1.68	.86
Phosphoric acid,.....	9.85	6.17	9.29
Sulphuric acid,.....	13.12	8.43	12.52
Silica,.....	1.81	3.99	.86
Carbonic acid,.....	11.96	9.98	...
Chloride of Sodium (common salt),...	8.13	15.3	16.05, as Chlorine.
Chloride of Potassium,.....	...	5.04	...
	99.93	99.94	100.00

to the acre, would abstract from the soil about 500 lbs. of the above ingredients, in something like the following proportions, which, of course, must be returned to the soil before it can regain its normal fertility or condition:—

Potash,.....	145 lbs.	Phosphoric acid,.....	50 lbs.
Soda,.....	28 „	Sulphuric acid,.....	65 „
Lime,.....	116 „	Chlorine,.....	80 „
Magnesia,.....	16 „		500 „

The *organic* composition of the turnip has been investigated by Dr. Voelcker, from whose careful and reliable analyses we now know that it consists of—

	White Globe (<i>depressa</i>).	Norfolk Bell (<i>oblonga</i>).	Swede.
Water,.....	90.430	92.280	89.460
Compounds containing nitrogen (flesh- formers),.....	1.143	1.737	1.443
Compounds destitute of nitrogen, as gum, sugar, pectine, &c.,.....	4.697	2.137	4.637
Do. do., as vegetable fibre,.....	3.102	2.825	3.837
Ash (inorganic matter),.....	.628	1.021	.623
	100.000	100.000	100.000

One great object in turnip cultivation is, of course, to obtain not only quantity but *quality of produce*, and it must be obvious to all, that those bulbs containing the

¹ Way and Ogston—the mean results of six specimens of different varieties, Skirving's Swede, Dale's Hybrid, Green-top White.

² Way and Ogston.

³ Fromberg.

smallest proportion of water and the largest proportion of nitrogen, and also other compounds, are those best suited for our purpose. In the foregoing table it is seen that the Swede turnip contained less water and more nutritive matter than either of the others, and as Swedes are always firmer and heavier than other turnips, it was suggested that some good indications of these desirable qualities might be deduced from the relative "specific gravity" of the bulbs, and thus varieties of improved feeding qualities be obtained. The *specific gravity* of the turnip has for some few years past, indeed, formed the subject of extensive practical experiments by the Marquis of Tweeddale, and by Mr. Lawson, with the view of effecting a permanent improvement in the quality of the crop. They have for several seasons been in the habit of selecting turnips of the highest specific gravity, and planting them for seed, from which again the heaviest bulbs were selected and again planted, the produce thus increasing materially in specific gravity in the course of a few years. The question, then, as to the *real nutritive value* of the roots was submitted to the chemist, as, practically, the end sought for, the mere increase in specific gravity, might be considered achieved. After a series of careful investigations, it was found that in all cases the Swedish turnip had a higher specific gravity than either the hybrids, yellow or white varieties, but that no safe estimates of nutritive value could be deduced from the mere specific gravity of the root, which appeared to depend upon the relative size of the cells in the mass of the root, and the quantity of air contained in them. Therefore, supposing it possible to displace the water, or a portion of it, and replace it by air, the mass would immediately become specifically lighter than it was, and yet have, for its weight, a far higher nutritive value. In experimenting upon the *expressed juices* of the bulbs, however, more satisfactory

results were obtained: they afforded a nearer approximation to the value of the whole turnip, as there appears to be a tolerably consistent relation between *their specific gravity and the proportion of nitrogen compounds contained in them*. Dr. Anderson,¹ to whom the investigation was confided, sums up his report by stating—1st, That the *specific gravity of the whole turnip* cannot be accepted as indicating its *real* nutritive value, the proportion of air in the cells being the determining element in such results; 2d, That there is no constant relation between the specific gravity of, and the nitrogen compounds in the bulb; and 3d, That such relation *does* exist between the specific gravity of the *expressed juice* and the *nitrogen compounds and solid constituents*; consequently, we may rely upon this as indicative of the true feeding values of the several varieties tested.

This investigation, though failing to confirm the original views, has been productive of much practical good; as we now know that difference in specific gravity of the whole root is due to the proportionate presence of air in the cells; consequently, that those varieties containing the least are the best adapted for keeping. Hence it is that the Swede is of all the varieties the best for storing away, and that the hybrids and the yellow are superior to the white varieties, which have the lowest specific gravity, and contain the largest amount of air in their cellular tissue. Thus the determination of the specific gravity of the entire bulb gives us its *relative keeping properties*, and the specific gravity of the expressed juice indicates at once the *real feeding value* of the specimen examined. These results are perfectly in accordance with those obtained by M. L. Vilmorin,² in France, in reference to the

¹ Details of this important investigation are given in the *Trans. of High. Soc.*, 1856, p. 184.

² *Instruction pour l'Essai des Betteraves*, par L. Vilmorin.—*Jour. d'Agri. Pratique*, 1858.

percentage of saccharine matter in the "beet," which is used largely for the manufacture of sugar. By determining the specific gravity of the juice of the roots, and then carefully propagating those of the highest value, M. Vilmorin has, in the course of a few years, been able to produce a variety containing a greatly increased proportion of sugar, and consequently of increased agricultural and commercial value. The mode of testing the specific gravity of the juice is very simple, and readily performed. The woodcut describes the only apparatus needed.¹

The turnip should be placed on a table, and the cylindrical borer plunged right through its centre; the portion carried out in the cylinder is then expelled by the piston, and rasped on to the fine cloth, the expressed juice being collected in the capsule, poured into the long testing-glass, and its specific gravity ascertained by means of the instruments for that purpose. Care is necessary to cut *clear*

A. Metal borer with wooden piston. B. Rasp or grater. C. Capsule. D. Test-glass for taking density of juice. e. Thermometer. f and g. Densimeters. H. Roll of linen for pressing the pulp.

out from the bulb the portion required for testing; in such case the perforated root is not injured for seed purposes, especially if the excised surfaces be dusted over with lime,

¹ The apparatus, arranged and used by M. Vilmorin, is sold by Deleuil, 6, Rue du Pont de Lodi, Paris, at 18 francs. For determining the *specific gravity of the root*, a simple apparatus has been arranged by Mr. Stevenson, Lothian Street, Edinburgh, of whom it can be obtained.

gypsum, or even dry sand: if any of the cut portion be left behind, it is sure to rot, and disorganize the whole mass.

The *organic* composition of the turnip tops has likewise been determined by Dr. Voelcker, and is thus given:—

	Norfolk Bell (white).	Swedes.
Water,.....	91·284	88·367
Compounds containing nitrogen,.....	2·456	2·087
Compounds destitute of nitrogen, as sugar, gum, } pectine, &c.,.....	·648	1·612
Do. do., as vegetable fibre,.....	4·092	5·638
Ash (inorganic matter),.....	1·520	2·296
	100·000	100·000

At first sight, judging from the percentage of nitrogen compounds (*flesh-formers*), these analyses would lead us to consider that the tops possessed higher feeding qualities than the bulbs of the turnip. It would be worth while to test this practically, as we have no recorded experiments as to their actual feeding value, which probably would not be so high as the amount of nitrogen they contain would lead us to expect, as from recent researches we have reason to believe, that in the case of succulent articles of food, and leaves especially, the nitrogen they contain does not entirely exist in the shape of albuminous or other available food compounds. The analyses of their inorganic as well as organic constituents, however, show us their manurial value to the farm—a crop of 20 tons of roots to the acre leaving behind them on the field in their “tops,” in round numbers, about $1\frac{1}{2}$ cwt. of valuable fertilizing mineral substances, and organic substances capable of producing about 40 to 50 lbs. of ammonia. These matters are worth consideration, especially when turnips are sold off the land.

THE KOHL-RABI CROP.

THE next one of our field crops coming under the head of "fallow or root crops" which we have to describe, is the KOHL-RABI. In its general characters and mode of treatment it very much resembles the turnip; while, at the same time, it possesses points of difference, which entitle it to a separate consideration. It belongs to the same order, "Cruciferae," and even to the same genus, "Brassica," as the turnip—and has received from botanists the specific name of *Brassica caulorapae*. In its habit of growth, however, it shows a marked difference from the turnip; as, instead of exhibiting under cultivation an abnormal development of the cellular tissues of the root, the kohl-rabi preserves its natural condition of the root, and shows the effects of cultivation in the enlargement of the foot-stalks of the leaves, which, under favourable circumstances, increase that part of the stem to which they are attached to an extent equal in size and weight to a fully-developed turnip.

This singular tendency to depart from original conditions is more evidenced in this "order" of plants than in most others, and exhibits itself in other ways than those alluded to in the turnip and the kohl-rabi. It is the more remarkable, as the *general* characters of the "order" are so constant as to clearly define its members—whereas, individual species are liable to great variations when placed under the influence of cultivation. This great tendency to change may be readily noticed in some of our

garden flowers (cruciferous), as the stock and wallflower, for instance. In these it is shown in the development of petals in the place of stamens and pistils, and the double-flowered varieties, as they are termed, become more valued than in their original single-flowered condition.

If these double-flowered plants were removed from the influence of cultivation, and returned to the poor soil from which the original stock came, they would speedily lose their valued characters, and reassume their natural condition. It is this tendency to variation under the influence of cultivation, so marked in individual species of this family, that renders various other plants belonging to the order so valuable to mankind as articles of food. The original stock of all the Brassica family of plants is supposed to be the *B. oleracea*—"the sea colewort"—a common plant, met with growing wild on the coast-lines of the southern and eastern counties of this country, and also in many other parts of the world. Its appearance is that of a broad-leaved glaucous plant, with a woody stem and tough fibrous roots, very unlike any of its numerous offspring; and, indeed, it is very difficult to conceive by what original train of circumstances the species was brought under the influence of cultivation, and how it was imagined that it possessed such a remarkable tendency to change its appearance in so many different ways, and increase the amount of the fleshy portion of its tissues, when supplied liberally with suitable nourishment.

This remarkable property of development is exhibited by different members of the family, in different parts of their structure. In the turnip and the radish we see it existing in varying forms in the upper portion of the *root*, which has been completely changed by cultivation from its original condition, giving us those fine specimens of increased yield, which add so much to the resources of the farm. Yet, if we take the seed of these same turnips,

and sow them for a few years successively, in a soil as poor as that in which the wild stock may be found growing, we should see them gradually recede to their original state, and in the course of a few years, the fully-developed and weighty bulb would have entirely disappeared, and left only the long, tough, stringy root, characteristic of the original prototype. (See page 317.) Again, in the turnip the increase of *leaf* is considerable; but this is better seen in the different varieties of the cabbage, where it is not accompanied by increase in the root. In the rape and colza, the *stem* especially, and the leaves show the peculiar development. In the cauliflower and the broccoli,¹ the tendency to increase is exhibited in the *flower-stalks*; in the sea-kale, the *leaf-stalks* them-

KOHL-RABI—Round or Globe Variety.

selves receive the increase of deposited matter. The “kohl-rabi,” which we have now to consider, exhibits

¹ A remarkable instance of this tendency to depart from the ordinary type

this tendency in a different form from any of the preceding plants; in this it is seen only in the enormous development of the *base of the leaf-stalks*, whose tissues are increased to such a degree as to cause the stem to assume quite the appearance of a bulb, which begins to be formed at an inch or two above the surface, where the first leaves are attached to the stem.

There are two distinct (?) varieties of kohl-rabi cultivated, the Purple and the Green, and these are both met with in an oblong and in a globular form. The purple is

KOHL-RABI.—1. Round Variety. 2. Oblong Variety.

considered the hardier variety, and better fitted generally for field culture, and the oblong shape is preferred to the globular, which is more frequently met with in the garden, where the green variety more particularly is

is seen in a new variety of broccoli, just introduced by Messrs. Lee, of Hammer-smith, the centre head of which is surrounded by from thirty to fifty subordinate heads, all of good size, and each exhibiting the same development of the flower-stalk, and possessing the same culinary value as the centre.

esteemed by some a valuable esculent vegetable. The plant is described by Gerardo, and figured in his *Herbal* (1567), and although mentioned by Arthur Young at the beginning of the present century, and well known in the agriculture of Germany, it appears to have been scarcely noticed in this country until about twenty years ago, when it was recommended as a substitute for the turnip, which at that time during one season (1837) had suffered severely from the attacks of a grub, which injured the stem immediately below the surface. Owing to the different habit of growth of the kohl-rabi, the part attacked by these grubs being of different texture to the young turnip, was sufficiently tough and strong to withstand any injury they might inflict upon it, and consequently more likely to produce a good crop. In the districts where the greatest losses were sustained the new plant was welcomed as a valuable addition to their crops; but before it had established itself in the favour of the farmers, natural causes had relieved their fields from the destroying insect, the old culture of the turnip was resumed, and the regular introduction of the kohl-rabi left for a future occasion.¹

Notwithstanding the little progress it has hitherto made in public favour, the plant offers us many advantages, which would appear even now to deserve our consideration. The great object of our present system of high farming is to advance the abnormal condition of the plant, and thus to obtain from it a greater yield; while, at the same time, it is generally admitted that the farther we depart from the original type the more delicate our plants become, and the more susceptible they are of injury from disease. This is particularly noticeable in the turnip; and we see its result each year in an increasing tendency to disease, notwithstanding our endeavours to check it by the means which an improved acquaintance with vegetable physiology places at our disposal. Now, although kohl-rabi cannot be ac-

cepted as so perfect a change as mangold in the rotation for turnips, owing to its belonging to the same order of plants (*Cruciferae*), and possessing the same food-requirements from the soil, still it offers great inducements as a substitute for turnips, especially in districts where the crop is liable to suffer from "mildew," which is so commonly the case in the southern parts of the kingdom. It also possesses the property of growing on stronger soils than the turnip; and, owing to its power of resisting the action of drought and mildew, may be sown safely before the turnip-sowing season commences, which on a large farm relieves the labour arrangements of that busy season very considerably.

The range of soils suitable to its cultivation is pretty large; in nearly every variety of soil it will thrive, if proper preparation be made as regards the mechanical and chemical condition of the soil for its cultivation. Extremes of either light soils, as sands and gravels, or of heavy soils, as clays of a plastic nature, are those least adapted for it—the one failing chiefly in its food-supplying powers to the plant, the other in those physical conditions which are equally essential to its growth and development. Both of these, however, may be materially altered by means quite within our reach; and in that case, may be rendered as capable of carrying a plant of kohlrabi as of any other root or fallow crop. In all cases and in all soils the conditions already described as essential to successful vegetable development, should be secured as far as possible—viz., depth of tillage-soil, fineness of division of its particles, and absence of stagnant water in it. Comparative success or failure in our crops generally marks the degree to which these conditions have been secured. In preparing the land for kohlrabi, the same directions may be followed as those given in reference to turnips (page 293), bearing in mind, that for crops of this description the land should always

be in good condition, and that farmyard manure may always be advantageously applied, as it contains *all* the mineral ingredients that the plants require, while, at the same time, its organic nature is not likely to exert the same influence on a green crop, like turnips or kohl-rabi, as it sometimes does on our cereal crops.

If from any deficiency of farmyard dung artificial manures are resorted to, it is important to recollect what the requirements of the plant are, so that they may be met as far as possible by the substances contained in the manure used. Chemistry has shown us that all the cultivated plants of this "genus" require large proportions of potash, and also of chloride of sodium (common salt), and if these are not obtainable in sufficient quantities, the plant must suffer more or less in its powers of growth. If either bone-dust or "superphosphate" be used, it is most desirable that the above-named substances be added to them—say in the proportions of about 2 to 5 cwts. of common salt¹, and half that quantity of potash salts, to the ton of "superphosphate." The Peruvian and some of the other better descriptions of guano contain potash salts in small quantities; to these, however, common salt may always be added with advantage.

One of the great advantages that kohl-rabi offers to the farmer, is that it bears transplantation better than any other of his field crops; and, indeed, this is the way in which it used to be most commonly grown. To this method of cultivation, however, there are objections, which increase every year as we substitute machines for hand-labour, which latter, of course, can only be employed in

¹ Common salt is in most places to be had at a comparatively small cost; potash salts, however, are always dear. These vary much, according to their composition, in the proportions of potash they contain, and consequently in their *real manurial* value. Rough sulphate of potash, the residuum of the tartaric acid manufacture, is generally the best form to buy it in; the muriate of the iodine manufacturers, or the common "pot and pearl ashes" of commerce, are other forms in which it may usually be obtained at a reasonable price in the markets.

the process of transplantation; and this no doubt has materially retarded its more general adoption on our farms. This method of transplantation, however, possesses some advantages, which, under certain circumstances, may very beneficially be rendered available on a farm, especially where from any cause a deficiency exists either in the fodder or root plants. The kohlrabi, raised in a seed-bed, and sheltered from the influences which have acted prejudicially to the crops on the farm, can then be moved out into the field, in time to secure to the farmer, at all events, a great addition to his means of providing keep for his stock during the winter season.

The method of raising and transplanting kohlrabi, as practised in the districts where it was chiefly grown, is thus described by Mr. Hewitt Davis, in his *Farming Essays*, published in 1848:—"My practice is to prepare a seed-bed, by well digging and dressing in the winter a corner of my earliest piece of tares. The seed is sown in the end of February, or early in March, thinly, in rows 12 inches apart, and kept perfectly clean by hoeing and hand-weeding; and as the tares are cleared off in May and June, the ground is deeply ploughed, ridged up, and planted. The plants at first are placed 3 feet apart, the ridges being 28 inches asunder, but as the season advances the distance between the plants is diminished. The value of the root in any season is very considerable, but more especially after a dry summer, when most other winter food is scarce."

The seed-bed can be made in any spare piece of ground where the soil is well prepared and in good condition. Where it is intended to use the plants for a succession of crops, it is desirable to follow Mr. Davis' plan, but where only one transplantation is required, they may be sown in the bed broadcast, like cabbages and other garden vegetables. In planting out at successive periods

the spaces between the plants should be progressively lessened, so that a larger number of smaller plants may be carried on the same area of surface. If the bed has been properly prepared, and a sufficient growth of young plants secured, they may easily be rendered available for planting out at several distinct periods, as soon as the ground has been cleared of the preceding crop. After the winter tares are fed off, for instance, as Mr. Davis recommends—or after rye or ryegrass, cut green for spring keep,—after the ground is cleared from the early potatoes or peas, and even after the earlier straw crops, as winter oats and rye, are harvested—they may be advantageously planted, and thus rendered available for a crop.

In such cases it is desirable that the seed should have been sown at different periods, so that the plants be not too far advanced for the later transplantings; that the soil be deeply tilled, properly worked, and in good heart; and that attention be paid to the state of the weather, so as to secure as much as possible those conditions of moisture and shade so necessary to the well-doing of all transplanted vegetables. A few days' delay in sowing or planting is of very little importance, compared with the condition of the soil as to moisture at the time the seed is germinating, or the plant resuming its functions, in its new abode. If these conditions are secured to them, and the young plants take root kindly, there is but little fear for their healthy growth, and their yield at the end of the season will in all cases be considerably more than could be expected from any of the varieties of turnips offered to us for late sowing.

In preparing the seed-bed for growing plants for transplanting, the size must be regulated in accordance with the number of acres to be planted. Two ounces of seed is about the quantity to be sown on a square rod, and this will produce from 4000 to 5000 good plants. The

number of plants required per acre will depend, of course, upon the area to be occupied by each, the distances between the rows, and between the plants in the row. This may be readily calculated by the tabular statement given at page 305. In the field a man and a boy will plant 4000 to 5000 per day.

Those, however, to whom this method of growing kohlrabi does not offer sufficient advantages to induce them to undertake the additional trouble and expense of transplanting, may grow the crop successfully by treating it exactly in the same manner as the turnip, the only difference required, being the time at which the kohlrabi should be sown. This should not be later than the first or second week in April. It may either be sown on the flat or on ridges, as the nature of the soil or the climate may render most advisable (p. 301). The same quantity of seed (from 2 lbs. to 4 lbs.) is sufficient, and the same drilling machine that is used for the turnips is equally available for this crop. Indeed, many persons who have occasionally tried kohlrabi, have noticed that the transplanted plants are more apt to depart from their variety than those sown in the field. The general treatment of the growing crop requires the same care and attention as has been recommended at p. 303. The hoeing should be commenced as early as possible, and the plants singled out to somewhat wider distances than the turnips,—say 15 to 18 inches,—the globe varieties requiring more space than those of the oblong form.

Owing to the early period at which the seed is sown, the young plant has advanced so far in its growth before the “fly” makes its appearance, as to be practically free from any chance of injury from it; while its peculiar aptitude for cultivation in *dry soils* and *dry seasons* preserves it from the attack of “mildew,” which at a later period of the year inflicts such injuries on our more

advanced fields of turnips. The power of withstanding the effects of drought adds greatly to its value as a farm crop; in places where it has been grown in the same field with mangold-wurzel, it has been noticed as being less affected by extreme hot weather than that plant. This freedom from the “fly” and the “mildew”—two serious sources of injury, which probably, one year with another, reduce the turnip produce of the southern districts of the country fully one-half—ought to have obtained for the kohl-rabi more consideration than it has hitherto received. We hear on all sides opinions expressed that our turnips are less hardy in their nature than they used to be, and are becoming each year more susceptible of injury from disease.¹ It is then quite time for us to look round us and see what substitutes can be found for a crop that is absolutely necessary for our present system of farming; and

¹ In the course of a discussion at a recent meeting (Dec. 5) of the Central Farmers' Club, one of the members (Mr. W. Bennett, Cambridge) spoke of the increasing tendency to disease of the Swede crop, and strongly recommended kohl-rabi as a substitute, which he himself had resorted to largely, and with a good deal of success. “He had been growing it,” he said, “for five years increasingly, and his opinion was, that it was the most profitable crop upon the land, with the exception, perhaps, of mangold-wurzel. It was excellent for transplantation after a green crop, such as tares, rye, &c. The land should be well cleaned, and the manure put on in the autumn. He transplanted it as late as the third or fourth week in July, and it was as beautiful a crop as he could wish to see. His practice was to drill it partly on the regular summer fallows, just before drilling Swede turnips, and the plants were in capital state when tares, &c., were gone. There was not much certainty about a crop of turnips after tares. Once in five or six years they might succeed pretty well, but, generally speaking, they did not; whereas kohl-rabi succeeded beyond a doubt. Being a hardy plant, it was difficult to kill, and for ewes and lambs it was as fine food as they could have in March and April. His hoggets were now doing well on that grown on the fallows. He would strongly recommend, therefore, that where the land was good for anything, kohl-rabi should be substituted for Swedes. He believed that it exhausted the soil something more than turnips did, but in such a year as the last it was of great advantage to him; for where he had grown turnips and fed them off with sheep, the barley was all down and good for very little, but where the kohl-rabi grew it was stiffer in the straw, of much better quality, and worth from £2 to £3 per acre more than any other barley he had. The certainty of the crop, and the good return, were, therefore, he thought, compensatory for any little exhaustion of the soil.”

when we recollect the character given to kohlrabi by a well-known writer in the *Royal Agricultural Society's Journal*,¹ who says, "As to 'mildew' or disease, I never saw or heard of either, and I can distinctly add, that I observed the plants to thrive better in the *dry* summers of 1847 and 1849, than during the intermediate *wet* one of 1848,"—we should neglect our own interests were we not, at all events, to give it the fair trial which, considering the great advantages it possesses, it certainly claims at our hands.

The plant comes to maturity in about twenty-five to thirty weeks, and may be pulled, trimmed, and stored away in the same manner as our root crops;² or the later planted portions may be left standing in the field during the winter, to be fed off in the usual manner. Owing to the constitution of the bulb, which it must be recollected is *not a root*, but merely an abnormal increase of a portion of the above-ground stem, it is not liable to be so injured by frost or wet as the ordinary turnips or other root crops; while the nature of the plant, and its habit of growth, render it especially suited for sheep-feeding, as, growing out of the soil, and being firmly attached to it by its roots, every portion of it can be eaten and cleared off without the labour and loss of food always experienced in feeding off a crop of turnips.

Mr. Hewitt Davis says:—"I have given the bulbs without the leaves freely to milch cows all the winter, and I find they prefer them to mangold-wurzel, and thrive better on them: their milk is richer, and I have experienced no ill flavour in the butter. I fancy, too, the sheep

¹ Vol. xi. p. 497.

² Owing to the extreme toughness of the stems, and their firm hold in the ground, it is, perhaps, easier to cut them with a stout knife or hook as they stand in the ground, and then to collect the roots after the land is ploughed up. In some cases the plants are turned out with the plough, and then trimmed in the usual way.

I have fed on them have fattened faster than I have ever before had sheep do at this season. 'A flock of ewes with their lambs, intended for spring killing, I have also been for some time feeding on this root, and never have I had a flock do better. In a word, this root seems to me much preferable to Swedes or any other, both for its goodness as well as certainty of a plant.'

The feeding qualities of the bulb, and its suitability for milking cows, are confirmed not only by the reports of other persons who have grown and practically tried it, but also by the analyses now given, which assign to kohlrabi a very high value among our fallow and feeding crops. When left standing in the field during the winter, however, it is always subject to depredation by hares, which are very fond of it—no bad evidence of its qualities for winter keep.

When carefully stored, it will keep good equally as well and as long as either Swedes, mangold, or carrots; and whether in the field for sheep, in the yards for cattle, or in the stables for the horses, it will generally be preferred to the other descriptions of home-grown keep. The produce varies much, according to the season and the general treatment the plant has received during its growth; under suitable conditions, we hear of very large yields being obtained; and, if we may judge of its ordinary capacity for growing by the magnificent specimens lately exhibited at our Christmas exhibitions at Birmingham, Baker Street, and Sydenham, we cannot be otherwise than satisfied with the prospects it offers for cultivation. At any rate, we may fairly assume that, weight for weight, its produce would be quite equal to a full crop of turnips, while the chances of having a full crop at harvest time, taking one year with another, would be greatly in favour of the kohlrabi.

A report of a crop grown by Col. North, of Wroxton-

Abbey (Warwickshire), in 1857, gives the following returns per acre:—

	tons.	cwts.	qrs.	lbs.	
Purple variety,.....	25	15	3	6	of bulbs.
„	1	11	1	20	of leaves.
	27	7	0	26	of gross produce.
Green variety,.....	23	1	1	20	of bulbs.
„	8	15	2	24	of leaves.
	31	17	0	16	of gross produce.

It also is stated that the bulbs stand frost and keep in store better than Swedes.

In Germany, whence it was introduced to this country, it is far more generally cultivated, both in the garden and in the field, than with us. Its taste when cooked more resembles that of the cabbage than of the turnip. In a raw state both leaves and bulb may be given to dairy cows without any risk of flavour to the milk, provided any bad leaves or parts be removed. They eat them readily, and always thrive on them.

Its *diseases* and *insect* injuries we are hardly in a condition to talk about, though, probably, were the crop more generally cultivated, we should find it liable to many of those already noticed as affecting the turnip and cabbage crops. The roots are sometimes injured by “clubbing” or “anbury,” and also by the attacks of the “turnip-gall weevil” (p. 324); but the bulb, in this plant the valued part, being above the ground, is not injuriously affected by them.

For its *chemistry* (inorganic), we are indebted to the analyses carried out under the auspices of the Royal Agricultural Society by Messrs. Way and Ogston, who have given us the following details of its composition:—

	Water.	Ash (mineral matter).
Bulbs,.....	88·24	·95
Leaves,.....	84·89	2·80

The ash of the bulb and of the leaves contained in 100 parts—

	Bulb.	Leaves.
Potash,.....	36·27	9·32
Soda,.....	2·84	...
Lime,.....	10·20	30·31
Magnesia,.....	2·36	3·62
Peroxide of Iron,.....	·38	5·50
Phosphoric acid,.....	13·46	9·43
Sulphuric acid,.....	11·43	10·63
Carbonic acid,.....	10·24	8·97
Chloride of Potassium,.....	...	5·99
Chloride of Sodium,.....	11·90	6·66
	100·00	100·00

In its mineral constituents, therefore, it very closely resembles the turnip; and although the percentage of mineral matter in the plants appears to be a little in excess of that in the turnip, they are so nearly alike in quantity as well as quality, that for all *practical* purposes they may be taken as the same; so that weight for weight per acre the kohl-rabi cannot be looked upon as a more exhausting crop to the soil.

Its organic composition has just been determined by Dr. Anderson,¹ whose investigation, from its very satisfactory results, will no doubt have the effect of securing more attention to the crop than it has hitherto received.

It is thus given:—

	Bulbs.	Tops.
Nitrogen compounds (flesh-formers),.....	2·75	2·37
Compounds destitute of nitrogen (heat-givers and fat-formers),	8·62	8·29
" " fibre,.....	·77	1·21
Ash (mineral matter),.....	1·12	1·45
Water,.....	86·74	86·68
	100·00	100·00

¹ We are indebted to Messrs. Lawson of Edinburgh for the organic analysis of the kohl-rabi. With their characteristic liberality they caused its feeding properties to be thoroughly investigated before recommending it to the notice of the agricultural public.

If we compare these results with those already given at page 328, in reference to the composition of the turnip, we see how greatly the kohl-rabi exceeds even the Swede in the proportion of those compounds on which the feeding qualities of the vegetable are supposed to depend. The nitrogen compounds (flesh-formers) are nearly double; those destitute of nitrogen exist in about the same proportion; while the diminished proportion of water it contains would indicate that its keeping properties would be fully equal to the best variety of turnip cultivated. It would be very desirable that before these important points indicated by the analysis are received as *facts*, they should receive confirmation by being practically tested in the feeding shed; so far, however, practice has in most cases been in accordance with theory, which would lead us to expect that in this case the feeding qualities of the kohl-rabi would be found to exceed greatly in value those of our other ordinary root crops.

THE RAPE CROP.

ANOTHER member of this important family (BRASSICA), which we meet with among our "Farm Crops," is the RAPE, which is a name commonly given indiscriminately to two different species of plants, the *Brassica campestris*, "Smooth-leaved Summer Rape" or "Colza," and the *B. napus*, or "Rough-leaved Winter Rape" or "Coleseed." They both have much the same habit of growth, but may be distinguished by the form of their roots and also of their leaves. In both the roots are tapering, hard, and fibrous; in the former the principal root is more cylindrical, while in the latter it is more fusiform in shape. The leaves of the first are smooth, fleshy, and of a glaucous tint; and the flowers are of a bright yellow colour, appearing and ripening late in the season. The leaves of the second are of a vivid green, rougher on the surface and less rounded at their extremities; and the flowers are of a darker yellow, and come out and ripen earlier. The name of "summer rape" is given to the *B. campestris*, from its arriving at maturity earlier, and also from being supposed to be less capable of withstanding severe winters, than the *B. napus* or "winter rape;" it is therefore generally considered to be better adapted for a summer or autumn than for a spring crop. They are both biennial plants, like the turnip and other members of the family; a variety of the colza, however, is cultivated in Germany, which appears to form the solitary exception to this rule, flowering and producing its seeds as an ordinary annual. Cultivation has effected well-nigh as great a change in these plants from their original

state as in the turnip or kohl-rabi; in these, however, the abnormal development is in the stem and leaves of the plant, which, when growing in a congenial soil, exhibit a wide difference from the parent stock met with in waste places in different parts of the country.

These plants offer great facilities for the cultivation of fodder and fallow crops on two descriptions of soils, where turnips are generally less successfully grown than on others, namely, those of a peaty and those of a strong argillaceous character. On the one the turnip plants run too much to top, and rarely carry the bulbs to a satisfactory size; and on the other, the growth of top as well as bulb is generally of a stunted character. Both of these plants, however, will thrive on soils rich in vegetable matter, and, indeed, are grown more largely than turnips on the soils of this character in the fen-lands of the eastern midland counties, and both may be seen in cultivation also on strong clay soils in Essex and Hertfordshire, and other districts of an argillaceous character.

Although both these plants will grow in these different descriptions of soils, they have their preferences, which should not be overlooked in determining upon their cultivation in any particular place; the "winter rape" (*B. napus*) being the best suited of the two for the humous soils, while the "summer rapè" (*B. campestris*) is the best adapted for growing in the stronger clay class of soils. In such soils, where the turnip meets with influences which check and deteriorate its development, these plants find conditions generally favourable to their growth; the large proportion of rich organic matter of the fen-lands furnish abundant materials for the rapid development of the succulent herbaceous rape, while the strong, tough, fibrous roots of the colza, are able to penetrate and ramify through the compact masses of the argillaceous soil, and abstract from it those materials necessary to

carry on the development of its above-ground stem and leaves, better than it could do of any portion which, like the bulb of the turnip, is limited to the soil. The rapidity of growth, too, is not one of the least advantages, the plant (for we may now, for the purposes of cultivation, speak of them both under the general name of "rape") offers to cultivation, as in about twelve to fourteen weeks after sowing it is, under ordinary circumstances, ready for stocking; On strong soils especially, this is a matter of some importance, as if well managed, the crop may be fed off and the field cleared before the wet weather sets in, thus saving the loss that is always sustained by delay in feeding, by injury to the remaining crop, and by poaching the soil, and also by the general disturbance of farm operations which occur so frequently in districts where turnips are cultivated on strong clay soils.

Rape, however, is not limited to the two classes of soils referred to, but will grow on any of our ordinary cultivated soils; on none, probably, in greater luxuriance than on the class of deep loams suited to the growth of beans or wheat. Here it would find all the conditions suitable to its requirements, and would no doubt produce a greater amount of nutritive matter—real food—than when grown on rich humous soils, where its produce in weight per acre might in some cases be greater. In the sheep-farming counties of Sussex, Hants, Wilts, Berkshire, it is cultivated to a considerable extent, as also on the wolds of Lincolnshire and Yorkshire, where the same class of soils are met with, belonging chiefly to the cretaceous series, and which seem to be fully as well suited to its growth as to that of the turnip. The same conditions in the soil are necessary for rape as for the other crops already described—depth, fineness of division (tilth), and freedom from stagnant water; and these conditions it is always within our power to secure on all land which is worth being taken into

tillage cultivation. Relatively to the conditions required by other crops, perhaps the last mentioned—freedom from stagnant water—is the most important for this. The plant is of rapid growth and necessarily of a vigorous habit, with great power of root-development, and penetrating deep into the soil, in order to provide for its food-requirements. If the roots get into a stratum charged with water, their functions are impeded, the general system of the plant becomes debilitated, the leaves assume a sickly yellowish tint, and further progress is checked.

The proper place in the rotation is the same as that allotted to turnips—between two straw crops. Owing, however, to the more rapid growth of the rape, it rarely occupies the same position in the farm cropping as the turnip; as, under a good system of management, the land may generally be profitably occupied during the interval between the harvesting of the grain crop and the time for sowing the rape. This, in suitable districts, is turned to good account by taking an intermediate crop of—say *Trifolium incarnatum* on the chalk and lighter class of soils, of winter vetches on the medium soils, and of Italian ryegrass for soiling on the stronger clay soils—or any other crops suited to the soil and the district or markets; taking care, of course, to avoid those—as cabbages, for instance—belonging to the same order.

In preparing the ground for rape, due consideration must be paid to its requirements as a rapidly-growing plant, producing a bulky yield when grown under suitable conditions. In all cases the land should be in good heart; and where manuring substances are applied for the direct use of the crop, they should always be in a *readily assimilable state*, or the crop, owing to its speedy growth, may arrive at its maturity without having had full access to the supply of food-materials provided for it. If farmyard manure is used,

it should be in a thoroughly decomposed state; if bones, they should be mixed with sulphuric acid, as a “super-phosphate;” and any other substances that may be applied should be in a sufficiently soluble condition to allow of the plants getting immediate access to them, as much of their future vigour and development depends upon the healthy manner in which their early processes of life were carried on.

The tillage treatment of the soil is the same as has been described for turnips. If the land be very foul, and need an open fallow before sowing the rape, full advantage should in all cases be taken of the autumn for cultivating and cleaning the land, which should then be laid up with a deep winter furrow. On strong soils it perhaps is better to plough in the manure at this period than to wait until the spring, as it keeps the soil more open, and more efficiently acted upon by the weathering influence of the frosts and rains of winter, and, at the same time, saves the labour and the injury that such soils so frequently sustain from the carting and consequent operations of applying the manure in the earlier part of the spring months. In such case, fresh or “long” farmyard dung may be used; if left until the spring, “spit” or well-rotted manure should be applied in equivalent proportions, so that the crop may at once be supplied with a supply of available food, which would not be the case if the manure was applied in a fresh or undecomposed state. Two valuable papers by Dr. Voelcker,¹ “On the Composition of Farmyard Manure, and the changes which it undergoes on keeping under different circumstances,” should be carefully studied by every one having charge of farming operations: they will amply repay the perusal, and show us how inconsistent our practice is with science in reference to the general treatment of our home-made manure, and

¹ *Roy. Agri. Soc. Jour.*, vol. xvii. p. 256, vol. xviii. p. 138.

how greatly we might economize our resources, were we to pay a little more attention to the principles which he and other chemists have made known to us.

The quantity of farmyard manure to be applied to the rape crop must, of course, be governed by the supply at command. Where this is ample, a liberal dose should be given—say 20 to 30 tons to the acre—of long dung, or from half to two-thirds of that quantity if in a well-rotted state. The addition of from 2 to 5 cwts. of “superphosphate” will always add materially to its fertilizing powers, and make up for any deficiency in the quantity applied. In all cases where rape is cultivated, chloride of sodium (*common salt*) should be added to the manure applied. On reference to the analysis (p. 362) it will be seen how large a proportion of this salt is required by the plant to perfect its growth.

If the land, however, be, from previous good management, sufficiently clean to admit of an intermediate crop being taken before the rape, choice would naturally be made of such an one as would admit of the ground being cleared at a sufficiently early period to allow of the rape crop being got in, so as to come to maturity at the time needed for stocking. Due preparations should always be made beforehand for such a mode of cropping, as time is of great importance at this, the growing season of the year; and the necessary tillage operations require to be carried through without any intervals of delay, as the ground gets speedily dry and hard, and the succeeding crop is sure, more or less, to suffer from it. Plenty of labour should be at command, and the proportion of manure in a fit state and ready for carting to the ground, where it should be spread and ploughed in as quickly as possible, no more being carried to the field than can be covered in by the ploughs on the same day. So important is it to preserve as far as possible the moisture in the manure and

in the soil from evaporation at this period of the year, that in hot climates it is the ordinary custom of the husbandman to plough the fields during the night, so that they may not lose the natural moisture they contain, which they would soon do under the influence of the summer's sun. This practice was graphically described by the *Times* correspondent during the late troubles in India, when considerable anxiety was caused during one of the night marches of the troops in the early part of the campaign, by the appearance of lights moving slowly in the fields, far and near to the line of march, but which, instead of an enemy watching the flanks of the marching body, proved to be the harmless lamps of the husbandman, attached to the beam of the plough, with which he was renewing the surface of his ill-worked fields.

Having arranged the mode of cropping with rape, and duly prepared the ground intended for it, both as regards the necessary manuring and tillage operations, so as to secure the conditions most suitable for the crop, the sowing may be effected either by broadcasting or by drilling, and either on the flat or on the ridge, in the manner already described. In all cases, however, drilling is to be preferred to broadcasting, and where advantage is to be taken of the crop for fallowing and cleaning purposes, it is, of course, the only admissible method. Ridging adds somewhat to the tillage expense of the crop; it however gives earlier and greater facilities for horse-hoeing, and is so far advisable where the land is foul and the soil and climate such as not likely to become too dry for the healthy growth of the plants. When any doubt exists as to these points, it is best to drill on the flat. The distance between the rows is generally less than that recommended for turnips—15 to 18 inches is probably the best width; that admits of all the tillage operations neces-

sary during the growth of the plant, and, at the same time, is not more than sufficient to give the plant that full access to air and light so necessary to insure a full and healthy development.

The quantity of seed used is from 3 lbs. to 5 lbs. per acre, which may be sown on the flat, by the ordinary drill of the farm; if sown on the ridge, the turnip drill described at p. 300 must be used for the purpose. In either case it is advisable to drill a small quantity of manure of a readily soluble nature with the seed, so that a supply of assimilable food may be furnished directly the young plant sends out its roots into the soil. The best manure for this purpose is the Peruvian guano; for the after use of the crop, phosphatic manures—bones or superphosphate, for instance—are found to be equally efficient, and considerably cheaper in price.

The time of sowing is determined by the purposes for which the crop is grown. If for early keep, March or April is the usual period; then the crop is generally ready for stocking in August, and the field may be cleared in good time for a winter straw crop. By sowing at different periods from this time, a succession of green forage crops can be obtained, upon which the stock may be kept until the winter fairly sets in, and the root crops take their place. In many places where rape is largely cultivated—the Lincolnshire fens, for instance—the sowing takes place from March to August inclusive, the crops coming into use in about twelve to fourteen weeks from the date of sowing.

In the sheep-farming districts a supply of rape is frequently provided for the ewes and lambs in spring, for which it forms a succulent and nutritious food. For this purpose the winter rape (*B. napus*) should be sown, as, although the other is tolerably hardy, and might stand the weather, it is not so certain, and

its failure would probably occasion considerable inconvenience or loss to the farmer; by depriving him of his expected keep at a very critical period of the year.

Rape, like kohl-rabi, may be raised in a seed-bed, and transplanted to the field. This practice has its advantages and its disadvantages, though the former are not so great as with the kohl-rabi, cabbage, and slower-growing plants, while the latter remain the same. Therefore, although the practice, which is general in Belgium and the Rhenish provinces, still is to be met with in this country, it is rarely followed on any scale, the common method of sowing in the field being fully as productive, and effected with less labour and less expense.

The germination and early growth of the plant is exactly the same as with the turnip; and as it is sown about the same period, it is liable to the same injuries from the "fly," which frequently clears off the entire crop. The great object, therefore, is to secure those conditions in the soil, at the period of sowing, which we know will assist and expedite the early growth of the plant, so as to force it as rapidly as possible through this critical period of its career. The same care should therefore be bestowed upon the seed-bed, as regards fineness of tilth and presence of fertilizing substances, as has been recommended, p. 293, in the preparations for turnip-sowing. If these have not been neglected, and good fresh seed has been used, the chances are greatly in favour of the plant speedily getting ahead of its enemy, and thus keeping its place as a crop on the farm. When the "fly" is very troublesome, the remedy recommended by Mr. Fisher Hobbs, p. 323, will be found to be equally efficient as with the young turnip plants; this and all similar preparations, it must be recollected, should be applied very early in the morning, *while the dew is on the leaves*, otherwise its effect is greatly diminished.

As soon as the plants have made a little growth, the horse-hoes should be sent in, to keep the spaces clean between the drills; and this operation should be speedily followed up, say when the plants are a fortnight old, by hoeing out the plants in the rows, so as to leave a certain space—3 to 6 inches between each—as, if they are allowed to stand too close, they grow up spindly and weak, and the leaves of the lower portion of the stem get discoloured and speedily drop off. A narrow hoe should be used for this purpose, though frequently the ordinary hoe is used, the narrower cut being made by holding it sideways, and care should be taken not to injure in any way the plants that are left standing, which should be, as well as can be managed, the best and stoutest in the drill. A slovenly, and after all, expensive way of thinning, seen in some places, is effected by merely dragging the harrows across the drills two or three times, which either pull up or destroy a proportion of the plants, and are expected, at the same time, to clean the surface as effectually as the horse-hoeing of the advanced farmer.

As the plant, under favourable conditions, is a rapid grower, the horse-hoe cannot be used so frequently or at so late a period of the growth as with the turnip crop; and if its growth continues unimpeded by injury from weather or from insects, it soon reaches its maturity, in the shape of a vigorous plant, from 3 to 4 feet high, with fleshy leaves, and a full succulent stem, which is generally the part most relished by the sheep, and eaten entirely down to the ground. In feeding it off by sheep, a small break should be hurdled off at first, and gradually increased; the stock should be carefully watched, as, owing to the richness and succulence of the keep, inflammatory attacks of the intestines, &c., sometimes ensue. It is always desirable to have some dry food, as straw or chaff, on the ground, for the sheep to resort to; a lump

or two of rock-salt in the troughs or racks is also beneficial; and some old clover, sainfoin, or even a stubble field, should be reserved for the stock to fall back upon should the food at first be too strong for them or should wet weather supervene. The great object of care in feeding off rape is to prevent the sheep gorging themselves with it on an empty stomach, or when it is wet—in such cases accidents and losses are sure to occur; indeed, it is better at first to give a small break to them, morning and evening, than a larger one that would suffice for the whole day.

In places where the crop is cultivated for seed, both the colza and the rape may be sown at the ordinary time, and after having been fed off, be allowed to remain for seeding the following year; or they may be sown at a later period, up to September, and left without being stocked at all. If fed off in the autumn, it is advisable not to let the stems be eaten down too close to the crown of the root, as in that case the wet and frosts of winter are apt to induce decay, and thus destroy the plant. For seed-growing purposes the “colza” is more productive than the “rape;” the yield of both, however, is materially influenced by the quality and condition of the soil in which they are grown. For forage purposes the humous class of soils are considered the most suitable, as they encourage and support the development of the herbaceous tissues; but for seed purposes the stronger class, as loams and alluvial soils, are generally the most productive. The crop is generally ready for harvesting about the end of June, and as the seed-pods mature very irregularly, some consideration is required as to the best time for cutting, so as to secure the largest yield. The upper pods are always ripe earlier than those on the lower branches of the plant; and in order to give these as long a time as possible, it is recommended not to cut until the earlier pods are dead ripe,

when they assume a dark red or brown colour, after which it is not safe to leave them standing any longer.

The crop is always cut with a broad, stout hook, care being taken not to shake the plants and thus disturb the seed-pods, which are then left lying on the ground in small bundles. They should be turned every day, so as to get perfectly dry and to allow the lower pods to perfect the maturity of their contents. It is always better, if possible, to thrash out the seed on the field, in the manner described for turnip seed; where the quantity, however, is large, or circumstances do not admit of this being done, it may be tied up in small sheaves, stooked, carted with sheets at the bottom of the vehicle to catch the seeds, and stacked in the usual manner; and then, at a suitable time, thrashed out by the flail or by the ordinary machine, which requires to be set to a greater width than when the ordinary farm crops are being operated upon. When thrashed out fresh on the field, the stems are readily eaten by horses and cattle, which are very fond of them; if kept any time in stack they get too dry and woody, and are then only fit to be picked over by the cattle in the litter of the courts or straw-yard.

The produce of seed is about the same as from turnips—from 25 to 30 bushels per acre on the average. It is at present grown but to a very small extent in this country, as there is a general prejudice against it, as being what is termed an “exhausting” crop; while, at the same time, owing to the increased facilities of commerce, it has to compete in the markets with the produce of other countries, where it enters more constantly into the system of cropping, and where the same fears of its effects on the soil do not exist. Formerly it held a different position in our crops, as at the beginning of the present century we read that no less than 9000 acres of the Great Bedford Level, equal to about one-thirteenth of

its entire extent, carried each year a crop of rape for seed. Since that period, however, our home consumption has enormously increased,¹ while our home production has in like proportion decreased; and it would therefore appear to be a subject worth our farmers' attention whether we could not, under an improved system of cropping, and with the vast mechanical advantages we now possess, profitably increase our production of rape seed, and thus, so far, lessen our annual money contributions to the agriculture of foreign countries.

The *diseases* and *insect ravages* incidental to the crop are well-nigh identical with those already described as affecting the turnip crop. The "mildew" is less frequent, owing probably to the growth of the plant shading the soil, and preventing evaporation from its surface. The "fly" is equally as destructive in its attacks on the earlier sown plants, which, however, owing to the difference in their form of development, escape the injuries inflicted by the "gall-weevil" (*Ceutorhynchus pleurostigma*) on the roots of the turnips (see p. 324), and also those peculiar forms of disease known as "fingers-and-toes" and "anbury."

The caterpillars of the "turnip saw-fly" are, however, equally disposed to take up their quarters on the leaves of the rape, and to commit the same ravages as they do with the turnip crop; while one of the butterflies which visits our fields has been named *Pontia napi*—the "rape-seed or green-veined white butterfly"—from its predilection for this plant, whose caterpillars, hatched on the leaves, commence their work of destruction as soon as they appear. Fortunately their numbers are kept down by an ichneu-

¹ The quantity of rape seed imported for the three years ending 1858 was 703,332 qrs., or an average of 234,444 qrs. per year; while the quantity of oil-cake imported during that same period was 263,150 tons, or 87,716 tons per annum, of which a considerable proportion—probably one-third—was rape seed. The consumption of rape oil, which is also largely imported, is enormous. In 1850 the North Western Railway alone required an annual supply of no less than 40,000 gallons, equal to the produce of about 200 acres of crop.

mon-fly (*Hemiteles melanarius*), which breeds in numbers from the pupæ.

1. Butterfly (*P. napi*). 2. Eggs of do. deposited on leaf. 3. Caterpillar of do.
4. Chrysalis of do. 5. and 6. Ichneumon-fly (magnified and natural size).

The seeding plants are sometimes sadly injured by the "turnip-seed weevil," whose presence is always indicative of a diminished yield. The remedies for the various insect attacks recommended at page 323 are equally applicable to this crop.

The *chemistry* of the rape plant has received considerable attention of late years, owing to the increasing use made of it and its produce, both as a fodder crop and for feeding and manuring purposes.

We find that the plant in a green or natural state contains about 87 per cent. of water, 11·5 per cent. of proximate organic compounds, and 1·5 per cent. of ash or inorganic matter, of which latter the composition is thus given:—

Potash,.....	10·32
Soda,	3·88
Lime,.....	25·45
Magnesia,	3·25
Phosphoric acid,.....	6·04
Sulphuric acid,	9·65
Silica,.....	1·07
Chloride of Sodium,.....	40·34
	<hr/> 100·00

The organic constituents of the plant, upon which its

value for feeding purposes is estimated, have been investigated by Dr. Voelcker, who has determined their composition as follows:—

Compounds containing nitrogen (flesh-formers),.....	3·133
Compounds not containing nitrogen (heat-giving and fat-formers),	8·209
Ash (inorganic or mineral matters),.....	1·608
Water,.....	87·050
	<u>100·000</u>

These results compare very favourably with those obtained from the analyses of turnips and our other crops, used in a similar way for feeding purposes. Not only are the nitrogen compounds present in greatly increased proportions, but the other compounds, sugar, oil, &c., are also in excess, and therefore fully explain and support the character which rape has received as being a crop admirably adapted for fattening and milk-producing, as well as for growing animals.

For our knowledge of the composition of rape seed we are indebted chiefly to foreign chemists. It has been investigated by Rammelsberg, Erdmann, Müller, and others, from whose analyses it appears to contain, on the average, from 4 to 4·5 per cent. of ash, which consists of the following substances:—

	Rammelsberg.	Erdmann.	Müller.
Potash,	25·63	22·70	21·34
Soda,	...	...	5·26
Lime,	13·20	14·65	14·63
Magnesia,	11·65	12·03	11·96
Oxide of Iron,	·63	·94	2·84
Phosphoric acid,	46·99	48·88	41·68
Sulphuric acid,	·54	·80	·77
Silica,	1·13	...	1·52
Chloride of Potassium,	·23	...	...
	100·00	100·00	100·00

The rape seed is found to contain on the average from about 35 to 40 per cent. of oil, which possesses a disagree-

able smell and taste, and being classed among the non-drying oils, is only used for lighting, lubricating, and other inferior purposes. This oil is obtained from the seed by pressure, the residuum being the common "rape-cake" of commerce. This, however, always contains, besides the solid matters of the seed, a considerable proportion of oil—on the average about 10 per cent.—which, under the ordinary processes of manufacture, cannot be extracted by the pressure applied. This residuum or "cake" is used largely as a feeding and also as a manuring substance, for both of which purposes its composition shows it to be well adapted. We have numerous analyses to refer to, differing more or less in their proportions, according to the quality, natural or adulterated, of the cake examined. The following results, by Dr. Anderson, were obtained from cakes of good quality—the first being a sample of the ordinary first market quality, the second having been made expressly for feeding purposes:—

	No. 1.	No. 2.
Compounds containing nitrogen (albumen),.....	29·75	27·68
Compounds not containing nitrogen—as oil,.....	8·63	12·50
" " " sugar, gum, &c.,	38·72	29·75
" " " vegetable fibre,.	7·30	12·47
Ash (mineral matter),.....	8·65	7·17
Water,.....	6·95	10·43
	<u>100·00</u>	<u>100·00</u>

The composition of rape-cake, it is seen, does not differ materially from that of linseed, and owing to the lower rate at which it is sold in the market, its consumption for feeding purposes is rapidly increasing. It differs from it, however, in its peculiar bitter taste, which is immediately perceptible, and makes it therefore less palatable to cattle, to which it should be given at first in small quantities, gradually increasing the weight as the animals get accustomed to it. It is also more liable to adulteration, for the peculiarity of the oil, which restricts the number of adul-

terating substances that can be used with linseed, does not exist here, and other oleaginous seeds may be readily mixed with it, without appreciable injury to the quality of the oil. On the other hand, the low price of the oil and of the cake prevents the use of any but the cheapest materials for the purpose. The chief adulterating substance appears to be mustard, or rather, perhaps, the "dross," as it is termed, obtained in grinding it for table use. This not only acts as an adulterating substance, by lowering the proportion of feeding compounds in the cake, but it adds to it injurious properties, which render it quite unfit for such purposes, and thus, in another way, depreciates its value.

These points, which in more than one instance of late have led to fatal results,¹ we have to discuss hereafter (page 400) in the chemistry of the mustard crop.

Dr. Anderson gives us the following physical characteristics of the genuine cake, to assist us in our selection of samples in the market:—Rape-cake of good quality, he says, is distinguished by its greenish colour, and by its more mottled appearance. When broken, the yellowish pieces of the inside of the seed and the dark fragments of the outer coat may often be very distinctly seen. When mixed with water, in the proportion of 100 grains to the ounce, it forms a semi-fluid paste, which runs like a thick fluid. The general colour is pale, studded with the dark-coloured particles of the outer husk. Its smell is oleaginous. Caustic potash gives a strong green colour. These qualities vary considerably in different samples, and

¹ From the evidence adduced at the trials (see *Agric. Gaz.*, 1855, pp. 42 and 73, and 1859, p. 730) it would appear that, in both cases, the cake was made from mustard and not from rape seed. A large quantity of seed is annually imported for oil purposes, under the name of East Indian or Guzerat Rape, which actually is the produce of plants belonging to the genus "*Sinapis*," and not to the rape family (*Brassica*) at all. Hence the fatal effects produced by employing its residuum or cake for feeding purposes.

sometimes the general colour of the cake is brownish, and very uniform, and a good deal appears to depend on the way in which the seed has been pressed; but when made into a paste with water, its appearance is very characteristic, and cannot well be confounded with that of other common cakes.

Rape-cake—or more commonly an inferior article, termed rape-dust, purporting to be the cakes reduced to a coarse powder—is used extensively abroad, in Belgium especially, and also in some districts at home, as a manure. On the Continent it is generally mixed with the liquid drainings of the house and cattle sheds, locally known as “purin,” and applied in that condition; with us, however, it is simply broadcasted, either before or after the land is ploughed for the crop. On the lighter class of soils generally, especially if subject to the “wireworm,” and on the soils of the magnesian limestone formation, skirting the coal districts of Yorkshire, Durham, and Northumberland, it is highly thought of, and largely used as a manurial application.

THE CABBAGE CROP.

THE CABBAGE is the most direct descendant from the original stock of this "genus" of plants—the common "Sea Colewort," or *Brassica oleracea*—by which name the cultivated cabbage of our gardens and fields is still known. It appears, in some of its varieties, to have been well known to the ancients, and, as a garden vegetable, it has been cultivated in Europe for many centuries past. It was a favourite culinary herb with the Romans, being described by Cato, Columella, Pliny, and others, and doubtless was carried by their victorious legions into Germany, Gaul, and Britain; and when not introduced into cultivation directly by them, it probably was so by their successors during the spread of religious corporations, the monks being for many years the sole depositories of learning, and also the advanced gardeners and farmers of the time. By their means it found its way gradually to the northern parts of the kingdom, and also to Ireland, as Gerarde (1597), in describing the family of coleworts, particularizes the cabbage as the *Brassica capitata alba*, which, he says, is "the great ordinarie cabbage knowne everywhere, and as commonly eaten all over this kingdome." In its wild state it is a biennial, and most of the species and varieties forming the genus in their cultivated state still remain so.

In the different varieties of the cabbage, the remarkable tendency to increase, induced by cultivation in the genus *Brassica*, is exhibited in the leaves of the plant; neither the root nor the leaf-stalks showing any tendency to swell

out, as is seen in the turnip or the kohl-rabi. There is a vast number of varieties of the cabbage cultivated as culinary vegetables. On the farm we have comparatively but few, and these may, for all agricultural purposes, be classed under two divisions—the “compact” and the “open-headed” varieties—of the former of which, the “drumhead” or common cattle cabbage is the best-known representative; while of the latter the “thousand-headed” variety is that which is, perhaps, best calculated for farm purposes.

Although the cabbage is not very particular as to the class of soil in which it is planted, provided it be well supplied with good farmyard dung, or other rich organic manure, still it always thrives better in the heavier descriptions of soil than in the lighter; rich loams and alluvial soils being, perhaps, those best suited for its powers of development. Owing to the mode of cultivation, by transplantation from a seed-bed, it may be grown successfully on a stronger class of soils than it would be safe to attempt to sow Swedes on; especially as at the time of maturity they (the drumheads) are rarely or never fed off on the land, and are lifted with less injury to the field than would be occasioned by feeding off, or even pulling and trimming a crop of Swedes on such soils at the same period of the year. On the humous soils of the fen districts of Cambridgeshire, Huntingdonshire, and Lincolnshire, large crops of cabbages are indeed grown; but in all soils the admixture of a certain proportion of clay exhibits a very beneficial action on the growth of this plant, probably, no doubt, in a great degree owing to the reasons adduced (page 282) in respect to the growth of the allied species, the turnip.

The cabbage is essentially a fallowing or cleaning crop; and, at the same time, owing to the mode of cultivation adopted, it may be looked upon as an intermediate or “catch crop,” as it may with advantage, in most instances, occupy

the ground between two crops, — say between winter vetches and wheat, or between early peas and oats,—which otherwise would be left in open fallow. The short time it requires to occupy the ground *in the field*, renders it more suitable for this mode of cropping than for taking a place in the rotation as a regular annual crop, as in that case the land would lie idle during a great part of the year. It can, however, be advantageously grown either before, after, or between any of the straw crops, or may be substituted for either of the green crops (turnips or rape) belonging to the same order, or indeed be used for fallowing or cleaning purposes in any rotation, provided it be not brought too closely in succession to the plants already named.

A very prevalent opinion exists among a certain class of farmers, that cabbages are a very *exhausting* crop; and this idea has, no doubt, caused a disinclination on the part of many to introduce their cultivation on their farms. How this idea originated it would be very difficult to say; probably it is based on nothing more than a common opinion, arising from the fact that to obtain a good crop of cabbages it is required that the soil shall be in high condition, and that the larger the crop the more exhausted the soil will be of its fertilizing constituents. Neither is it by any means clear that an “exhausting crop,” as it is termed, is detrimental to the interests of the farmer; indeed, under ordinary conditions and skilful management, it should be a benefit rather than a loss to him. If we reduce *the business of farming*—“*agriculture*”—to *its simplest formula*, we should define it as *the conversion of inorganic matter into organized structures through the agency of vegetable life—the plants we cultivate*. Therefore the plant that is possessed of this power to the greatest extent, that is to say, that can by its own natural powers abstract from the soil and convert into its own

structure the largest amount of mineral and other matters, is certainly that which offers the most benefit to the farmer, and ought to be the most remunerative in cultivation.

We are sufficiently advanced in the chemistry of vegetable substances to know that there is a certain relation in plant development between their inorganic and organic constituents; that the first are derived from the soil, while the latter are obtained from the atmosphere; that the first (inorganic) are restricted to what the soil contains, and to the powers of assimilation possessed by the individual plant, while the latter (organic) are inexhaustible in quantity, and are always ready to supply the plant to its fullest powers of appropriation. If, therefore, a plant is possessed of a great capacity for abstracting and assimilating mineral constituents from the soil, it generally possesses an equivalent capacity for abstracting from the atmosphere the relative proportions of materials necessary for building up its organic structure, and thus completing its growth. Its bulk and produce, then, mainly depend upon its feeding capacity and its power of obtaining sufficient supplies from the soil in which it is grown; and the larger the amount of matter it has thus been able to obtain and convert into its own structure, the heavier the crop and the greater the amount of keep there will be for the farmer, and the greater the quantity of the resulting manure.

When we come to consider these points, and then turn to the chemistry of the cabbage, we see how far it bears out that which we are endeavouring to explain in reference to what are termed exhausting crops.

We place out the young plants in the field in May or June, and in about four or five months we expect them to have reached their maturity, and to have produced a satisfactory yield. In this time their bulk generally exceeds that of the turnip crop, while their relative proportion of mineral constituents is also slightly in ex-

cess. If the soil be not in good condition, the large amount of readily assimilable food materials they require cannot be obtained, and their growth is proportionably restricted; if the condition be such as to allow them to satisfy their fullest requirements, by the time they have reached their maturity they will have abstracted so much of the fertilizing materials, as to have considerably reduced its condition, and so far left it in a comparatively exhausted state. These abstracted mineral materials, inert and comparatively useless in themselves while in the soil, now have been converted by the powers of the plant into organized structures, valuable not only as food substances, but also subsequently as manures, fully equal, if they are all consumed on the farm, to replace those abstracted from the soil during the growth of the crop, and to sustain its general state of fertility; at any rate, the increased produce thus obtained has always a money value, and that is always more than sufficient to pay for any amount of additional manurial substances required to restore the soil to its original condition.

As a general rule, we may consider that the crop which in the shortest time can take the most out of the soil, that is to say, convert most mineral substances into food materials, is, *cæteris paribus*, the most beneficial for cultivation, as it not only increases our powers of production in the first instance, but also in regard to subsequent crops, by the large amount of resulting manure the increased produce has afforded us. Let the cultivation of the cabbage, then, rest upon its real merits, and not be checked by an erroneous idea about its injuriously exhausting the soil, and thus rendering it less productive for the following crops. There are some disadvantages, it is true, in regard to the labour required in its cultivation; still there are many circumstances that may greatly outweigh these, and render it both desirable and advantageous to have a certain breadth of them on the farm every year.

When the breadth of land to be planted with cabbages has been decided upon, the seed-bed should be carefully prepared in some convenient place where the soil is good, and more shelter can be obtained for the young plants than the open field generally offers. A deep soil is here of less importance than at the later periods of their growth; it should, however, be in the finest possible tilth, and liberally supplied with well-rotted farmyard manure. Two square rods of seed-bed are sufficient for each acre to be cropped, and 4 oz. of seed will be found sufficient to stock this surface with good plants, of which about 8000 to 10,000 are generally required to the acre, when planted at the ordinary distances. The seed may be sown broadcast, and carefully covered in with the rake, after which a light roller passed over the surface will finish the operation. After the young plants have made a little growth, it is generally good policy to thin the beds of sickly or superfluous plants, so as to induce a more vigorous and branching growth in those that are left. It is also desirable to have a succession of young plants coming on, to meet the requirements on the farm for plants as the ground is cleared after the earlier crops. These must be sown at intervals, according to the periods at which they will be required for transplanting, recollecting that young plants may always be moved more safely than those more advanced in growth, especially in the later periods of the season, when the necessary moisture is deficient both in the soil and the air, and the heat of the sun conducive rather to the maturity than the growth of vegetables generally.

Before the young plants are removed from the seed-bed to the field, it is most important that due preparations should have been made for their reception, as upon the necessary conditions being secured to them hinges their future development, and consequent beneficial return to the farmer. If these conditions are present, the crop usually is

a very useful and remunerative one; if they have been neglected, it is very probable that the growth will be stunted, and that another crop would have produced more satisfactory results. These are all matters for our consideration, and should be duly weighed before we determine upon the breadth of cabbages we intend to grow, as it will be found far more advantageous to get a large crop on a small extent of ground, previously well prepared for it, than to have an increased breadth of the farm occupied by a thin and stunted crop. Deep cultivation, so important to all our "Farm Crops," is always amply paid for by vigour of growth and increased bulk in the cabbage plant, as it not only extends the feeding area of its roots, but it also offers the means of better dividing and distributing through the mass of the soil, the manurial matters which should always be liberally supplied to this crop. Of these nothing is better than good, well-decomposed farmyard manure, which should be spread and ploughed in with as little exposure on the surface as possible, and the more that can be spared to the acre, the better pleased the plants will be. Where the other arrangements of the farm will not admit of a full supply being allotted to this crop, the deficiency may be made good by an equivalent in Peruvian guano; this it would be more advantageous to apply separately, by broadcasting it on the surface after the manure has been ploughed in, but before the harrows have been sent on to finish the surface for planting. Twenty tons to the acre of good spit-dung would be a satisfactory dressing; or if not more than 10 or 12 tons could be spared, from 3 to 5 cwts. of the guano, or "superphosphate," previously mixed with as many bushels of ashes, sand, or other suitable materials, may be advantageously applied in the manner described, for the purpose of supplying the necessary amount of fertilizing constituents. To this, as well as to our other cultivated

plants of marine origin, "common salt" may always be applied with beneficial results.

When all the necessary preparations have been made on the farm, the operation of removing the plants from their seed-bed to the field takes place, and this should receive more care and attention than usually are bestowed upon it. In lifting the plants it is most important that their rootlets should be preserved free from injury, and that the particles of soil attached to them by small, hair-like filaments—the true mouths or feeding organs of the plant—should be disturbed as little as possible, as not one of these minute parts can be destroyed without a *pro tanto* diminution of feeding-power in the young plant, and the more this is diminished the more the plant will have to do to replace them, before it can exercise its full powers of assimilation in the new soil in which it has been placed.

A close-tined steel fork is better for the purpose of lifting them from the seed-bed than a spade; and if this be forced in beneath the plants at a depth of a few inches—say 4 to 6—in a horizontal direction, the slice removed by it will readily separate and fall to pieces by a slight movement of the wrist of the labourer, and the plants may be picked out from the disintegrated soil with but comparatively little injury to their finest rootlets. If the weather be very dry at the time, which frequently is the case with the later transplantings, it is a good plan to have a suitable vessel at hand, containing a compost in a thick liquid form, and to dip the roots of each plant into it as they are taken up. The compost speedily dries up on their surface, and the natural moisture of the roots is thus preserved, until they are again protected by being duly planted in the field. Common garden soil mould, mixed with the drainings of a dung-heap, or even with water, provided the composition be tenacious enough to adhere to the roots, will answer the purpose intended; it should

not be too plastic, as in that case, unless the soil be moist, the roots would have difficulty in developing themselves, and the plants would consequently be sufferers. In all cases it is desirable to get them into the soil again as quickly as possible, therefore all the necessary arrangements for transplanting should have been previously made.

In determining the distances at which they should be planted, the character of the variety—whether “compact” or “open-headed”—and the time and purposes for which they are planted, are the principal points to be considered. The open-headed varieties require more space for their growth than the compact varieties, as the common drum-head; and those planted early, and intended for autumn and winter keep, are more likely to attain a greater bulk than those planted at a later period. In no case, however, is it advisable to plant even the drumhead variety closer than at 2 feet distances; this would allow 4 square feet to each plant, and would require nearly 11,000 plants to the acre. At $2\frac{1}{2}$ feet distances, $6\frac{1}{4}$ square feet of surface would be allowed to each plant, and an acre would then require about 7000 plants; and at 3 feet distances, which is recommended for the open-headed varieties—the thousand-headed, for instance—each plant has 9 square feet, and 4840 are then sufficient for each acre to be cropped.

In cases where it is desirable to have a supply of cabbages both for winter and for spring consumption, it is a good practice to plant out the “drumheads” at the usual time, and at wide distances—say 3 feet—and then to plant out the “open-headed” variety at a later period of the season, in the intermediate spaces between the drumheads. The latter have acquired their full growth, and are ready for cutting, before the others have need for more space; and as these have to stand for spring keep, they have time to develop themselves after the first crop is cleared away.

Or the same practice may be followed advantageously with an early and a late variety of the "drumheads"—the early plants being matured and carried off in time to give the less advanced growth of the others the benefit of more space and exposure to the atmosphere.

In order to insure uniformity in the lines of plants, both for the sake of appearance, and of more securely using the horse-hoe during the growth of the crop, it is usual to mark out the given distances, by running a light furrow along the field with a marker attached to the plough, or a marking frame alone may be used, by which arrangement parallel lines can be drawn over the extent of the field. The same process should then be carried out across the previous lines, and the whole surface will then be divided into squares of the size previously determined upon, and the plants always kept in strictly straight and parallel lines. This arrangement requires but little extra labour and trouble, and it has the advantages of giving much better access to the crop, for the purposes of hoeing and cleaning, as the work can be done with equal facility from both sides of the field, so as to lessen materially the necessity for hand-labour in hoeing along the line of plants, as is the case in most of our root crops.

The planting, if only a small breadth is to be occupied, is usually done by dibbling; an active man, with a boy to serve him with plants, will do from 4000 to 5000 per day. When a large extent of surface is to be planted, the plough may be used advantageously in the work. Instead of a light furrow for marking the distances between the rows, it should be held in pretty deep, so as to form a sufficient bed for the plants; these are then carefully laid one by one at the marked distances on the side of the furrow where the soil has been thrown out, care being taken that the roots shall lie at the bottom of the newly-drawn furrow, and the crown of the young plant about on a level with the

surface. The plough on returning throws the soil of the next furrow over the roots, and thus completely covers them up, and the man superintending the planting follows, and finishes the work by placing his foot obliquely against the furrow slice at the place where the crown of the plant appears above the ground. By this method children can be employed for laying out the plants in the furrow, the man being required merely for finishing off, and generally superintending the work; at the same time, it is more likely to be better done than by the ordinary process of dibbling, in which the young plants are too commonly thrust into the holes in a careless manner, and their roots doubled up, instead of spread out as in the opened furrow.

It is not, however, necessary, any more than with the preceding crop—the kohl-rabi—that cabbages should always be grown by transplantation in the manner now described; they may equally well be sown in the field as turnips, and treated exactly in the same way. In this case they require to be sown at a very early period if they are expected to reach their full growth at the usual time, and we all know the difficulty of getting any large extent of our farms into sufficient order and tilth for such crops at the early season—February or March—at which this crop would require to be sown. They offer to our improved system of farming advantages in following up crops, from their being ready at any season, which the ordinary root crops do not possess, as it is practically impossible to transplant the latter without injuring the tap-root, upon which the subsequent development of the plant entirely depends. In the cabbage and kohl-rabi the abnormal development is not in the root, but in the leaves and stem, consequently they can be removed without regard to their tap-roots at all; indeed, it is always the practice to nip the end of the root off previous to planting, in order to induce

a development of lateral roots, so that they may ramify and spread through the upper part of the soil, in which the largest amount of available food is usually to be found. Their lateral roots, too, by extending the base of the plant, have the power of fixing it more firmly in the soil, and enabling it to carry its large and weighty head more erect, and free from contact with the soil, which weak or badly-grown plants have a difficulty in doing, and consequently suffer from it more or less in the shape of injuries or early decay.

If due care be taken in the process of transplantation, and the weather be favourable, but few losses will occur, and these should be made good from the seed-bed at once.

STRASBURG CABBAGE—Compact-headed Variety.

During their subsequent growth they need no more attention than to keep the horse-hoes at work until the surface weeds are entirely destroyed, and this operation

is greatly facilitated by the width of space between the plants, whether in the rows or across the line of planting.

When the drumhead variety alone is grown (*woodcut*), the crop generally comes to maturity in October, when the cabbages may be used for feeding purposes. As they keep better while standing in the field than when cut and stored, it is advisable to leave them out as long as the weather is suitable, or your field tillage arrangements will permit, and to cart off from time to time as many as you require at the homestead. They should always be cut off with a stout hook, or "bill-hook," as, if they are pulled by the hand, the fibrous roots carry with them a quantity of soil, which, when thrown into the cart, dirties the cabbage, and renders a portion of it unsuitable for the stock. The stalks can then readily be pulled up and left on the field until a heap is collected sufficient for a cart-load, when they should be taken to the yards for the pigs to pick over, and help to make it into manure.¹

Frost does far less injury than rain to the cabbage when out in the field; it is desirable, however, to avoid extremes of both as far as possible, and where these are likely to occur, it is the safer plan to take advantage of suitable weather to cut them and store them under cover in moderate-sized heaps, taking care to arrange them with the crown of the head downwards, so that any water they may contain may drain out. Owing to their regular shape and size they may be built up in heaps of any convenient form, and if due attention is paid, so as to secure proper ventilation, they will keep perfectly sound and good during the whole winter. The open-headed varieties are usually treated in a different manner.

¹ The stalks should never be allowed to remain standing in the field, which is often done, for the chance of the few sprouts that they may in favourable seasons produce. The ground in that case too often gets stocked with grubs and other insect vermin generated in the rotting roots and stems, which must do some injury to the following crop.

These sometimes are of great size (*woodcut*), though their weight may not exceed that of the compact drumhead cabbage. They are usually fed off by sheep on the ground, in the manner of rape or mustard; or, if required for cattle,

JERSEY KAIL or COLE—Open-headed Variety.

they are carried direct from the field to the feeding sheds. Stock of all kinds, indeed, are very fond of cabbages, the sheep eating even the stalks down to the very surface of the ground. As they stand very well the winter climate of the southern districts of the country, one portion may be planted later in the season, so as to be ready for the spring keep of the ewes and lambs, for which, owing to

their succulent and nutritive properties, they are well adapted.

In the Channel Islands, and some parts of the Continent, where the soil and climate are especially suited to them, some of the varieties (open-headed) grow to an enormous size. The Giant Cow Cabbage, the Palm Cabbage, and the Jersey Cole attain proportions far beyond anything we are accustomed to see in our fields, some of them growing to the height of 12 to 15 feet, carrying leaves all up the growing stem, which may be stripped off as the growth progresses, leaving the upper part to furnish the principal crop. Of the compact-headed varieties the Strasburg Cabbage grows to perhaps the largest size; under favourable cultivation it may be seen weighing as much as from 50 to 70 lbs.; indeed, this weight is sometimes reached in those grown in Ireland, and exhibited at the winter show in Dublin. The Early York is also a vigorous and productive variety. On the Continent it is the practice to cut up these large cabbages in slices, as we do our roots, and give them, mixed with straw and hay chaff, to all their farm stock,—working horses as well as feeding cattle. Their nutritive properties, as is seen by their analyses, are very great; for milking cows they form excellent food, if the precaution be taken to remove any decaying leaves from the outside, as they do not occasion the peculiar flavour which turnips give to the milk of cows fed upon them.

The returns per acre are generally very satisfactory where the conditions necessary for their cultivation have been properly secured to them. From 30 to 50 tons per acre are frequently obtained; while, if full advantage has been taken of the facilities afforded by transplantation, they may be taken as a second or intermediate crop, the field being left not in an exhausted but in an improved condition, owing to the liberal application of manure, and

the deep and extra surface tillage which the crop has received.

In the neighbourhood of good markets of consumption, as large cities, some of the finer of the "compact-headed" varieties are very profitably cultivated for culinary consumption. The yield is generally less in weight per acre, but the money returns far greater than with the field varieties.¹

The *diseases* to which the cabbage plant is liable do not appear to be very numerous, or, at any rate, to have received much attention. The only one of any importance with which we are acquainted is unfortunately of very common occurrence, and always, in proportion to its vigour, prejudicial to the healthy growth of the plant. This is the peculiar form of disease known as "clubbing"—analogous, apparently, with that disease termed "an-bury" in the turnip, to which reference was specially made at p. 316. Formerly this disease was supposed to be the result of injuries inflicted by an insect, the *Ceutorhynchus pleurostigma*, already described, which, puncturing the stem just at the crown of the root, deposited its eggs in it, causing in due time those knots or tubercles indicative of the disease, as we see in the galls or excrescences of the turnip, as figured at p. 324. By others, again, it was attributed to the larvæ of the *Anthomyia brassicæ*, or "cabbage-fly."

There are some peculiar features, in reference to "clubbing," which in some districts is comparatively rare, while in others where prevalent, it is rather capricious in its occurrence, passing from one garden which it had infested for years, to another, in which it had not during that time been noticed to any prejudicial extent. Yet,

¹ Exhibition Lectures (1851-2), Society of Arts, vol. ii., lecture 1. An instance is given of a crop of 40 tons to the acre being sold at the rate of £6 per ton, equal to £240 per acre under crop.

notwithstanding it has been commonly attributed to the attacks of insects, *wood ashes* have from long experience been recommended as the best remedial agent to be applied. Thanks to Mr. Berkeley, we now know more about the true cause of the disease, which is not the effect of injury from insects; their presence in the tubercles is, in fact, attributable to a diseased condition of the part. From his investigations¹ "it appears that the peculiar feature of the disease is the condensation and organization of the nitrogenous matters of the root; the whole energies of the plant are arrested here, and, in consequence, the leaves make no progress, and after a short time the plant dies. It is highly probable that the disease arises either from the abundant nitrogenized matter in the soil—upon which some chemical influence is exercised, either within or without the plant, by the *wood ashes*—or from the defect of salts of potash. We are not in a condition at present to explain what that exact influence may be, but the fact of the cells being gorged in every part of the root where there are not vascular bundles, with such dense masses of nitrogenized endochrome, and the prevention of the disease by the application of *wood ashes* (containing *potash* salts), lead us to imagine that these salts are in some way requisite to prevent this accumulation, by entering into new chemical combinations, and, at the same time, supplying one of those ingredients which abound in coleworts, and in the absence of a due proportion of which, vegetation cannot proceed without disturbance." The accompanying woodcut, taken from Mr. Berkeley's sketches, shows the different forms the roots assume under the influence of this disease. In one or two cases only, he says, the most careful search has detected the presence of larvæ, which appear, therefore, to have nothing to do with the production of the malady.

¹ For details, see *Agri. Gaz.*, 1856, p. 500.

In the mode of attack of this disease, and its general appearance, it would appear to be analogous with the "anbury" of turnips, which it is probable commences its

"CLUBBING"—Different forms of Diseased Roots.

attack at an earlier period than we are aware of, as, owing to the mode of cultivating turnips, they are not subject to the same examination as those which are transplanted like the cabbage. Experience has shown that the disease is most common where the plants follow each other too closely in succession on the same spot; that plants reared on fresh soil, and even if removed to it directly the disease has commenced, rarely suffer from its effects; and that the application of *wood ashes* effectually prevents its recurrence, even in places usually subject to its visitations. The value of wood ashes mainly depends upon the proportion of *potash* they contain; and we may therefore fairly assume that an ingredient known to possess such a beneficial preventive action in regard to this form of disease in the coleworts, would be equally

beneficial in its effects if judiciously applied as a remedy to the analogous form of disease, the “anbury,” of a species so closely allied as the turnip.

The cabbage is liable to the attacks of the same class of *insects* that infest our turnips, and other plants belonging to the same genus. In their early growth, when first planted out in the field, they often are greatly injured by slugs; which, especially in the early spring and autumn months, commit great depredations on the wheat and other young crops on the farm. These all belong to the “genus” *Limax*. The two most commonly met with in our

1. The Milky Slug (*Limax agrestis*). 2. Black Slug (*L. ater*). 3. *L. empericorum*.
4. Eggs of do.

fields, are the *L. agrestis*—the “milky slug”—recognized by its whitish reticulated back, and the *L. ater*—the “black slug”—whose back is furrowed with deep wrinkles, and has a rough shield. These all are hardy insects, sheltering themselves under loose clods, or in cavities round the roots of plants or bushes in hedgerows, and making their appearance whenever the weather is mild enough for their operations. They are very destructive, and should be attacked as soon as they are noticed. Salt and lime are the remedies generally recommended; these should be

broadcasted liberally over the field, if before daybreak so much the better, as then the depredators are at full work. If the field be near to the homestead, a visit from the poultry—ducks especially—is attended with good results. The larvæ or maggots of the “cabbage crane-fly”—*Tipula oleracea*—in some seasons are very destructive to the roots of the plants during the time they remain

1. Grub of the *T. oleracea*. 2. Pupa-case, from which the fly has emerged. 3. Crane-fly, or “Daddy-long-legs.” 4. Eggs of do.

in the “larvæ” state. They are of a dirty brownish or clay colour, exceedingly tough, quite destitute of legs, which readily distinguishes them from the true wire-worm, with which they are commonly classed. They are hatched about April, and change into their next form, that of the “pupa,” about August, during which interval they find subsistence in the fields or gardens, and chiefly upon our cultivated plants, the Brassica family being special favourites with them. Slices of potatoes have been recommended as a bait for them; if these are placed between the rows, they are attracted to them, whence

they can readily be picked up by children, and destroyed.

About the same period, too, the leaves are perforated by little skipping beetles, the "cabbage-fleas"—*Haltica consobrina*; these, however, are rarely noticeable to the same extent, as with the turnip crop. The caterpillar of the "white cabbage-butterfly"—*Pontia brassicæ*—

1. Cabbage-butterfly, *P. brassicæ* (female). 2. Eggs of Cabbage-butterfly. 3. Caterpillar. 4. Chrysalis. 5 and 6. Parasitic Fly—*Pteromalus puparum* (natural size and magnified).

is another enemy that visits the plant at a somewhat later period of the season. The butterfly is met with in the fields and gardens, from about May to October, and lays its eggs upon the leaves of the plants and pods, upon which the caterpillars feed, sometimes to such an extent as completely to strip the plant, and thus insure its death. The cabbage-butterfly is the largest of the three varieties; the female has two large black spots on the upper wings, and a splash upon the lower margin; on the under side the two black spots are apparent in both sexes, and the tips are yellow, the under wings being

pale yellow freckled with black. These butterflies, which make their appearance regularly each season, are happily kept more or less within bounds by several different parasitic insects, which puncture their bodies, and thus procure a suitable *nidus* for the eggs which they deposit in them. The eggs in due time generate maggots, which feed upon the bodies that hatched them, and thus befriend the farmer, by destroying the insect that so frequently destroys his crops.

When a crop is attacked badly by these caterpillars, it is difficult to stay the injury they inflict. Broad-casting soot, salt, and lime, early in the morning, while the dew is on the plants, will frequently do good service; or the plants, if there be not too great a breadth of them, may be shaken, and the caterpillars that fall off be killed with the foot. Ducks driven through the fields, if the plants be not too advanced in growth, will clear them off; while the large class of insectivorous birds—all of them real friends to the farmer—are on the look-out for them, and no doubt dispose satisfactorily of large numbers. In Russia they cultivate cabbages largely in the hemp fields, taking them in alternate rows. The hemp is said to be obnoxious to the butterfly, and thus preserves the cabbage from its attacks, while the latter occupies profitably the wide intermediate spaces necessary between the rows of the erect-growing hemp plants. While these caterpillars are at work chiefly on the outside leaves, the inner portion or heart of the plant is being bored into, by those of the “cabbage-moth”—*Noctua brassicæ*;—the larvæ, too, of other smaller moths frequently attack the same portions of the plant, and inflict great injuries on the crop.

The *chemistry* of the cabbage plant has lately received more consideration, since the attention of our farmers has been attracted to it by the great advantages it offers as a crop in our advanced systems of farming. The pro-

portion of water contained in the fresh leaves of the plant is about the same as in the turnip—from 90 to 92 per cent. The proportion of ash of the whole plant is from 1 to 1·5 per cent. In Dr. Anderson's¹ investigations, the outer leaves were separated from the inner leaves or "heart" of the cabbage, and were separately analyzed. As might be expected, their constituents were found to differ considerably; the proportion of water in the outer and in the heart leaves was severally 91·08 per cent. and 94·48 per cent., and the proportion of ash was 2·23 per cent. and 0·56 per cent.

The composition of the ash is given as follows:—

	Whole Plant. ²	Outer Leaves. ³	Inner Leaves (heart). ³
Potash,.....	11·70	14·96	38·74
Soda,	20·42	...	1·05
Lime,.....	20·97	24·68	11·64
Magnesia,	5·94	3·22	2·91
Iron (peroxide),.....	·60	1·89	·43
Phosphoric acid,	12·37	2·95	5·47
Sulphuric acid,	21·48	16·56	13·99
Chlorine,.....	5·77	...	...
Silica,.....	·75	2·77	·83
Chloride of Potassium,.....	...	8·71	...
Chloride of Sodium,.....	...	9·16	5·73
	100·00	100·00	100·00

The organic analyses have been conducted in the same way by Dr. Anderson—the inner portion of the leaves showing a like deficiency in the valuable proximate compounds, as is seen in its inorganic constituents.

	Whole Plant. ²	Outer Leaves. ³	Heart Leaves. ³
Water,.....	93·40	91·08	94·48
Compounds containing nitro- gen,.....	1·75	1·63	·94
Compounds destitute of nitro- gen, as gum, sugar, fibre, &c., }	4·05	5·06	4·08
Ash (mineral matter),.....	·80	2·23	·56
	100·00	100·00	100·00

¹ *High. Soc. Trans.*, 1855, p. 196.

² Dr. Fromberg.

³ Dr. Anderson.

On examining the composition of the young plant before its growth was sufficiently advanced to form the heart, its proximate compounds were found to possess a higher feeding value than it possesses at a later period of its growth.

Composition of young plant:—

Water,	91.78
Compounds containing nitrogen,	2.11
Compounds destitute of nitrogen—as fibre, gum, sugar, &c.,	4.51
Ash,	1.60
	<hr/>
	100.00

The results obtained by these investigations confirm the opinion generally entertained, that plants, or parts of plants grown under conditions sheltered from light, contain more water, and a less proportion of nutritive matter, than those which have been exposed to the sun's rays, and have carried on their processes of development under natural conditions. A practical deduction of some importance may be based on these results. The fact of the outer leaves of the drumhead cabbage containing such a large increase of food-materials over those forming the heart of the plant, would lead us to infer that, weight for weight, the "open-headed" varieties are more nutritive than the "compact-headed," and that where the crop is for home consumption, it would be to our interest to cultivate the former rather than the latter, especially as the tillage expenses are not increased, and the yield is equally large.

The feeding qualities of the cabbage are highly estimated, especially for sheep and cattle. In some comparative feeding experiments,¹ in which cabbages (drumheads)

¹ Report on "Cultivation of Cabbage, and its Comparative Value for Feeding Purposes," by J. M'Laren, Rossie Priory, Inchture.—*High. Soc. Trans.*, 1857, p. 373.

were tried against Swedes, the latter were found to have a slight advantage as far as weight for weight was concerned; but, owing to the great excess of produce per acre of the cabbages over that of the Swedes—the former being 42 tons 14 cwts., and the latter only 26 tons 12 cwts.—the balance per acre in favour of the former was very considerable.

THE MUSTARD CROP.

WE have in this section of our "Farm Crops" another member of the order Cruciferæ, but belonging to a different though closely-allied genus, SINAPIS, of which it is the principal member, and from which it takes its name. This is the MUSTARD, of which there are several species known to botanists, many of them indigenous to this country, in the shape of well-known weeds. Two species, however, are met with in cultivation—the White Mustard (*Sinapis alba*), which is grown pretty extensively, and usually as a forage or fallow crop; and the common Black or Brown Mustard (*S. nigra*), which is cultivated for its seeds. They are both annuals, readily known by their brilliant yellow flowers, and by the general well-marked characteristics of cruciferous plants. The White Mustard is distinguished by its stem and branches being covered with rough hairs, which in the black mustard are smooth and free from them; the seed-pods of the latter are smaller than those of the former; their shape is also somewhat different, those of the black species being bluntly four-cornered, with a short beak or end of the same shape, while those of the white species terminate in a broad two-edged or dagger-shaped beak.

Mustard has long been known and cultivated in this country for the sake of its seeds, but its introduction into our improved system of farming as a fallow and forage plant is of comparatively recent date. Its rapid growth, and the large amount of its produce per acre, make it a very valuable addition to our intermediate crops, and

enable us to occupy our land profitably, even when only short intervals occur between two regular crops, or to repair, in an expeditious manner, the losses so frequently sustained by the failure of the turnip, or other stock-supplying crop. Combined with this rapidity of growth, it offers the additional advantage of being adapted for almost every description of our cultivated soils; the extremes of either the light or heavy class, sands and pure clays, are those in which it, in this respect, like most other plants, is least likely to thrive. On soils of a loamy character, containing a maximum amount of moisture—provided it be not in a stagnant condition—and in a favourable climate, it arrives at its fullest development, frequently under such conditions reaching the height of 3 to 4 feet, and being ready for stocking in 6 to 7 weeks from the time of sowing. To obtain these results the soil, of course, must be well manured and in a high state of fertility, as, owing to the vigorous habit of the plant, and the large proportion of mineral substances (see p. 400) it requires to carry on its growth, it is necessary that these should be present in the soil in an available state, or its powers of development will be more or less checked. In all cases it should be remembered that the more rapidly a plant grows, the more important is it that all the conditions necessary for its development should be secured to it.

In regard to mustard, the same attention should be paid in preparing the soil for its proper reception as for other crops which occupy the ground for a longer period, and are considered of more importance than this crop. The tillage operations should be carried as deep as possible, and the soil well broken up and finely divided. If farmyard dung be used, it should be in a well-rotted condition, and any artificial manures should be such as admit of ready assimilation by the growing plants. When

grown for feeding purposes, Peruvian or other ammoniacal guanoes are perhaps the best that can be applied, either alone or mixed with "superphosphate"—the proportions and quantity used being determined by that of the farmyard manure at command. The artificial manures may be either ploughed in with the farmyard dung, broadcasted and harrowed in previous to sowing, or drilled in with the seed by the manure-drill in the usual manner. In either case, it is always advisable to add to manures of this description, before they are applied, at least an equal bulk of ashes, sand, or other suitable substance, which should be well mixed up with them, so as to separate their particles, and thus allow the rootlets of the plants more chance of meeting with them in the soil. When the crop is grown for seeding purposes, the addition of gypsum is recommended (p. 404), and as this is inexpensive, it may be used pretty freely—say half a ton to the acre—and is well adapted for mixing with the other manures, as just described.

In this case (as a seed crop) it enters into the regular rotation, and may then take the same place as the other fallow crops, between two straw crops; the only objection being, that where the mustard is carelessly harvested the seed is very apt to shell out on the field, and, if covered in by the plough in preparing the land for the succeeding crop, to show itself the next year in a crop that will not admit of the use of the hoe after a certain period of its growth. This drawback, however, may always be prevented by broadsharing, or otherwise cultivating the surface immediately the field is cleared, so as to cause the seed to germinate before the ploughs are sent in; or by following the crop with winter vetches instead of winter corn, they may be allowed to remain, and form part of the crop to be fed off in the following spring. When cultivated as a seed crop, it is usually sown from

the end of March to the end of April, as the character of the season permits. If frosts occur after it is up, it is very likely to be entirely destroyed.

The quantity sown to the acre is from half a peck to a peck, which should always be deposited by the drill, in rows from 12 to 18 inches apart; the plants being afterwards thinned out to about the same distances in the line of drill. To a plant whose habit is to throw up a branching seed stem from 4 to 5 feet in height, it is good policy to give plenty of room on the ground, so as to secure the full effect of light and air during its growing period. Vigorous, well-branched plants, at 18-inch distances, will always give a better yield per acre than when they are left more crowded on the ground, at the usual distance of 12 inches. The tillage operations during the growth of the crop are the same as those already described. The horse-hoe should be used during the earlier period, and the hand-hoe subsequently, as long as needed for keeping the surface clear from weeds, and in an open and fit state for the general purposes of vegetation.

The seed time is one of some anxiety to the grower, as the pods ripen irregularly, and have a great tendency, directly their maturation is complete, to open their sheath, and cast out its contents. To prevent this occurrence, which is not only a direct loss of crop, but inflicts a serious inconvenience, by securing a growth of mustard plants, should it be the black species, in all the subsequent crops, for even years afterwards, the field should be carefully watched, and its progress noted, so that the crop may be harvested directly the seed-pods on the lower part of the stem assume a brownish tint, by which time those on the upper branches are generally fully ripe. They should be carefully cut with a broad-bladed hook, so as to shake them as little as possible, and left lying on the ground in small-sized heaps, which, if the weather be fine, are ready for threshing

out in the course of three or four days. This may be effected either by the flail or by the usual machine at the home-stead, whither the crop is carried in carts or waggons, as the case may be, with a cloth spread over the bottom to catch the seed, which is always shelled out on the road. In Essex, where mustard is largely grown for its seeds, the ancient practice of treading it out by means of cattle is still generally resorted to. A convenient part of the field is selected, carefully levelled, and beaten down, and covered by a cloth of suitable dimensions. On this cloth the bundles of mustard are laid, a team of horses driven round in a circle effecting the separating process, by crushing the stems and pods, which are from time to time removed and replaced by fresh bundles, the seed being collected on the cloth at bottom. Of course, fine weather is necessary for this operation, and, indeed, it is a matter of great importance to harvest the mustard altogether without rain; as much of the value of the mustard seed in the market depends upon its colour and brightness, which is sure to be more or less affected by exposure in the field to wet.

If, instead of separating the seed on the field, the crop is intended to be carried home and stacked, it is usual to cut it before it has quite ripened. The stacks or "pies," as they are called in some districts (Cambridgeshire, Lincolnshire), should be of small dimensions, with high conical roofs, the bundles being laid so as to incline outwards, in order to guard against any rain penetrating the mass. The crop is usually ready for harvest at the end of August or the beginning of September; the yield and the price both are subject to great variations, which, of course, have their effect upon its cultivation. Instances are on record where a waggon-load of seed taken to the market fetched for its owner £500; and again, there is no lack of instances where its market price per bushel did not equal

that of wheat. From 30 to 50 bushels may be taken as an average crop where the soil and seasons have been fairly suitable to its growth; and the growers are not generally satisfied unless it obtain in the market a price about double that of wheat. The straw produce is of little value. It is of a dry, ligneous character, and very difficult to decompose and make into manure. In most places it is only used as a bottom for strawyards and feeding courts; in some districts, however, it is sold at a low price to persons who burn it in large quantities, lixiviate the ashes, and thus obtain the potash it contains, for which there is always a ready sale. If burned in small heaps on the field, the ashes, carefully distributed over its surface, would go far towards restoring to the soil those more valuable ingredients which the crop had abstracted from it, and which, from the practice of selling both seed and straw off the farm, has acquired for mustard the character of an exhausting crop.

When the crop is grown for fallowing and feeding purposes, a far greater latitude of cultivation may be taken; indeed, this suitability to furnish a crop in almost any soil, and at almost any time of the season, is one of the great inducements which mustard offers to cultivation. At the same time, we must recollect that mustard is subject to the same laws that govern all vegetable productions; that under favourable conditions its growth is accelerated and its development increased to a greater extent than when they are absent; and that we must not expect to obtain the same yield from a crop sown on an August stubble as we may fairly calculate upon from one sown after vetches or rye-grass, cut for soiling in May or June.

When sown early in the season—say May, June, or July—it is always desirable to drill in the seed at moderate distances—12 to 15 inches—for which purpose $\frac{1}{2}$ peck to 1 peck of seed is quite sufficient. At this period

the growth of weeds is equally vigorous with the growth of the plant, and wide spaces give opportunities for the use of the hoe in keeping the surface clean, and the crop gives all the advantages of a regular fallow cultivation. At a later season—stubble sowing, for instance—a light furrow, with a moderate dose of a suitable artificial manure, is all the preparation that can be given; and as the weeds that germinate will not have time to come to maturity, the object of drilling for the purpose of cleaning the land no longer exists, and the seed may safely be sown with the usual broadcast barrow, the light seed-harrows and roller finishing the operation.

In all cases the feeding off of the crop should be commenced *before flowering*, as immediately that process is begun the functions of the plant undergo a change, and its feeding properties immediately begin to decrease; the substances stored up in its tissues are now required to carry on the changes the organism of the plant is undergoing, and to support its new duties of reproduction—forming and maturing its seed. In feeding it off with sheep, it is always recommended to give some other food at the same time, of a drier nature, or to run them on the stubbles or an old grass field, between each time of giving a fresh break of mustard.

Mustard is a very useful crop, too, to the farmer as a green manure, to be ploughed in as a preparation for a corn crop, where the field is in poor condition, and the stock of farmyard dung too small to improve it. For this purpose, it is best to broadcast it pretty thick upon the ground, and at the proper time to run a light roller (if ribbed so much the more efficient) over it previous to ploughing it in. The work is always better done, and the vegetable matter is decomposed more speedily, than when buried in a comparatively unbroken state. On strong soils and for spring crops the effect

of this practice is generally beneficial; the soil is kept open at bottom, and has the full benefit of the winter's action. On lighter soils, or for winter crops, it is advisable after sowing to roll the field, in order to consolidate the soil, and close it from the action of the weather, which in this instance would act prejudicially to the growing plants. Mustard ploughed in this way has the reputation of being obnoxious to the wireworm. If this be the case it adds to its value when used for this purpose.

In sowing mustard, either for feeding or manuring purposes, it must always be recollected that the *white* species should be used. The brown or black is never sown, except for its seed, as it is not only less vigorous in its habit of growth, but its seeds have the property of, remaining in the soil for many years without injury, and then germinating and growing, as from time to time in ploughing they are brought into favourable conditions for their growth. For grinding, however, the black mustard is superior to the white, and, under ordinary circumstances, fetches a higher price in the market.

The *diseases* and *insect* ravages that the crop is subject to have not been very particularly noticed; its close alliance, however, with those crops belonging to the same order (Cruciferae), already described, would indicate that it is more or less liable to the same injuries which are inflicted upon them. The "fly," however, is that which is most commonly noticed; and, as an indigenous congener, the "charlock," or wild mustard (*S. arvensis*), is generally to be seen liberally distributed over our fields, we are pretty certain to rear and to preserve on the land a sufficient stock of these destructive insects until our valuable cultivated plants, turnips, cabbages, kohl-rabi, &c., are ready for their entertainment. A disease of the parasitic fungoid class, which is not uncommon with the indigenous species, has been noticed occasionally attacking

Mustard seed is grown in this country chiefly for grinding purposes—the manufacture of mustard for home consumption. On the Continent, however, it is cultivated far more extensively for the oil it contains, which is obtained by pressure in the usual way, and is used chiefly for burning in lamps. The residuum after the oil is extracted forms a cake, which has been imported into this country, and sold both as a manure and as a feeding substance, either by itself, or mixed with rape-cake, for the adulteration of which it is used to some extent. According to some experiments made at Hohenheim with mustard seed, it was found that, when submitted to a proper pressure, a yellow-coloured fatty oil was obtained in the following proportions, the residuum forming the mustard-cake of commerce—

	White Mustard.	Black Mustard.
Oil,.....	22·2	23·3
Cake,.....	77·0	75·8
	<hr/> 99·2	<hr/> 99·1

In addition to this fatty or fixed oil, the cake contains the elements of another of a highly volatile and irritating character, which is generated immediately the substance comes into contact with water, and which consequently renders the cake containing it perfectly unfit for cattle food, and readily accounts for the disastrous effects which recent experience has shown it to produce, where it has been given even in probably a diluted state. In 1854 a quantity of oil-cake was imported from Russia, and was originally intended for manurial use, in the same manner as rape-cake. Owing probably to the amount of feeding materials it was found on analysis to contain, it was recommended and sold for feeding purposes, but was speedily found to be followed by very serious consequences, causing the death of all the animals that partook of it. An action

for damages sustained was raised against the vendors,¹ when it was proved that the cake was made from mustard seed, in which a peculiar principle, known to chemists by the name of "myrosine," exists. This in itself is a harmless compound in the seed, but when macerated in water it is immediately converted into a highly acrid and irritating oil—the oil of mustard (*ol. sinapis*)—to the presence of which our table mustard owes its stimulant property. In this case the fatal effects were due to the excessive irritation of this oil, generated by the process of mastication and salivation, acting upon the coats of the stomach of the animals, who swallowed it without difficulty, as the action was not set up until it had passed down the œsophagus. When mustard powder is mixed with boiling water, this curious change in its constituents does not take place, as the albuminous ferment, by which the action is set up, is coagulated and thus rendered inert; this should be remembered in mixing mustard for use, either for the table or local application. In the black mustard this peculiar property exists in a much greater proportion than in the white, and consequently for all purposes in which this is valued the former is the most valuable to cultivate.

The composition of the "cake" has been determined by Dr. Voelcker and by Dr. Anderson, and is thus given:—

	No. 1.	No. 2.	No. 3.
Compounds containing nitrogen—albumen,	23·481	23·87	19·81
Compounds not containing nitrogen—oil,...	6·690	6·79	5·91
" " gum, sugar, &c.,	...	24·93	33·91
" " vegetable fibre,..	...	22·27	26·16
Ash—inorganic matter,	5·796	13·70	5·45
Water,	11·901	8·44	8·76
	...	100·00	100·00

¹ Details given in *Agri. Gaz.* for 1855, pp. 42, 73. Another case of poisoning by mustard-cake took place last year, and was again the subject of an action at law. The details will be found in *Agri. Gaz.*, 1859, p. 730.

The analysis No. 1 was made by Dr. Voelcker of a mustard-cake imported for manure purposes; Nos. 2 and 3 were made by Dr. Anderson, of cakes manufactured from black (2) and white (3) mustard "dross," the refuse of the mustard grinding-mills. Although by these analyses a considerable difference is shown between mustard and rape cakes, they are sufficiently alike to admit of the one being very readily mixed for the purposes of adulteration with the other in considerable proportions. Dr. Anderson, however, tells us "that nothing is easier than to detect mustard in a cake; all that is necessary is to mix it with a sufficient quantity of cold water to form a soft paste, and leave it for some time, when the pungent smell of mustard will become more or less apparent. If the quantity be large, it can be detected almost immediately; but in all cases it is advisable to leave it for some hours, as the smell becomes more and more apparent, but after six or eight hours it begins to diminish again." On closely examining the particles with an ordinary magnifying glass, a great difference will be seen between the mustard and the rape.

The composition of the ash, or inorganic constituents of the seed, which averages from 4 to 4·5 per cent., have been determined as follows:—

	White.	Black.
Potash,.....	10·02	12·66
Soda,.....	9·48	4·09
Lime,.....	21·28	17·34
Magnesia,.....	11·25	14·38
Oxide of Iron,.....	1·46	1·12
Phosphoric acid,.....	37·41	37·39
Sulphuric acid,.....	5·41	7·14
Silica,.....	3·36	2·78
Chloride of Sodium,.....	·33	2·27
	100·00	100·00

While the proportion given in the above analyses shows

that the potash abstracted from the soil is less in amount than seeding crops usually require, the phosphoric acid is shown to be required in large quantities. The large quantity of lime and of sulphuric acid would indicate that manurial applications containing these ingredients—gypsum, for instance—would be beneficial to the crop when grown for seed purposes.

THE MANGOLD-WURZEL CROP.

HAVING now described the several cultivated plants belonging to the order "Cruciferae," we will take the next in importance of our root crops—the MANGOLD-WURZEL, the only representative of the order CHENOPODEÆ that enters into our ordinary "Farm Crops." This plant, like the Brassica family, no doubt derives its origin from a littoral plant, the *Beta maritima*, a plant indigenous to this and to many other climates of the temperate zone, where it is still met with growing wild on the sea-coast, especially where an argillaceous formation borders the sea-line, and gives a little staple to the sandy deposits of the shore. In its natural state it is seen growing to the height of 3 to 4 feet, with a branching stem: the roots have a natural tendency to be somewhat fleshy where the soil is suitable, and its narrow dark-green leaves are in some places collected and eaten as a pot-herb.

The cultivated beet, from which our mangold is derived, was well known to the Romans, and also before them to the Greeks; though by neither does it appear to have been grown except for culinary purposes. Theophrastus¹ describes two varieties, which he terms the black and the white. Several of the Roman authors speak of its cultivation and virtues. Columella and Pliny tell us that it was sometimes transplanted like lettuces, that it possessed a twofold advantage, partaking of the nature of the cabbage as regarded

¹ Theophrastus, *Historia Plantar.*, lib. vii. cap. iv.

its leaves, and of a turnip as regarded its root. The latter, however, does not appear to have been valued by them as much as the former, for we find no distinct mention made of the use of the root, while there are copious references made to the mode of using the leaves, and to the virtues they possessed.¹ The variety of the Garden Beet (*Beta hortensis*) known as the *B. cyclo*, or Chard Beet, was probably that referred to by the ancients. This variety is cultivated largely on the Continent for its leaves alone, the central part or midrib being very fleshy, and considered when cooked a delicacy. There is no evidence of the plant having been cultivated for its roots until a comparatively recent period. It appears to have been introduced into this country about the middle of the sixteenth century. We find it figured by Gerarde (1597) as the *B. rubra romana*, who, describing its cultivation and uses, says, "But what might be made of the red and beautifull root (which is to be preferred before the leaves, as well in beauty as in goodnesse), I refer unto the curious and cunnige cooke, who, no doubt, when he hath had the view thereof, and is assured that it is both good and wholesome, will make thereof many and divers dishes both fair and good."

On the Continent it appears to have been grown in the gardens for its roots long before it was so applied in this country; and, indeed, we are indebted to the Continent for our knowledge of the mangold-wurzel as a field crop, whence it appears to have been introduced into this country by Thos. Boothby Parkins in 1786, the seed having been procured from Metz, where, under the opposite names of *Racine de disette*, and *Racine d'abondance*, indiscriminately applied,² its cultivation had been attended with

¹ Martial, lib. xiii. epigram 10.

² The German name is somewhat indefinite also. *Mangel* means wants, deficiency, and *wurzel* is root, while *mangold* is a word signifying white beet and other plants.

very successful results. The mangold, by Thäer and others, is considered to have originated from a cross between the red and the white varieties of the garden beet, the offspring possessing a greater power of development, and a more vigorous and hardy habit than either of its parents, while its persistent botanical characters, during so many years, have acquired for it the general admission as a distinct species. Being the produce, however, of natives of a southern climate, it still preserves somewhat of the natural delicacy, as both the young plant and the matured root are susceptible of ready injury from even a slight degree of frost. This species, represented by our mangold-wurzel, is known as the *Beta vulgaris*, of which we have now several different varieties entering into general cultivation in this country. These are commonly distinguished by their colours—as red, orange, yellow—and by their shape, which is either—globular or oblong. The following are those which are generally selected:—

Long Red (fig. 1) is a productive variety; root long, large, and fleshy; stands well (about one-third) out of the ground, but requires a deep friable soil for its development. The top is full and bushy; midrib and veins of leaves tinged with red.

Red Globe resembles the preceding in the colour of its root and of its leaves. It is generally less productive, and better suited for the shallower class of soils.

Fig. 1.

Orange Globe (fig. 2) is perhaps the favourite variety, and most extensively cultivated. It is a hardy variety, of a globular shape, growing well out of the ground, and of

Fig. 2.

an orange tint externally, with a yellowish-white interior. It is a large cropper, and suitable for growing in a heavier class of soils than the Long Red. It carries a good bold head, the leaves having their midrib and veins tinged with yellow.

The *Long Orange* resembles the Long Red in its habit of growth, the colour of the root and of the leaves being the principal point of difference.

By some it is preferred to the Long Red; the light-coloured varieties being generally considered more hardy than the red varieties. In a suitable soil and climate, however, the Long Red is generally the most productive.

The *Yellow* varieties, both Long and Globe, differ merely in tint from the preceding, and are frequently seen growing in the same field, the produce very likely of the same seed.

A *Long White* variety has lately been introduced; in no respect, however, does it appear to excel those already in cultivation; and therefore, save for its novelty, is not likely to attract much attention.

The *Silesian Beet* (fig. 3) is largely grown on the Continent, and also is met with sometimes in cultivation as a field crop in this country. In appearance this variety resembles the Belgian carrot rather than the mangold. It is white, either with or without a *green top*; long, grows deep into the ground, and has a far sweeter taste than

the mangold. It contains a larger percentage of sugar, for which purpose it is generally cultivated; but its weight per acre, and consequently food-produce, is far below an ordinary crop of mangold.

Fig. 3.

The "mangold-wurzel" has a wide range of soils, and thus offers an opportunity to farmers for introducing it into their regular rotations over the greater portion of the country. Like most of our other farm plants, the extreme classes of soils—light sands and strong clays—are those least suitable to it; but of the two extremes the latter would be the least unfavourable, as mangold naturally thrives best in soils containing a certain amount of argillaceous matter. Indeed, on some of our strongest clays, such as those met with in the London basin, where, by thorough draining and deep tillage, the surface has undergone a change in its mechanical condition, we frequently see crops of a most vigorous and productive growth, far beyond what we ever meet with on the light sandy soils, even under the most favourable conditions of cultivation. These latter soils, again, are better suited for other root crops, as carrots and turnips, of which, when well farmed, they give equally productive and remunerative returns. The medium classes of soils are those in which the mangold delights—those in which there is a sufficient propor-

tion of clay to give a moderate tenacity to the mass, and to secure to the growing plant not only the mineral substances required for its structural development, but also the amount of moisture necessary to sustain its functions in a vigorous state during the whole period of its growth.

Clay, we know, possesses these properties to a greater degree than any of the other soil constituents; it usually contains sulphates, phosphates, and potash; it possesses the power of abstracting ammonia from the atmosphere, and also of absorbing and retaining moisture—all points of direct importance to plant development, which is always more or less affected in proportion to their absence or presence in the soil. These necessary conditions are met with probably to the least extent in the soils of the chalk (upper) formation. They are generally shallow, deficient in clay, and deficient in moisture; and consequently are those least suited for mangold, which is rarely seen in chalk districts presenting the same vigorous growth as it exhibits elsewhere.

The different habit of growth of the Long and of the Globe varieties gives an opportunity of selecting the most suitable for cultivation, according to the class of soils in which they are to be grown. The Globe varieties are those best suited for the strong clay loams or for shallow soils; the Long varieties for soils of medium strength, or of greater depth. The first, perfecting their bulk chiefly above the surface, are more readily lifted at harvest from the stronger soils than the Long Red, which, in such soils, owing to the fleshy brittleness of the roots, are very apt to break off a portion of their lower end in the ground; while the habit of growth of the Globe keeps their roots nearer to the surface, and thus fits them for cultivation in shallower soils than those of the Long varieties, whose characteristic is to penetrate and develop themselves deep in the ground. Possessing this suitability,

either in its Long or its Globe varieties, for cultivation in such a wide range of soils, and at the same time exhibiting a vigour of growth and a power of production, under suitable conditions, greatly exceeding that of the turnip, we can readily understand why the mangold cultivation steadily increases each year in the districts where it has once been introduced.

The proper place in the rotation for mangold is between two straw crops; the autumnal cultivation of the preceding crop preparing the ground thoroughly for the reception of the mangold, while the liberal manuring, and the extra tillages bestowed upon that crop during its growth, leave the soil in excellent condition for the grain crop that has to follow it. Where mangold is admitted as a regular portion of the root crop on a farm, it is always desirable that it should alternate with turnips in occupying the different fields set apart for the root crop each year; that is to say, that the field occupied by turnips in the last rotation should, when it comes round to roots again, be occupied by mangold, and that the field originally in mangold should then be sown with turnips. By this arrangement, the interval between the growth of turnips on the same ground would just be doubled, and each of the other supplementary crops, as mangold, kohl-rabi, carrots, cabbages, &c., would have the same advantage, which would be sure to tell very beneficially on their healthy development and produce. The greater the number of different plants possessing the same agricultural advantages that we can introduce into our cultivation, the more secure we shall be from the chances of weather and other casualties to which our crops are always subjected, and the better will it be for the health and general well-doing of the stock. The good effects of a change of food on stock of all descriptions are readily acknowledged. By having a variety of farm produce we have the power not

only to afford a change of keep, but also when we find the one (say turnips) decreasing in their effects, either from their own diminishing value or from satiety in the animals to which they are given, to follow them up by another (mangolds), which are not only fresh to the stock, but at that period in their full value as a feeding substance; these again being succeeded by carrots for instance, which are always relished by the stock, and will sustain their nutritive properties until the vetches or other fresh keep are ready.

Where, however, from any causes, mangold is only grown as a casual crop, the selection of the particular field on the farm for its cultivation is more free. In this case the strongest soil of the *root-break* should be chosen, provided, of course, it be in the condition necessary for carrying a root crop, as mangold will, *cæteris paribus*, thrive better than turnips in such soils.

As the stronger class of soils are those generally allotted to this crop, autumnal cultivation and preparation of the land is even of more importance than with the turnip crop, especially as there is less time for preparation in the spring, the mangold being sown usually about a month before the turnip-sowing season. Labour is rarely so beneficially bestowed upon a farm as in cleaning the stubbles and getting the land into proper condition before the winter, with its rain and frosts, sets in. After that time but little in the way of preparation for the next year's crops can be done, and if attempted, the soil frequently suffers more than an equivalent injury for the small amount of good conferred by the work, which at the best can only be very imperfectly executed. The stubbles should be treated in the manner described at p. 293, and the field not left until it has been thoroughly cleared of all its annual as well as perennial weeds. When this is satisfactorily achieved, the farmyard manure

allotted to the crop should be carted on and carefully spread, and the ploughs sent in with instructions not to spare the teams, but to cover it up with a 9 or 10 inch winter furrow before they leave the field. In the labour, as well as the other arrangements of a farm, *quality should be always preferred to quantity*; the first should be secured before the other is sought for. In autumn ploughing for mangold or any other root crop, a team getting over two-thirds of an acre per day, 9 inches deep, would, in nine cases out of ten, pay the farmer better than if they got over an acre with a 6-inch furrow in the same time. Where the subsoil plough is used for the purpose of adding to the available agricultural soil of the farm, a crop of mangolds will take advantage of the increased feeding area as well as a crop of carrots would do. To these last, however, it is of more immediate importance, as they cannot content themselves with the comparatively shallow soils in which mangolds can be successfully cultivated. If the field has been properly worked, and laid up with a good high-shouldered furrow, it will not require any attention until the time arrives for preparing for the intended crop.

The preparation consists in securing the conditions, "mechanical" as well as "chemical," in the soils which experience has shown to be necessary to the healthy development of the plants cultivated. In all cases it is desirable that the soil should be as deep as possible; in a fine state of division; that it should contain sufficient moisture to supply the requirements of vegetation, but that no water should remain in it in a stagnant state; and that it should contain all those ingredients, in an available condition, which the crop requires to carry on and to perfect its growth. These are all points of direct importance to the healthy development of our "Farm Crops," and none of them can be neglected without the penalty of a proportionate diminution of produce.

The depth of soil can be obtained by deep tillages following the use of the subsoil plough once in a rotation, or even if only once during the term of lease. The necessary supply of moisture is naturally present in the stronger class of soils usually selected for mangold, while all surplus water is carried away by the thorough draining which ought always to precede the use of the subsoil plough. Although mangold, from its habit of growth and great powers of development, requires a large amount of moisture to enable it to carry on its processes in a healthy and vigorous manner, it is most important that the soil in which it is cultivated should be quite free from stagnant water, which shows its injurious effects on the plants directly their roots reach the water-holding stratum; their leaves speedily assume a yellowish hue, and the plant exhibits a sickly aspect. If the land has been deeply ploughed and well tilled, it will naturally retain in its particles the necessary amount of moisture for vegetation, which it is the habit of the mangold to seek for low down in the soil, below the influence of surface evaporation. The tendency of the plant to send down its roots deep into the soil in search of food and moisture, has led to some inconveniences in regard to the draining of the field in which it was growing—in some cases where the drains were laid too near the surface, in others where an unusually dry state of the soil induced a greater necessity for obtaining moisture from below. This has been noticed and recorded by Mr. Moore, Mr. M'Lagan, and others—drains laid as deep as 3 feet to $3\frac{1}{2}$ feet below the surface have been found stopped by the roots of the growing crop penetrating through the substratum, and filling up the interior area of the pipes or drain. The necessary “chemical” conditions are secured by the previous cropping, and by the additions of such manurial substances as are needed to replace those abstracted by preceding crops, or

to meet the known requirements of that which is to follow.

The mangold crop has already assumed a very important place in the farm rotations of the southern and midland counties of England, and also of Ireland. In the northern counties and in Scotland it has not yet made such progress, owing no doubt, in a great measure, to the climate being relatively more favourable to turnip growth, thus reducing the superiority of the mangold crop, so generally recognized in the south. On the Continent it is much more extensively cultivated than in this country, as there it forms the basis of an enormous and important industry—the manufacture of sugar—which has given to the crop a great economic value, and has obtained for it the attention of scientific men, whose object has been, of course, to increase the gross produce of the crop, and also the proportion of its valuable constituents. Now, although our object in growing it is somewhat different from theirs (with us it is merely as an article of food—with them its sugar is its chief value), we may derive much valuable information from their experience, both as regards the general increase of the crop, and also as to the development of its more desirable constituents. The general increase is, of course, determined by the mode of cultivation followed and the manure used; and this is a point which ought to be considered before we proceed further with the preparation of the soil for the reception of the crop.

In all root crops it is desirable that the soil should be as finely divided as possible, and quite free from any obstacles that might obstruct the roots of the young plants, and induce either a distorted growth of the main root, or a growth of lateral roots, which always diminish the bulk and value of the crop. Stones, and broken materials, frequently carried on with the manure, will

obstruct the main or tap-root; while manure applied at the time of sowing, especially if it be in a fresh or long state, has a tendency not only to obstruct the tap-root, but also to induce a development of lateral roots, and to give them that stunted and fibrous character so indicative of a careless cultivation, and which is commonly known by the term "fuzzy." In order to avoid this latter frequent source of injury, it is always desirable to avoid using green manure to the mangold crop, and to apply it only in a more or less decomposed state, according to the time at which it is used. If not applied until the time of sowing, it is more important that it should be well rotted than if ploughed in with the winter furrow.

The general practice in this country is to manure directly for the crop, and to apply it at the time of sowing rather than at the time of ploughing the land intended for the crop in the autumn. On the Continent the evidence is in favour of manuring the land heavily for the preceding crops, and then planting the mangold, without additional manure, and allowing it to range through the richly charged soil, with the certainty of finding the ingredients necessary for its growth, which by this time have become intimately incorporated with and distributed through the soil, and thus placed not only more within its reach, but also in a more assimilable form. Where this method has been practised the results have been very satisfactory,¹ which would at all

¹ At one of the monthly meetings of the Royal Agricultural Society (April, 1852), Mr. Gadesden, of Ewell Castle, in describing Mr. Reeve's mode of cultivating sugar beet and mangold-wurzel at Randall's Park Farm, Leatherhead (Surrey), stated that his crop last year was 38 tons 16 cwts. to the acre of the sugar beet, and 39 tons 13 cwts. to the acre of mangolds. Mr. Reeve attributed his success in growing these roots to his not applying manure *directly* to the crops, and stated that when he had dunged for them the bulbs proved small, and had a large mass of "fuzzy" fibres, and gave but a small weight per acre, viz., from 15 to 18 tons; but that since he had put his manuring matter farther off the crop, he had raised fine large roots, and a much greater weight per acre.

events lead us to infer that it is far better to plough in the manure for our mangold land in the autumn, than to apply it at the time of sowing in the spring, when it could have but little chance of giving its full value to the coming crop. Organic manures, such as farmyard dung, are always found to increase the yield; but the evidence in reference to the use of special ammoniacal manures is, that although they increase the bulk, the increase is mainly due to the extra proportion of water contained in the root. Boussingault¹ recommends that the land intended for mangold should be kept in high condition by farmyard manure. Count de Gasparin² states, that the cultivators in the "*département du Nord*," the great sugar-preparing district of France, consider that the addition of farmyard dung increases the weight of the crop in the proportion of 1.65 ton for every ton of dung applied. M. de Dombasle,³ farming a poor soil, estimates the resulting increase at only about half as much; while M. Crud,⁴ upon a naturally good soil (Bas Boulonnais) obtained an average increase of 2 tons to his crop, over and above the natural produce of the land, for each ton of farm dung he applied. Mr. Pusey's experiments⁵ on the action of dung and artificial manures upon beet-root, show that upon a soil whose natural produce, unmanured, was $15\frac{1}{2}$ tons per acre, an increase was obtained of 1 ton for each load of manure applied, up to a certain yield, $28\frac{1}{2}$ tons, after which the addition of more dung produced no effect. By combining highly nitrogenized manures—Peruvian guano or woollen rags—with the dung, the yield was forced up to 36 tons per acre—no bad return on land which only four years before, when he took it in hand, was reputed to be incapable of growing a turnip.

¹ *Economie Rurale.*

² *Cours d'Agriculture*, tome i. p. 655.

³ *Annales de Roville*, tome vii. p. 255. ⁴ *Economie de l'Agriculture*, § 255.

⁵ *Roy. Agri. Soc. Jour.*, vol. vi. p. 531.

We may therefore fairly assume that good farmyard manure may always be beneficially applied to the mangold crop, and that it is desirable to apply it to the land some time, at all events, before the crop is sown. Our ordinary practice is to manure heavily for our root crops, and to use them as a preparation for the succeeding grain crop. We may still adhere to this, and at the same time derive the advantages which continental experience has pointed to us in regard to the time of manuring, if we take the precaution of applying the farmyard manure in a thoroughly decomposed state (spit dung) at the time of ploughing the winter furrow. If this practice has been followed, the labour arrangements for preparing the land for sowing in the spring are greatly lessened; all that is now required is to run the "grubber" or "cultivator" across the furrow slices, so that they may be thoroughly broken up and the soil well stirred, which can be done without disturbing the weathered and finely divided surface so desirable and so suitable for the reception of the seed. If the common practice of applying the manure in the spring is followed, the difficulties and expense of preparation are greatly increased, and the crop cannot be placed under the same favourable conditions. The fine-weathered tilth of the surface is disturbed by the carting on and distribution of the manure, and is then buried with it by the cross ploughing, which is rendered necessary for the purpose of covering in the manure, and also for the formation of a new seed-bed for the crop, which, on the strong class of soils suitable for mangolds, and at the early period at which they are sown, is not very readily obtained.

In all cases where the land is intended for a root crop, it is desirable to avoid, if possible, ploughing the land a second time in the preparations for sowing. It is generally an unnecessary expenditure of time and labour; the benefit of the first ploughing is materially negated by the second,

the fresh soil and the weathered winter surface being again buried, and the old and more or less exhausted surface soil of the preceding year being again brought up to form the seed-bed for the new crop. A turn of the grubber across the line of ploughing will generally act more efficiently than the plough; the work is done much quicker, the surface is left unchanged, and the land is likely to sustain far less injury from the pressure of the horses employed than if the plough had been used.

Owing to the early period at which mangold should be sown, it is important that no chances of suitable weather for the work of preparation should be neglected, as much of the success of the future crop depends upon the conditions, favourable or otherwise, under which it is got in. On a farm where autumnal cultivation and preparation have been judiciously carried out, and under ordinary circumstances as to soil and weather, the spring preparations are readily made, and the land got into a suitable state for the reception of the seed. This may be sown either on the flat or on the ridge, as described in the cultivation of the turnip crop, at p. 301, and the mode of preparation for either practice is the same as that already referred to. The advantages of "sowing on the ridge" are chiefly the greater facilities it gives for horse-hoeing and generally cleaning the land, and at the same time securing a greater depth to the soil round the growing plant; its disadvantages are the increased labour expenditure in forming the ridges, and the increased surface it gives for evaporation from the soil, which, in some districts and in some seasons, is very prejudicial to the healthy growth of the crop. This will account for the practice of ridging for roots being so much more prevalent in some parts of the country than in others—in the north, for instance, than in the south—where the general system of farming practices may be equally advanced. Whether the farm-

yard dung has been applied, as recommended, in the autumn, or left until the spring, it is desirable to give an additional supply of manurial matter, in the shape of a top-dressing, which may either be harrowed in at the time of preparing the field, or applied more directly to the plants at the time of sowing, by means of the ordinary manure-drill. For this purpose nothing is better than Peruvian guano, carefully mixed with at least an equal quantity of some other substance, as sand, coal-ashes, &c.; and if passed through a coarse sieve, the dilution or separation of its particles, the main object of mixing it, will be more effectually secured.

To all descriptions of manure used for this crop, whether home-made or artificial, the addition of chloride of sodium (*common salt*) is followed by most beneficial results. The mangold is a direct descendant of a marine or rather littoral plant, the "*Beta maritima*," growing naturally on the shores of our own and other coasts, in whose soils an abundant supply of salt is always to be found. Our mangold, though greatly altered from the original type by cultivation, still preserves its natural habits, and chemistry has shown us (see analysis, p. 450), how large the proportion of salt is in its general composition. In those parts of the country situated within a certain distance of the coast-line, the soil generally contains a considerable quantity of salt, and therefore an addition in the shape of a manurial application is less needed. But in other places situated beyond the influence of the salt-carrying sea winds and rains, the soil rarely contains sufficient for the healthy growth of plants of this and of similar origin—the *Brassica* genus, for instance—and we must add it to our fields before we can expect them to produce the crops which, from their general condition of fertility, we might reasonably calculate upon. In all cases we must recollect that *production in a soil is deter-*

mined by the "minimum" proportion of the ingredients necessary for the crop under cultivation (see p. 290). In the mangold the percentage of chloride of sodium is so large, as compared with the other necessary substances, that unless this is present in the soil in equivalent proportions, the other valuable fertilizing matters, phosphates, ammonia, and potash, no matter how liberally they have been applied, can only be rendered partially available to the growing crop. Common salt, therefore, should always form a portion of the manure used for the mangold crop, the quantity per acre being regulated by the locality, or by the known composition of the soil. It may be mixed with the farmyard manure intended for the crop at the time of forming the heap, or it may be broadcasted at the time of ploughing it in, or, if left until the spring, it may be advantageously mixed with the guano, and distributed with it over the surface previous to sowing. As it is not a very costly article, and acts very beneficially on most soils, especially those of a dry character, it is desirable to give a good dressing of it, say from 5 to 10 cwts. to the acre to the mangold, and also to the turnip crop; this is not more than sufficient for the interval between their recurrence in the rotation on the same field.

The beneficial action of salt upon the growth of the mangold is clearly shown by the results of Mr. Caird's experiments.¹ In order to satisfy himself as to the best manure for the crop, he directed certain portions of a field of uniform soil to be manured with different substances—farmyard dung, Peruvian guano, superphosphate, and nitrophosphate—by themselves, and mixed together in certain proportions. In every case when salt was added to either of these, an increased yield was obtained. The following tabulated statement of the results of the experiments gives the various manures used, with their respec-

¹ *Roy. Agri. Soc. Jour.*, vol. xvii. p. 400.

tive produce. In the first and second the effects of the salt are clearly shown—20^c cubic yards of dung and 4 cwts. of Peruvian guano giving a return of 23 tons 16 cwts. of roots, while the addition of 5 cwts. of salt to the same materials gave a return of 30 tons 12 cwts. An increased produce of 6 tons 16 cwts. to the acre was thus obtained by the addition of 5 cwts. of salt, costing only 7s. 6d.

No. of Lot.	Description of Manure, and Quantity per Acre.	Cost.		Total Cost per Acre.			Produce per Acre.	
		s.	d.	£	s.	d.	tons.	cwts.
1	20 cubic yards of dung.....	3	6	5	18	0	23	16
	4 cwts. guano.....	12	0					
2	20 cubic yards of dung.....	3	6	6	5	6	30	12
	4 cwts. guano.....	12	0					
	5 cwts. salt.....	1	6					
3	20 cubic yards of dung.....	3	6	4	18	6	25	10
	1 cwt. guano.....	12	0					
	1 cwt. superphosphate.....	7	0					
	1 cwt. nitrophosphate.....	6	6					
4	2 cwts. salt.....	1	6	7	0	0	21	3
	40 cubic yards of dung.....	3	6					
5	2 cwts. guano.....	12	0	2	14	0	20	6
	2 cwts. superphosphate.....	7	0					
	2 cwts. nitrophosphate.....	6	6					
	2 cwts. salt.....	1	6					
6	7½ cwts. guano.....	12	0	4	10	0	17	17
7	12 cwts. superphosphate.....	7	0	4	4	0	14	19
8	12 cwts. nitrophosphate.....	6	6	3	18	0	15	6
9	1½ cwt. guano.....	12	0	1	16	0	19	11
	1½ cwt. superphosphate.....	7	0					
	1½ cwt. nitrophosphate.....	6	6					
	1½ cwt. salt.....	1	6					
10	5 cwts. guano.....	12	0	3	0	0	12	15
11	8 cwts. superphosphate.....	7	0	2	16	0	11	18
12	8 cwts. nitrophosphate.....	6	6	2	12	0	12	11

It is desirable that all these preparations should be completed by the middle of April, which is the period recommended for sowing the mangold crop, provided the condition of the soil and the weather are suitable for the work. The seed of the mangold differs from that of any of our other "Farm Crops;" as, instead of each seed being separate and distinct from another, they are packed together in threes, and enveloped in a thick, wrinkled skin,

which, while it preserves them from injury, greatly retards their process of germination, and renders it irregular when in the soil. Though in appearance but a single seed, the removal of the envelope shows that the interior contains three seeds, two of which are fertile, and one usually barren. These have been separated by being passed through a bean-mill, and it is stated, by thus depriving them of their covering, they germinate more readily. This irregularity of germination has everywhere been remarked, and has led to the practice of steeping the seeds previous to sowing, so that the outer covering might be completely saturated, and thus furnish to the germs within sufficient moisture for their initial processes of vital action, which, when once well started, would be supported by the moisture naturally contained in the soil. Simple immersion in plain water for twenty-four to forty-eight hours previous to sowing, is all that is required. The seed should then be spread out on the floor to dry sufficiently to prevent them from adhering to each other, which can readily be secured by sprinkling a little sand or fine ashes over them, to absorb any surplus moisture that may remain. If this is carefully managed, the seed thus steeped is sown as easily as dry seed, while its more equal germination and regular growth in the drill testify to the advantage of the practice. Still, a great difference of opinion exists as to its merits; if from any cause the sowing be delayed after the seed is steeped, it is apt to heat and be injured; or if it be sown in a very dry or badly tilled soil, the seed may commence but not be able to carry on the process of germination, and thus be destroyed, whereas in such soils unsteeped seed would remain dormant until sufficient rain had fallen to saturate them, and thus to start the seed and insure its presence above the ground.

The seed is either deposited by "dibbling" or by "drilling;" the former is the original practice, and is still to be

seen adhered to in some parts of the country, especially where the soils are strong, and the acreage to be sown small. The usual practice, however, is to sow it with the ordinary drill used for turnips; and whether on the flat or the ridge, the only alteration required to be made is in the size of the cups, and which is readily effected by changing the spindle when used for mangold seed. In about ten or twelve days after the time of sowing, if all goes on well, the young plants make their appearance above the ground in the shape of small, delicate plants, at first with difficulty to be distinguished from the weeds, which usually get the advantage of them at starting. In about a week or so afterwards, according to the state of the weather and the labour arrangements of the farm, the horse-hoes should be sent into the field between the rows, and these should be followed as soon as possible by the hand-hoers, with directions to bunch out the young plants in the manner directed (p. 303) for turnips; the singling of the plants forming a subsequent operation, to be performed in the way already described in the turnip crop.

The only difference to be observed is in regard to the distances apart in the drill, which should be always somewhat more than recommended for turnips, recollecting that the *Long* varieties may be placed always closer together than the *Globe*, and that the distances apart in the drill of both varieties should be regulated by the distances between the rows. Twenty-seven inches is probably, taking all circumstances into consideration, the most suitable width between the rows, and at this width the *Long* varieties should be placed at a distance of from 12 to 18 inches apart, and the *Globe* varieties at distances of from 18 to 24 inches. If the rows be at a less distance than 27 inches, a greater space should be given between the plants in the drill, so that they may have an equal area of surface for their growth. It is

always more advantageous that the crop should be made up of large, sound, and well-developed roots, than that it should consist of a greater number of smaller roots, even though the gross produce be the same in weight per acre. The latter cost more to lift at harvest time, and lose more in trimming, while, owing to the greater proportion of outside and other comparatively valueless portions, their feeding value is considerably diminished. The only attention the crop requires during its growth is in regard to the weeds, which, on soils and in districts suitable for mangold, generally display great vigour of growth, and require to be as vigorously attacked. Later in the season, even when the plants have well advanced in growth and the weeds have been destroyed, it is a good practice, should the surface be very dry and parched, to move and pulverize the soil between the rows, so that it may absorb moisture from the dews and night air, for the use of the plants. If proper care be taken, this may be done without injuring crop up to a late period of growth. About the middle of October the plants have reached their maximum growth, and the leaves begin to show, by their incipient decay, that the time for harvesting the roots has arrived.

Before, however, we proceed further, let us see how far the continental practices differ from our own in the cultivation of this important crop. We find that in Belgium, France, and Germany, it is very much the practice to grow the plants in a seed-bed, in the manner described in the cultivation of the kohl-rabi and cabbage (p. 372), and then to remove them to the field. By this method, in the northern parts of Germany, and in Russia, where the plant is largely grown for sugar purposes, and where the seasons are more rigorous than with us, they are enabled to accelerate the time of harvest by fully a month or six weeks, a matter of great importance to the preservation of a root so susceptible of injury from frost as the mangold.

Koechlin states that it saves two months in the ground, and that in ordinary seasons it gives an increased return in the proportion of eight to five. In Belgium the farmers avail themselves of the same practice, and manage to obtain a crop of mangold or beet after having harvested a crop of rye or of flax. Either of these is ready at the end of June or beginning of July; the stooks are shifted in the field to make way for the ploughs, which are sent in as soon as the crop is down; the liquid manure carts, conveying the fertilizing compound (rape-cakes dissolved in "purin"), accompany the planters, and give a certain dose of their valuable contents to each plant as it is dibbled in the field.

In France this method of transplanting has enabled M. Auguste de Gasparin to obtain extraordinary results in the cultivation of his mangold crop. In the *Transactions of the Agricultural Society of Rochelle* for 1855, an account is given of the enormous produce obtained by M. de Gasparin the preceding year, and of the mode of cultivation adopted by him. The committee appointed by the society to examine the crop, mode of cultivation, &c., reported that on carefully measuring off a certain portion of the field, 1000 square metres, equal to 39 rods 16 yards English, and weighing the produce, it was found to amount to 27,800 kilogrammes, or equal to 27 tons 7 cwts. This gave a total produce of 275,000 kilogrammes to the hectare, or about 109 tons per English acre. The principal conditions of cultivation necessary to obtain such results were stated to be—

That the soil should be deeply trenched, tilled, and well manured.

That the seed be sown (in a suitable seed-bed) in January, and the plants be moved out into the field in April.

That sufficient moisture be furnished to the plants by irrigation during their growth.

That they be kept free from weeds, and the surface soil stirred by hoeing.

That they be allowed to remain in the ground until November, as their increase is in greater proportion at the later than at the earlier periods of their growth.

M. de Gasparin stated that by sowing in January and transplanting early in April, when the plants were thicker than a man's finger, his crop had nine months for its development, instead of five or six when sown in the ordinary manner; and that as they form a concentric ring about every fifteen days, his plants had eighteen, whereas the number formed in those grown in the usual way rarely exceeds twelve—while each succeeding ring or layer being external to the one preceding it, its diameter and bulk must increase in an increasing ratio, the last six being more than equal to the twelve internal ones, and consequently more than doubling the gross produce of the crop. Some of his roots were of great size, but they appear to have been exceeded by those cultivated in the rich vine-growing districts on the banks of the Canal de Saint Gilles, where one of the roots exhibited reached the enormous weight of 132 lbs.

That these results are very far beyond what we in this country obtain, or probably, owing to the difference in our climates, are ever likely to arrive at, is very true. They show us, however, what an enormous increase may be obtained in farm crops by securing to them those conditions of cultivation which are most conducive to their development. The largest crops of the district referred to, obtained by the ordinary method of cultivation, had not previously exceeded 48 tons 2 cwts. to the acre; and when we recollect the enormous produce that has been obtained at home from rye-grass—exceeding 100 tons per acre—by suitable treatment, we should not despair of being able, at all events, largely to increase the yield of our mangold

crop, by bestowing upon it the care and attention that in the hands of M. de Gasparin led to such desirable results. The produce of our mangold crop is rapidly increasing at home, as we become better acquainted with the conditions suitable to its development. A few years back 20 to 30 tons were considered a good average return; now we hear of crops of 40 to 50 tons per acre on suitable soils, and last year reaching as high as 60 tons per acre.¹ On the Continent we find also that, by attention to cultivation, the returns are greatly increasing. M. Koechlin, who each year grows a large extent of beet at Homburg (Haut Rhin), states that while his average produce by the ordinary mode of cultivation was from 80,000 to 90,000 kilogrammes per hectare²—in round numbers, from 32 to 36 tons per acre English—it has now, by an improved cultivation, increased to an average of 120,000 to 150,000 per hectare=48 to 60 tons to the English acre.³

One of the inducements offered to the cultivators of mangold is the advantage it is asserted by some to possess of furnishing a double crop of leaves and roots—the leaves being removed from the plant during the later periods of its growth, and affording a supply of food to the stock at an important period of the year, without affecting the root

¹ At Rainham, 64 tons per acre, in *Agri. Gaz.*, 1859, p. 976; at Eynsham Hall, 67 tons 13 cwt. per acre, *Agri. Gaz.*, 1859, p. 915.

² The kilogramme = 2 lbs. 3½ oz.; hectare = 2 acres 1 rood 31 poles.

³ We have had occasion before (p. 135) to refer to the fine specimens of farm produce of the New World, and we now give an extract from the Report of the Exhibition of the California State Horticultural Society, held at San Francisco, Sept. 7 of last year. "Perhaps the most wonderful article in the fair is the 'Monster Red Beet,' weighing 115 lbs. It beats all. It is two years old, and after having been exhibited last fall by Mr. John Llewellyn, when it weighed 42 lbs., it was stuck in the ground a second time to produce seed, and in twelve months it has gained 175 per cent. in weight without attaining that object. If the owner should pursue the same policy for several years more, and it should grow in the same proportion, it would weigh 315 lbs. in Sept. 1860, 855 lbs. in 1861, 2300 lbs. in 1862, and so on. It is now about 4 feet long, and nearly a foot through. California beets the world!!!"

produce at the usual time of maturity. This practice, which is quite opposed to our knowledge of vegetable physiology, was far more general a few years back than it is now. As there are many, however, who still adhere to it, it is worth while to discuss the principles involved, and see how far the practice is admissible or not. We have already (page 285) alluded to the functions of the leaves in the plant economy, and have shown the important duties they have to perform, which would at once lead us to believe that they cannot be removed, in part or in whole, from the plant, without a proportionate injury being sustained by it. As, however, the plant progresses in its growth, the necessity for the first-formed leaves no doubt decreases—the later leaves, naturally more vigorous, assuming the active functions of food-providers for the plant, and the lower leaves droop and show symptoms of decay. If at this particular period they are carefully removed from the plant without injuring the other leaves, the loss to the plant would probably be too slight to affect its growth in any way, while the removed leaves would have some value for feeding purposes. To effect this, however, an amount of careful labour would be required, under ordinary circumstances, far beyond the value of the substance obtained; the leaves would require to be gathered very frequently, which could not be done without inflicting some injury on the crop. The *opinions* of a large majority of our leading growers are certainly opposed to the practice;¹ it has, however, been the subject of *direct* experiments, which, although they leave the question in an unsettled state, are not inconsistent with the opinions now given.

¹ In a paper "On the Cultivation of Mangold," Mr. Paget, M.P., says—"Let nothing induce the grower to strip the leaves from the plant before taking up the root. A series of careful experiments has convinced me that by so doing we borrow food at a most usurious interest."—*Roy. Agri. Soc. Jour.*, vol. xvii. p. 400.

Professor Buckman's experiments, carried on at the Royal Agricultural College (1854), comprised five varieties of mangold, which were sown in the same soil at the same time, and treated in every respect in the same way. Two rows were sown of each sort; and when the plants had attained the size of about $1\frac{1}{2}$ inch in diameter, one row of each sort was closely stripped of all the outside leaves, by cutting them carefully away with a sharp knife, so as not to produce injury by tearing—a process which was from time to time repeated, as often as the outer leaves had again attained a size to be used as a feeding substance. The result of this treatment, at the time of lifting and weighing the roots in November, is thus given:—

Varieties.	Leaves Intact.	Leaves Cut.
1. Red Globe,.....	31·0	23·5
2. Yellow Globe,.....	45·0	18·5
3. Long Red,.....	49·0	18·0
4. Long Yellow,.....	35·5	18·0
5. Long white,.....	32·5	19·5
Total of.....	193·0	97·5

These results show that the average produce of the five varieties tried was reduced just one-half by removing the leaves from the plants while in a growing state, the most productive varieties, the Yellow Globe and Long Red, being those which suffered most by being deprived of their leaves.

These experiments of Professor Buckman were confirmed by those of Dr. Wolff, the professor of chemistry at the Royal Agricultural College at Hohenheim (Würtemberg), who found that, by merely stripping the leaves off for feeding purposes in September, and again in October, the root produce was diminished one-fifth. This was not the only loss the crop sustained by the practice; for on removing them to his laboratory, and making a comparative analysis of their organic constituents, he found that a

considerable difference existed in their relative feeding values in favour of the roots of the untouched plants, as will be seen in the following tabulated statement:—

	Globe Variety.		Long Variety.	
	Cut.	Uncut.	Cut.	Uncut.
Compounds containing nitrogen,	·937	1·019	·772	1·000
Compounds not containing nitro- gen, as sugar,.....	5·076	6·183	4·594	5·365
Do. do. as pectin, gum, &c.,	2·605	1·090	3·201	4·024
Do. do. as woody fibre,.....	·869	·843	·936	1·004
Ash (mineral matters),.....	1·010	1·050	·943	1·125
Water,.....	89·494	89·815	89·554	87·482
	100·000	100·000	100·000	100·000

Another experimental trial, carried on last season by Professor Buckman,¹ gave similar results. In April last two experimental plots were sown with Yellow Globe mangolds, without manure. The after cultivation was carried on in the usual manner; and in August the one which was apparently the most vigorous lot had the large outer leaves stripped off each plant, which operation was repeated in September, and again in October; the other lot pursued their growth untouched. They were both lifted at the end of October. The roots, trimmed and weighed, gave the following results:—

Lot 1.—*Stripped Mangolds.*

	lbs.	oz.	Average circumference of Roots.
Six largest roots,.....	10	10½	12 inches.
Six smallest roots,.....	3	9	
Nine remaining roots,.....	10	1	
	24	4½	

Lot 2.—*Untouched Mangolds.*

	lbs.	oz.	Average circumference of Roots.
Six largest roots,.....	27	4½	19 inches.
Six smallest roots,.....	11	10	
Eight remaining roots,.....	22	7	
	61	5½	

"Here, then, we see the immense preponderance of

¹ *Agri. Gaz.*, Nov. 19, 1859.

root-growth of the unstripped over the stripped roots, and from it we deduce the following important conclusion—*that as long as the mangold leaf is in a fit state to be useful as food for cattle, so long is it important to the well-being of the plant itself.*”

Now let us see what evidence we have to meet this strong charge of injury inflicted on the crop by this questionable practice of stripping. This is at once supplied by an experimental trial made at the Albert Model Farm, Glasnevin,¹ last season, the results of which not only testify to the absence of any injury sustained by the practice, but also that, if properly carried out, the root crop is actually benefited by it, the produce of roots per acre being increased in addition to the large supply of valuable food obtained from the stripped leaves. It appears to have been the custom of the institution, for several years past, to strip the mangolds at certain periods of their growth, and give the leaves to the dairy cows. “An experiment was instituted last season, and carefully carried out on a pretty large scale, with the view of determining whether the roots gained or lost in weight by the stripping off at intervals of the falling outside leaves. The leaves, it must be borne in mind, were most carefully and rather sparingly removed at the first and second strippings, and not more than three or four taken from a plant at one time. In this way 5 tons of leaves per statute acre were taken off for feeding purposes from the 12th August to the 15th October. The experiment was carried out on 4 acres of the mangold crop: twelve drills, each 200 yards in length—that being the entire length of the field—were left untouched, whilst the remaining portion of the crop was treated as above detailed. It is deserving of remark that there was no apparent difference in the two lots at any period during the season, and the crop was considered by the numerous

¹ The full details are given in *Agri. Gaz.*, Jan. 7, 1860.

visitors to the institution and farm as a remarkably even and regular one."

The following tabulated statement gives the general particulars of the experiment as regards the cultivation of the crop, and the results:—

Variety.	Date of Sowing.	Manures per Acre.	Leaves stripped per Acre.	Weight of Roots per Acre.	Date of Lifting.
Lot 1. New Oval Yellow	April 21	{ 20 tons of dung 1 cwt. of Peruvian guano } 6 cwt. of salt	5 tons	tons. cwt. qrs.	Oct. 27
Lot 2. New Oval Yellow	April 21		none	45 1 0 40 8 6	Oct. 27

"Although the practice of stripping had been followed for many years on the farm without any perceptible injury to the crop, these results, showing so considerable an addition to the crop from taking off the leaves, were hardly anticipated."

The experiment appears to have been carried out with great care, the entire crop of both roots and leaves having been accurately weighed, and every precaution taken to give it a reliable value. In the report of the experiment it is suggested that by removing the leaves the plants are more exposed to the direct action of the air and the light—both agents of importance to vegetable growth; which suggestion seems to be strengthened by *the fact* that the outside drills of mangold, which had been weighed separately for many years past, invariably had given a produce at the rate of several tons per acre more than the general crop. These important results will probably induce other growers to test the practice by experiments in the ensuing mangold crop. It is very desirable that this should be done on a sufficiently extensive scale—say stripping every alternate row in the field—to avoid those chances of error which are so common in similar trials where only small selected areas are experimented upon. It would be desir-

able also that the experiment should be made in *different districts* of the country, and with the *different varieties* of mangold; and that the method of stripping practised so successfully on the Albert Model Farm should be followed as closely as possible. If the increased produce promised is confirmed, it would then be desirable to see how far Dr. Wolff's theory of depreciated feeding value is sustained, as we know, from our own investigations into the composition of turnips (page 327), that an increased bulk of produce does not necessarily indicate an increased amount of food. The supply of leaves is no doubt of value to the farmer, especially coming as they do at the period of the season when the grass is always short, and the root crops not sufficiently advanced to be available as keep; their real food value has, however, probably been over-rated, as we have reason to believe that a considerable part of the nitrogen they contain exists in the shape of ammonia, and not of those compounds (flesh-formers) upon the proportion of which we are accustomed to base our estimates of the food value of different substances.

Dr. Wolff's experiments would show that at all events they are not very valuable for dairy purposes.

The milk produce of three cows was submitted to examination. In the first experiment they were fed principally on aftermath; in the second this was replaced by mangold leaves:—

Experiment A.—*Fed on Aftermath.*

	1.	2.	3.
Dry substances in milk,.....	12·47	12·49	11·89
Water in milk,	87·58	87·51	88·62
Butter ,,	3·13	3·39	2·53

Experiment B.—*Fed on Mangold Leaves.*

	1.	2.	3.
Dry substances in milk,.....	11·30	12·08	11·04
Water in milk,	88·70	87·42	88·96
Butter ,,	2·60	2·88	2·20

These results show a considerable deterioration in the

quality of the milk produced. Not only is the proportion considerably less of butter, but the solid substances—the caseine, sugar of milk, &c.—show a corresponding decrease when the cows were fed on the mangold leaves.

All these points ought to be well weighed and considered before we come to a verdict either in favour of or against the practice of stripping. If subsequent experiments, fairly and properly conducted in the field and in the laboratory, show us that the results obtained at the Albert Model Farm can be secured without any practical deterioration in the feeding value of the roots, it is clearly our interest to cast aside all prejudice, and adopt the practice at once on our farms. The evidence we have already quoted in reference to the disputed points shows us the importance of further experiments. These can be conducted without either trouble or expense; and, whatever may be their results, they must be of value as tending towards the settlement of a question of more or less importance to every farmer in the kingdom.

In ordinary seasons, about the third week in October is the best period for harvesting the mangold crop, for which fine and dry weather is of great importance. The labour involved in this operation is somewhat heavier than for turnips, and more care is required in its application. The Globe varieties can usually be lifted by the hand, but for the Long varieties a fork is generally used, except where grown on the lighter and deeper class of soils. On strong loams or clays, or where the subsoil is rough and rocky, occasioning a twisted growth, the roots are very apt to break off and leave a portion in the soil if attempted to be pulled out by the hand. The roots when lifted are left lying in the rows, women or girls following and finishing the operation by removing the dirt with the hand, trimming off the principal roots with a knife, and either wrenching or cutting the top off, so as to leave the crown of the root perfectly uninjured;

they are then placed in heaps at suitable distances for carting off the field. In fine weather it is very desirable to let them remain in this state a few days in the field, in order that they may not only get dry on the surface, but also lose a little of the moisture which they naturally contain. The natural tendency of the root, directly it is removed from the soil and trimmed, is to heat and "sweat," as it is commonly termed, due probably to the great check the vital forces of the plant have sustained by being separated from the soil, and by the removal of the leaves, through which all the surplus moisture of the tissues had been, while in a growing state, evaporated. In the individual root this action is hardly perceptible, the increment of temperature is but small, and the "sweating" is confined to a continuous moisture on the surface. If removed, however, to the store heap in this condition, and piled in quantity, without due ventilation, the heat and moisture would rapidly increase, and fermentation and decomposition as rapidly follow. In our hay fields we have good evidence each year of this tendency to heat and to be injured if due attention is not paid to the "making" and the stacking of the hay crop. If stacked too soon it is sure to heat, ferment, and be more or less injured by it; if the hay, however, has been properly made, and stacked at the proper time, the temperature in the mass is raised a little, which always improves the quality of the produce. So it is with our mangolds, and, indeed, with all our other root crops. If they are left on the ground in small heaps—say of about a cart load each—and exposed to the air for a few days—of course, paying due regard to the weather—this process of "sweating" is carried on in the small heaps with good ventilation, the moisture and heat pass off readily, and no injury is sustained. They can then with safety be carted to the homestead and stored in the usual manner for consumption, as may be required. All the protection neces-

sary in the field is to cover them carefully at night with their own leaves.

The labour required, and its cost per acre, in harvesting a crop of mangold, necessarily vary according to the amount of produce and the variety of mangold grown. The Long varieties are always more expensive than the Globe. Probably, taking the three operations of lifting, trimming, and filling, the cost would amount to something like 6*d.* per ton of roots produced.¹

The produce of our mangold crops, as has been already observed, is increasing each year, and appears, from the details of M. de Gasparin's cultivation, to be susceptible of even still further improvement. We can, however, hardly draw any comparison between it and the turnip crop, as their climatal requirements are entirely different—the one thriving best under those conditions which are least favourable to the other—a difference, however, which renders it so advantageous to divide the root-break between them wherever practicable, so as to render an average crop of roots far more certain in this variable climate than if we relied upon either one of them for our winter stores. In the southern parts of the country, where 20 tons of turnips can be obtained, the mangold would probably give as a return for the same cultivation 30 tons per acre.² In the northern parts this difference could not be expected, as the climate is less suitable to the mangold and more suitable to the turnip cultivation.

¹ In cleaning and trimming mangold, great care should be taken not to cut the roots off too close, and not to injure the crown in taking off the top. In all cases, too, it is advisable to throw aside any injured or decaying roots; they may be quite fit to be used for present food, but would be liable to injure the heap if stored with the rest.

² The results of Lord Lovelace's experiments, conducted for twelve consecutive years on the same farm (Surrey), show that the mangold produce averaged 20 per cent. more than the Swedes.—*Roy. Agri. Soc. Jour.*, vol. iv. p. 23. Mr. Paget, M.P., finds that on his farm (Notts) on his good turnip land the yield of mangold is one-third more than of Swedes, and that where there is a large proportion of clay in the soil the comparative produce is still more favourable to the mangold.—*Roy. Agri. Soc. Jour.*, vol. xvii. p. 400.

In Scotland the introduction of mangold is progressing slowly but surely, as, notwithstanding the advantage the climate offers for turnip cultivation, the increasing tendency to disease exhibited by that plant has shown the farmers the policy of at once securing themselves against the losses and inconveniences of a decreasing root crop by providing themselves with another, which would take the same place in their rotations, and thus double the interval of turnip cultivation on the same field. At one of the monthly meetings of the Highland Society,¹ the "cultivation of mangold in Scotland" was discussed. The opinion of several of the leading agriculturists present was, that although the climate was less favourable than that of the south for the growth of the plant, in ordinary seasons and in good low-lying soils it might be cultivated very advantageously, and that neither in the spring nor in the autumn was it more liable to be injured by frosts than elsewhere; that it possessed the great advantage of being improved by keeping until after the turnips were all consumed; and that although, from the character of the climate of Scotland, it could not be regarded as a substitute for the latter, its freedom from disease and bulky produce rendered it invaluable as a supplementary crop.² In some experimental trials³ the following season at East Lothian, where mangold was sown in the same field and at the same time with turnips, the results in each case were greatly in favour of the latter. Here, however, the mangold was placed under great disadvantages. It was sown a month later than it should have been, in a soil

¹ Full details of the discussion are given in the *High. Soc. Trans.*, 1856, p. 367.

² In the Agricultural Statistics of Scotland we find the area under cultivation in mangolds thus given:—

1854,.....	1946 $\frac{3}{4}$ acres.		1856,.....	3531 acres.
1855,.....	2299 $\frac{1}{2}$ „		1857,.....	2803 $\frac{1}{2}$ „

³ *High. Soc. Trans.*, 1857, p. 552.

probably more suitable for turnips, and at an elevation of 200 to 290 feet in one set of experiments (Thurston), and at an increased elevation of 550 feet in the other (Woodhall), by which, of course, the climate was materially changed. The results of another series of experiments, carried on in Berwickshire for several successive seasons, are more favourable to the mangold. These are best seen in the tabulated form given by the experimenter.¹

Manure per Acre.	Date of Sowing.	Date of Storing.	Weight per Acre of Roots.	Weight per Acre of Leaves.	Value of Crop per Acre.	Expense of Crop per Acre.	Value of Turnip Crop per Acre.	Expense of Turnip Crop per Acre.	Difference in favour of Mangold.
Crop 1852. 12 loads of dung and 8 bushels of bones.	May 11 and 12	Nov. 9 to 29	tons. cwt.s. 23 13½	tons. cwt.s. 5 8	£ s. d. 15 10 0	£ s. 10 5	£ s. 9 18	£ s. d. 9 2 8	£ s. d. 4 9 8
Crop 1855. 10 loads of dung and 1½ cwt. of guano.	May 16 and 17	Nov. 3 to 30	16 7½	6 10	11 9 0	9 0	9 10	8 2 0	1 1 0

The reports of the crops last season throughout the country, though irregular in many places, were, on the whole, very satisfactory; 40 to 50 tons per acre were frequently heard of;² while the Banbury Agricultural Society, on inspecting the crops in their district, for the adjudication of their prizes, met with a field on the farm of Col. North, of Wroxton Abbey, which gave a produce of no less than 63 tons 11 cwt.s. to the acre. In Jersey, where the soil and climate are naturally well suited to the plant, we find, from the report of the Royal Jersey Agri. Society (1857), that 70 tons of trimmed roots to the acre were obtained at St. Peter's, upon a piece of common grass land which had been broken up the previous autumn. When the Regent's Park in London was formed, some

¹ Report on the Cultivation of Mangold-wurzel, by James Turnbull, junr., Crooks, Coldstream.—*High. Soc. Trans.*, 1859, p. 443.

² By the report of the Inspectors of the Manchester and Liverpool Agricultural Society (1859), the crops of mangold to which the prizes were awarded averaged respectively 51 tons, 46 tons, and 45 tons per acre.

thirty years since, it was planted with mangold, and the crop, sold on the ground by auction, realized £80 per acre.

As the mangold is a more delicate root than the turnip, and is usually not required for consumption until the Swedes are all gone, the method of storing it claims the especial care of the farmer, as upon the success of this he depends mainly for keep for his stall-fed stock at a very important period of the year, just when they are being finished off for market. The great object to be attained is to secure the stored roots from injury from their own internal heat and moisture, and from the external injuries of rain or frost. The chances of the first may be entirely met, or at all events materially lessened, by exposure in the field previous to carting; and the second may be effectually prevented by the following method of arranging the store heap.

A dry spot of suitable dimensions, and in a convenient locality, having been selected for the store, a common hurdle should be firmly fixed in the ground, to form the head of the heap; and attached to this, at right angles on either side, other hurdles should be placed, thus forming a passage with parallel sides 6 feet (the width of the hurdle) in the clear apart. This width admits of an ordinary farm-cart being easily backed in, from which the mangolds are tilted out, and arranged so as to fill the space between the two sides by the man intrusted with the building of the heap. This process may be carried on as long as the crop of roots holds out, or it is convenient to extend the line of the heap. To close the heap, a cross-hurdle is firmly set in the ground, and the roots are built up against it as at the commencement.

Here, then, we have built up the heap 6 feet wide, 3 feet high at each side, and with a ridged top, say 6 feet, in the centre (see *diagram*), resting on the dry surface, or upon a thin bottom of any dry rubbish at hand. This has now

to be protected from the weather—rain and frost—which is effectually done by placing another row of hurdles

parallel and exterior to the others, and 9 to 12 inches from them, and filling the interval with litter *firmly pressed*

down, so as to become as firm and compact as possible. The sides thus formed admit of the escape of any moisture or heated air from the interior of the heap, while, owing to their construction, the non-conducting property of the air they contain between their own particles is rendered available in protecting the interior from the action of a low temperature outside. It is desirable to use "wattled" hurdles where they can be obtained for the sides—common flake hurdles do equally well for the top. These should be laid on the top of the heap, from the outer hurdles to the ridge, to keep the thatch clear of the roots; the thatch should be about 4 to 6 inches thick, and be carried down so as to drip clear of the sides.

This method may appear to involve the use of a few hurdles and a little more straw than the common mode of storing on the ground, with merely a thatch or the addition of a layer of soil. Practically, however, it requires no more per ton of roots covered; besides which, the straw is quite fit for litter purposes as the heap is opened and consumed. However, the straw used is of little moment compared with the success of the operation, and if the method of storing now described secures those conditions which we know to be necessary for the preservation of vegetable substances, a very small percentage of gain in the condition of the heap will amply repay any extra outlay for straw, hurdles, and labour that may have been incurred.

In growing mangolds *for seed*, the roots should be selected at the time of lifting them. Symmetry of shape, both of root and head, should be considered of more importance than extraordinary size, which may be due to exceptional circumstances. The root should be well and equally developed, without forks or lateral roots, and the head should be single, and rise from a narrow neck set on in the centre of the crown of the root. The roots selected should not

be touched by the trimming-knife, and the tops should be wrenched off so as not to injure the crown. They require to be well protected during the winter, and in the spring, about March, they should be planted out in a piece of ground previously prepared for them by deep tillage and good manuring, at distances of about 3 feet apart, the roots being covered, so that the crown should just be on a level with the surface. The hoe should be freely used between them during their growth. As the season advances, a stout flower-stem is thrown up 4 to 5 feet high.¹ The seed is formed in due course, and about September is sufficiently matured for harvesting, which is carried on in the ordinary way, the seed being thrashed out by the flail on the ground, or on the barn floor, as may be most convenient. The produce is subject to great variations from the effects of weather, injuries from birds (which are very fond of it), insects, &c. It may be taken at from 8 to 20 cwts. per acre—12 cwts. are usually considered a satisfactory crop.

In France, where a largely-developed industry is based upon the beet-root cultivation, the percentage of sugar contained in the root is a point of great economic importance, the pecuniary success of the operation being, of course, largely affected by it. This led M. Louis Vilmorin to turn his attention to the subject, and he found that, by testing the expressed juice of the roots with the saccharometer, in the manner and with the apparatus described at p. 331 in reference to the specific gravity of the turnip, and selecting those for seed purposes containing the highest percentage of sugar, he was able, by carefully pursuing this method, in the course of a few years to produce a stock which contained a great increase upon the ordinary

¹ Mr. Baker, of Writtle, Essex, an extensive and careful grower, recommends that the flowering should be carefully watched, and that all the plants bearing deep orange-coloured flowers should be at once pulled up.

proportion of sugar in the root.¹ The method made known to us by M. Vilmorin² is so simple, and attended with so little trouble or expense, that it naturally recommends itself to the consideration of all who are desirous of following up practices, the result of sound principles, applied to the development and increase of our agricultural resources.

The mangold in this country has enjoyed almost a perfect immunity from *disease*. At both an early and a late period of its growth it has been, in certain seasons and certain localities, affected by frost, and thus has either been killed or rendered unfit for being stored in the usual manner; but at present cases of injury from disease have been very rare. On the Continent, however, great losses have been sustained by a diseased condition of the root, induced probably by the continued use of rich manures, stimulating an abnormal development which the vitality of the plant, diminished by causes, such as being grown too frequently on the same ground, neglect of seed, &c, was not able to perfect. We have, unhappily, analogous cases in some of our crops—the disease, for instance, that has visited our potatoes, and that of which we hear more and more of every season as affecting our turnip crops. This disease was first noticed in Belgium in 1846, by Kühlmann, and in France the following year, by Crespel and Payen.³ The attention of MM. Kühlmann and Crespel was first attracted by finding that the juice of the roots that had been stored a short time, instead of yielding the usual proportion of sugar, gave only a brown, viscous syrup, possessing an offensive odour, and incapable of crystallization. On examining the suspected roots, M.

¹ The proportion of sugar in the ordinary varieties of beet-root is about 8 per cent. The produce of M. Vilmorin's *improved* variety is giving, this season (1859-60), no less than 12·3 per cent. of sugar—an enormous benefit in an economic point of view.

² *Notes sur un projet d'Expérience ayant pour but d'augmenter la Richesse Saccharine de la Betterave*, par M. L. Vilmorin.—*Annales de l'Agriculture*, tome xxii.

³ *Annales de l'Agriculture*, tome xvi. 1847.

Payen found that the tissues in the upper portion of the root were changed in colour, and had become more or less disorganized, and that these were rapidly carrying the disease downwards into the body of the root. The appearance of the diseased tissues was very similar to that which occurs in the potato murrain. The disease was noticed to progress much more rapidly when the roots were stored together than when they were kept separate and with access to the air. On testing the juice of the diseased portions, it gave an *alkaline* instead of *acid* reaction; the sugar had entirely disappeared, and that which remained in the sound portion of the root was materially changed, and rendered quite unfit for the ordinary manufacturing purposes.

The disease appears to be due to the influence of a parasitic fungus—a species of *Botrytis*—which attacked the leaves, causing them to wither, whence the disease was carried by the spiral vessels of the leaves to the root, where its presence was first indicated by the appearance on the surface of small violet-coloured spots tinged with red. The skin soon became disorganized, and the spots assumed a blackish hue, penetrating the tissues, and thus spreading the disease through the neighbouring parts.

As the disease appears to be conveyed through the leaves to the root, the latter may be preserved from injury by separating the top directly it is observed to wither. This practice has been followed in the sugar-making districts; and as the root contains at the mid-period of its growth a *larger percentage* of sugar than when more fully developed, the loss occasioned by the disease is materially diminished. In this country, where mangold is grown only for feeding purposes, this remedy would not be so available, as its bulk and consequent nutritive value at that period would be much less than at the usual harvest time. The breadth of mangold is increasing with us every year, and with its in-

creased cultivation we shall no doubt become less attentive to its general health, and more careless of those conditions of cultivation—manures, soil, seed, &c.—which increase in importance as our crops are forced from their normal habits of growth. We have had notices that this disease has already been met with in our mangold crop, and the best way to keep free from it will be to sustain the vigour and health of our plants by growing them in soils suitable for them, taking care that they are supplied with proper food, making the interval between their occupation of the same ground as long as possible, and by using only seed upon the quality of which we can place reliance. If these conditions are observed, the chances of disease are at once proportionably diminished, as these parasitic fungi never attack sound and healthy plants.

The comparative freedom from disease and from the attacks of *insects*, were no doubt favourable circumstances to the introduction of mangold into this country; and until within these last fifteen or twenty years, it was supposed that its chances of injury were so few and of so little importance, as practically not to interfere with its cultivation at all. As the breadth sown increased every year, more attention was paid to it, and it was soon found that it enjoyed no such perfect immunity from insect injuries as was supposed; and that although we at present are not so well acquainted with its enemies as we are with those infesting either the turnip or the potato crop, still we find continually, on comparing notes with each other, fresh instances of injuries sustained, and that our list of predatory insects increases every season.

As soon as the young plants appear above the ground, they are attacked by the grubs of the “crane-fly”—*Tipula oleracea*—(p. 386), and by the surface-caterpillars of the heart-and-dart moth—*Agrotis segetum* and *A. exclamationis*. The upper part of the root is eaten through,

and the plant either entirely destroyed or seriously injured. In France, one of the greatest pests to the mangold crop is a small beetle, the *Atomaria linearis*, belonging to the family Cryptophagidæ, which infests the leaves and roots, destroying the young buds as they appear. It appears to secrete itself among the particles of the soil, whence in fine weather it emerges, ascends the stem, and devours the leaves. "These little creatures often appear," says M. Bazin, "in families, on a small plant, of which in a few hours nothing remains but a leafless stalk, which presently withers and dies." A few years since it devastated whole fields in the neighbourhood of Lille, so that nothing remained but to plough up and re-sow the land.¹ The beetle appears in May and June, less seldom in July and August. Curtis tells us that it is abundant in England, and no doubt occasions some of the injuries which our mangold crops sustain. In the early period of their growth, the leaves are punctured by the "common turnip-fly" (*Haltica nemorum*), though apparently not to any injurious extent; another insect, however, appears about the same time, whose visits are attended with more serious consequences. This is the "beet carrion-beetle"—*Silpha opaca*—an insect long known to us as delighting in decaying animal matter, but which, until a few years ago, was not known to have a propensity for a vegetable diet also. On the Continent, and also in Ireland, they have committed great ravages, and have been noticed from time to time committing their depredations in various parts of this country.² They are small, in shape like the "wood-louse," but black and shining; at first they are covered with hairs (*tomentosa*), which drop off as they assume their black colour. They confine their attacks to the leaves, which they entirely devour down

¹ *Annales de la Société Entom. de France*, 1847, p. 1.

² The detailed observations are given in *Farm Insects*, p. 392.

to the crown of the root, the plant being in that case effectually destroyed. In 1846, M. Bazin noticed that

1 and 2. Young and full-grown larvæ of *Silpha opaca* (natural size) devouring a mangold leaf. 3 and 4. Do. magnified (female and male). 5. The beetle flying (female). 6. Do. male, slightly magnified.

the leaves of his mangold crop were nibbled into small round holes, which, on examining them closely, he found were due to the larvæ of the "clouded shield-beetle"—*Cassida nebulosa*—which infested the under side of the leaves. The larvæ are of a pretty green colour, marked with white, and the margins are armed with barbed yellow spines; they have at the extremity of the body two long spreading tails, which the insect keeps turned over its back when at rest, by way of shelter, and also as a protection against the attack of parasites, to which, however, it frequently falls a victim. The leaves of the plant are also liable to injury from the "mangold-wurzel fly"—*Anthomyia betæ*. The maggots are of an ashy gray colour, and as soon as they are hatched, make their way into the interior of the leaf, feeding on the pulpy substance (*parenchyma*), eating through the integuments, and giving the leaf a blistered appearance. These, like those of the turnip-leaf miner (p. 321), are readily destroyed by merely pinching the leaves containing them, when, unless the leaves have been greatly injured by them, they recover, and the roots are not checked in their

growth. A question is raised by Mr. Curtis as to the effect leaves thus injured might have upon cattle, should they be used for feeding purposes. The roots of the mangold have been the means of calling attention to a new British genus of Aphidæ, which, from the circumstance of having first been discovered there, has received the specific name of "*Smynthuroides betæ*;" its peculiar habits, however, have not yet been sufficiently studied to enable us to know how far it is likely to affect our crops. In the autumn, however, when from any circumstances a root begins to decay, it is soon taken possession of by a numerous variety of insects. Amongst these, large broods may generally be seen of a small beetle called *Cercyon boletophagus*, of which an acar, the *Uropoda umbilica*, is a constant companion.

The great economic value of beet as the basis of extensive industries on the Continent, and the important position it has acquired in the agricultural rotations of this country, have caused the *chemistry* of the crop to be well investigated, both as regards its sugar-producing and its feeding properties. The proportion of top to root varies with the soil and the season. The average may be taken at from 20 per cent. to 25 per cent., or one-fifth to one-fourth. The proportions of water and of ash are subject also to variations; in bulky crops the proportion of water would be greater and of ash less than in crops where the growth was stunted and the roots small. The average proportion of water in the bulbs may be taken at 86 to 90 per cent., and in the leaves at about 90 per cent. The proportion of ash (mineral matter) in the bulbs averages from 1 to 1.2 per cent., and in the leaves from 1.5 to 2 per cent., the Long varieties appearing to contain rather a higher percentage of ash, both in the bulbs and the leaves, than the Globe varieties.

The composition of this ash was determined by Messrs.

Way and Ogston, in the series of ash analyses of the Royal Agricultural Society, and is thus given :¹—

	BULBS.			LEAVES.		
	Yellow Globe.	Long Red.	Long Red.	Yellow Globe.	Long Red.	Long Red.
Potash,	23·54	21·68	29·05	8·34	27·90	27·53
Soda,	19·08	3·13	19·05	12·21	3·01	5·83
Lime,	1·78	1·90	2·17	8·72	8·17	9·06
Magnesia,	1·75	1·79	2·79	9·84	7·03	9·10
Peroxide of Iron, ...	·74	·52	·56	1·46	·96	·48
Phosphoric acid, ...	4·49	1·65	3·11	5·89	5·19	4·39
Sulphuric acid,	3·68	3·14	3·31	6·54	4·60	6·26
Carbonic acid,	18·14	15·23	21·61	6·92	6·45	6·11
Chloride of Sodium, ...	24·54	49·51	14·18	37·66	34·39	29·85
Silica,	2·22	1·40	4·11	2·35	2·26	1·35
	99·96	99·95	99·94	99·95	99·96	99·96

Assuming, therefore, an average crop of mangold to yield 20 tons of roots and 4 tons of tops, we should find that, according to the foregoing analysis of the composition of the mineral portions of the crop, it had removed from the field the following principal substances, in about the quantities now given :—

	lbs.
Potash,	133
Soda,	70
Lime,	21
Magnesia,	22
Phosphoric acid,	21
Sulphuric acid,	22
Chloride of Sodium,	160

The *organic* composition of the mangold has been well worked out by our chemists. The first investigations were carried on in Professor Johnston's laboratory, by Mr. Cameron and by Dr. Fromberg. According to the analysis of the latter, the percentage of flesh-forming (nitrogen) compounds was found to be as follows :—

Long Red,	1·60 per cent.
Red Globe,	2·12 „
Orange Globe,	1·94 „

¹ Roy. Agri. Soc. Jour., vol. viii. p. 184.

More recently, Dr. Voelcker and Dr. Anderson have investigated the organic composition of the bulb grown respectively in England and in Scotland. Their determinations agree very closely with each other, and also with that of Dr. Fromberg, so as to give us a perfectly reliable estimate of the amount of nutritive matter furnished by the crop. Dr. Voelcker gives the results of his analysis thus:—

Compounds containing nitrogen (flesh-formers),.....	1·81
Compounds destitute of nitrogen (heat-givers and fat-formers), ...	11·19
Ash (mineral matters),.....	·96
Water,.....	86·04
	<hr/> 100·00

Dr. Anderson's¹ attention had been called to an opinion that existed, that the portion of the root growing above the ground was superior in feeding value to that portion beneath the surface; he therefore carefully divided the roots subjected to analysis into their respective portions, and determined their composition separately. In the two varieties experimented upon a marked difference was seen between the nitrogen compounds (the only object sought for) of the two portions of one variety, the Long Yellow, but so slight a difference in the other, the Long Red, as practically to be of no importance; therefore, although we are quite right in assuming that that portion of vegetable bodies exposed to the light contains more nitrogenous substances than the portions covered up and deprived of light (as is shown in the analysis of the cabbage crop, p. 389), still the difference, if it really exists as a rule in the mangold, would but little affect its cultivation, as for other reasons of a practical nature, the general opinion is in favour of those varieties which carry the bulk of the produce above the ground.

¹ *High. Soc. Trans.*, 1855, p. 276.

The following are the results of the investigation—

	Long Yellow Variety.		Long Red Variety.	
	Upper part of Bulb.	Lower part of Bulb.	Upper part of Bulb.	Lower part of Bulb.
Nitrogen compounds,....	2.28	1.52	1.49	1.59
Other constituents,.....	7.82	8.85	7.02	6.41
Ash,.....	1.25	1.41	1.21	1.16
Water,.....	88.65	88.22	90.48	90.84
	100.00	100.00	100.00	100.00

The composition of the entire bulbs would thus be—

	Long Yellow.	Long Red.	Yellow Globe.
Nitrogen compounds,.....	1.90	1.54	1.75
Compounds destitute of nitro- gen,.....	8.34	6.62	6.75
Ash,.....	1.33	1.18	1.26
Water,.....	88.43	90.66	90.24
	100.00	100.00	100.00

Dr. Anderson then takes the average composition of the turnip¹ for the purpose of comparing the feeding values of the two crops, which, according to his analysis, stand thus:—

	Nitrogen Compounds.	Total of Solid Substances.
Turnip—average composition,.....	1.27	7.89
Mangold—Long Red variety,	1.54	9.44
„ Yellow Globe,.....	1.75	9.76
„ Long Yellow,.....	1.90	11.57

In this table the superior value of the mangolds is unmistakeably shown; therefore, if we take the turnip as

¹ Nitrogen compounds,.....	1.27
Other constituents,.....	6.84
Ash,.....	.78
Water,.....	92.11
	100.00

This analysis gives a lower estimate of the organic constituents of the turnip than that given by Dr. Voelcker at p. 328.

the standard for the comparison, we should find the following arrangement would represent their relative feeding properties:—

	Relative Values.	or	Feeding Equivalents.
Turnips,.....	1.00		100 lbs.
Long Red Mangold,.....	1.21	,,	82 ,,
Yellow Globe ,,	1.37	,,	72 ,,
Long Yellow ,,	1.49	,,	67 ,,
Mangold—average,.....	1.35	,,	74 ,,

In the first column we have the relative value of the mangolds as compared with the turnip, and in the second these are reduced, for practical application, to their equivalents in lbs. weight. For instance, we find that the relative value of Long Yellow mangold is nearly half as much again as that of the turnip; consequently, that 67 lbs. of the former are equivalent in feeding properties to 100 lbs. of the latter.

These data are strictly comparative so far as their theoretical values are concerned, and no doubt fairly represent that the actual feeding properties of mangold are superior to those of the turnip, though, owing to the difficulty of carrying on a feeding experiment with the two roots under conditions equally suitable to both, the results might not be quite in accordance with the equivalents given. It is well known that the mangold, when given in a *fresh* state to cattle, is very apt to purge them, and thus lower their condition; whereas, by storing it for a certain time the peculiar acrid substance which it contains undergoes a change, and no longer acts in that manner upon the economy of the animal. Experience has shown us, therefore, that in order to obtain the best effect from mangolds, they should not be given to stock until they have remained (say three or four months) in the store-heap; whereas the turnips rather deteriorate by keeping, and exhibit their highest values when given in a fresh state. Thus, were their relative feeding values tested by

an experiment carried on in October and November, the conditions would be in favour of the turnips; whereas, if the experiments were carried on in March and April, they would be greatly in favour of the mangold; and to render a practical experiment of any real value, it is of vital importance that the conditions throughout should be equal and strictly comparative. In reference to this peculiar feature in mangolds, Dr. Voelcker has found "that in keeping, the proportion of sugar in the root increases considerably, whilst the 'pectin' diminishes. As 'pectic acid' is readily changed by weak acid into sugar, and as it is also transformed into sugar during the ripening process of apples, pears, and other fruit, there can be little doubt that the additional quantity of sugar in old mangolds has been formed at the expense of the 'pectin,' which is found in all varieties of mangolds."

The results of several feeding experiments have been from time to time recorded; the evidence given, however, as to the mode in which the experiments were conducted, is not such as to enable us to make any very satisfactory deductions from them. Lord Spencer's experiments,¹ though somewhat incomplete, and of not very recent date, give us, as far as they go, reliable information in favour of mangold. The more recent "Experiments on Fattening

¹ At Christmas I put two Durham steers to feeding, the one upon Swedish turnips, the other upon mangold-wurzel. I ascertained the weight of the steers by measurement.

1st month.—No. 1.	Fed on Swedes,	gained	34 lbs.	consuming	1624 lbs.
No. 2.	„ mangold,	„	52	„	1848 „
2d month.—No. 1.	„ „ „	„	32	„	1884 „
No. 2.	„ Swedes,	„	14	„	1880 „
3d month.—No. 1.	„ mangold,	„	50	„	1792 „
No. 2.	„ „ „	„	31	„	1792 „

His lordship says—"The comparison between the increments of the two animals during the two first months should not only be observed, but the fact that when No. 2 was changed from mangold to Swedes in the second month, his growth was nearly stopped, but as soon as he was put on mangold again in the third month, he began at once to increase."—*British Husbandry*, vol. ii. p. 254.

Cattle," by Col. M'Douall, of Logan,¹ show that 75 lbs. of mangold produced equal results with 107 lbs. of Swedes; while those of Mr. M'Culloch (Auchness), quoted by Dr. Anderson, "have led him to the conclusion that 30 lbs. of mangold are equal in feeding value to 40 lbs. of turnips, which is exactly the average proportion deduced from the foregoing analysis."

The organic composition of the mangold leaves has been determined by Dr. Anderson in the same manner as that of the bulbs, by which we see that the amount of nitrogen compounds they contain is considerably in excess of that found in the bulbs. We must not, however, be led into the error of estimating their feeding properties by this test alone; as, for the reasons given at p. 332, it is probable that the nitrogen does not exist altogether in the form of those compounds on which it is the custom to base our estimate of feeding properties.

Organic Composition of Mangold Leaves.

	Long Yellow.	Globe Yellow.	Long Red.	Average.
Nitrogen compounds,	1·77	2·83	2·39	2·33
Other constituents,	4·86	5·50	4·45	5·27
Ash (mineral matter),	1·77	1·56	2·04	1·79
Water,	91·60	90·11	91·12	90·61
	100·00	100·00	100·00	100·00

A recent examination by Dr. Voelcker (May, 1859), of a root of mangold, the produce of 1857, showed that sound and healthy roots, if properly stored, may be preserved without any material diminution of their feeding properties for the period named.

On analysis the root gave the following composition:—

Compounds containing nitrogen (flesh-forming),	1·13
Compounds not containing nitrogen, as sugar, gum, pectin, &c.,	4·08
" " " as woody fibre,	1·18
Ash (mineral matter),	1·36
Water,	92·25
	100·00

¹ *Roy. Agri. Soc. Jour.*, vol. xiii. p. 117.

Dr. Voelcker remarks, that while the feeding value differs but slightly from the average composition of the fresh root, the proportion of both the water and the mineral substances is in excess. This would indicate that the long period for which it had been kept had had an unfavourable effect upon the constitution of the root, as, under the ordinary conditions of storing during the winter, the proportion of water at the time of consumption in the spring is invariably less than at the period of storing them in the autumn. The increased proportion of inorganic matter would also indicate that this, like the water, had been occasioned by changes in the organic constituents of the roots, by which their proportions were diminished. On examining this inorganic matter it was found to contain nearly 50 per cent. of common salt, which would naturally suggest the question, whether mangolds generally possess the property of keeping sound when stored for so long a period, or whether the keeping properties of the root in question were due to the large proportion of chloride of sodium it contained. Dr. Voelcker appears to incline to the opinion that the character of the manures which are used for mangolds has a material influence on their composition, which no doubt must affect likewise their keeping qualities.

Some idea of the importance attached to the mangold crop on the Continent, may be gathered from the enormous consumption of mangolds and of the sugar-beet for sugar and distilling purposes. From the official returns for the past year (1858-9), of one country only (France), we find that the make of sugar amounted to 132,651 tons, the production of 359 factories, while there were, at the same period, upwards of 200 distilleries at work, consuming 2500 tons of roots in their daily operations.¹ For the

¹ In Russia (1850) the make of beet-root sugar was 35,000 tons; in the Zollverein (1851) it amounted to 43,000 tons, having doubled itself in the last three

manufacture of sugar, the Silesian beet is preferable to the mangold. For distilling purposes the latter may be used with equal advantage; and as the yield of mangold is generally more per acre than of Silesian beet, it is more commonly grown for that purpose. In the manufacture of sugar it is necessary that the sugar should be in a crystallizable form, as "cane sugar" ($C_{12}H_{12}O_{12}$), while for the manufacture of spirits, where the sugar itself has to undergo a change, the uncrystallizable form, known as "grape sugar" ($C_{12}H_{14}O_{14}$), is equally available. The mangold and the beet in the fresh state both contain crystallizable sugar; this, however, is very readily changed by fermentation, either natural—resulting from injury or from storing,—or forced—occurring during the process of manufacture,—into the other form (uncrystallizable), and thus cannot be obtained in the state desired. The sugar is obtained from the expressed juice of the root, and it is found that the larger the proportion of soluble salts and organic matters the juice contains, the more difficult is the separation of the sugar, and the greater is the loss sustained during the operation; consequently, it results that the development of the cellular tissues of the roots, although it gives bulk to the crop, and adds to their feeding value, renders them practically less valuable for sugar-making purposes. For distilling where the alcohol is obtained from the decomposition of the sugar, it does not matter in what form it is, whether crystallized or not; therefore, the larger the produce of bulbs per acre, the better the returns in alcohol.

This change in the condition of the sugar of the root has an important bearing upon the process of its manufacture. Although for our own purposes (feeding) we find years (in 1857 this had increased to 110,000 tons); in Austria (1850) about 6000 tons were produced; and in Belgium (1851) the quantity manufactured from beet-root amounted to 14,000 tons.—See paper "On the Manufacture of Sugar from Beet-root," *Roy. Agri. Soc. Jour.*, vol. xiii. p. 145.

mangold improving in sweetness by keeping a few months, the manufacturer¹ finds that for his purpose the value of the root decreases each day it is kept, the natural process of fermentation, slow and imperceptible though it be, changing the constitution of the sugar, and gradually converting it into an uncrystallizable form. To meet this difficulty—for it is obviously impossible to use the root entirely in its fresh state—a vast amount of chemical ability has been displayed, the whole question has been well worked out, and agriculture has largely benefited by it, as may be seen from the well-marked consequences to a district attendant upon the successful development and prosecution of the sugar-making industry.² The residuum, after the juice is expressed, forms a cake suitable for feeding purposes, and as about 20 tons of “cake” (pressed pulp) remain from each 100 tons of roots consumed, which is obtainable by the growers at a moderate price,³ a large amount of stock is kept and fattened, and a large amount of manure produced. This, of course, reacts upon the land, and its fertility is increased, as, practically, all its mineral constituents abstracted by the crops, are again returned in the residuum from the manufacturer. In the arrondissement de St. Quentin (Département du Nord), the sugar manufacture has doubled the area of corn cultivation, and has increased the average yield from 13 hectolitres per hectare in 1823, to 28 hectolitres in 1852.

The manipulation of the roots for distilling purposes is

¹ M. Paul Hamoir (Serret, Hamoir, Duquesne, & Co., of Valenciennes) says—“If the roots be taken from the field and stored, even under the most favourable conditions, the quantity of crystallizable sugar is found practically to diminish, according to the time they have been kept. For instance, if the fresh root yielded in October 7 per cent. of sugar, in January it would only give 5 per cent., and in February probably less than 4 per cent.”—*Roy. Agri. Soc. Jour.*, vol. xiii. p. 154.

² *Roy. Agri. Soc. Jour.*, vol. xiii. p. 154-161.

³ In 1859 the average price given for the roots was 16s. per ton, and the pressed pulp was sold at 12s. per ton.

somewhat different from that in the manufacture of sugar. Here the root is sliced and macerated in hot water for a certain time, for the extraction of the saccharine matter; it is then drained, and the hot pulp carted away to be used as a feeding substance. The results of some experiments at Grignon Agricultural College, for the purpose of testing practically its value, show that the milk produce was greater when the cows were fed on the pulp than on the fresh roots, that the proportion of butter was increased, and that their weight and general condition were improved.¹

In this country both the manufacture of sugar and the distillation of alcohol from mangold have been attempted, the former on a considerable scale in Ireland, and the latter on a comparative small scale at Farningham (Kent), and at Minety (Wilts).²

In neither case, however, were the operations successful in a pecuniary point of view, notwithstanding, the question, both in a scientific and in a practical point of view, has been so successfully and so extensively worked out on the Continent. In Ireland, the luxuriant growth and largely developed cellular tissues of the mangold interfered no doubt considerably with the extraction of the sugar in a crystallizable form, and reduced the manufactured production. This cause, however, would not operate against the fermentation and conversion of the sugar into spirit, the only adverse conditions under which the process of distillation laboured here, as compared with the Continent, must have arisen, either from an imperfect acquaintance with the chemical principles involved in the process, or from the difference in the control over it exercised by fiscal regulations.

¹ The details of the process of distillation from mangold are given in a paper by M. R. de Tréhonnais, in the *Roy. Agri. Soc. Jour.*, vol. xx. p. 68.

² Full details are given in *Agri. Gaz.*, 1857, p. 28, and 1860, p. 72.

THE CARROT CROP.

WE now have to pass on to an entirely different order, which, though containing many plants of importance to us—chiefly used for medicinal purposes—contains only four genera which enter into the agriculture of this country. Of these, two only—the Carrot and the Parsnip—come under the head of “root or fallow crops;” the other two, Coriander and Carraway, will be more appropriately considered when we come to the “crops cultivated for special purposes.”

These all belong to the order “Umbelliferæ;” and the two we will now describe are met with as weeds common to all the light-soil districts in the country. Of the genus *Daucus*,¹ the common carrot, *D. carota*, is the only species worth attention, and of this there are many different varieties cultivated. It is a biennial plant, with, in its natural state, a tough fusiform root, carrying a light graceful top, surmounted by the readily recognized and characteristic umbelliferous flowers and seed-stalks. These are generally depressed in the centre, so as to form a sort of cup, whence the name of “bird’s nest” has been commonly given to the wild species of our fields and waste places. The carrot and the parsnip are both good representations of the effect which cultivation has upon the original condition of a plant. The plant in its natural state is the same in appearance as when cultivated, but in the place of the tough, stringy, fibrous roots of the former, we have now a single fusiform root, largely developed in the cellular

¹ *Daucus*, from *δαίω*, to make hot, from the strong pungent taste of the seeds.

tissue of its upper portions, and possessing a sweet mucilaginous taste, with but little of the strong and disagreeable bitter that is so marked in the roots of the wild plant.

Carrots have been too long in cultivation in this country to be able to trace them back to their original departure from this wild type, from which there is no doubt they originally sprung, as in a series of experiments upon our cultivated plants¹ M. Louis Vilmorin succeeded in obtaining roots sufficiently developed to be perfectly tender and fit for cooking, from plants only four or five generations from the indigenous stock. There is no doubt the carrot was known for its edible, as well as for its medicinal properties, to the ancients, as it is mentioned by Dioscorides, and a drawing exists in his manuscript in the Vienna Museum. The description given by Dioscorides is quoted by Pliny, but does not appear to have been noticed by the other Roman agricultural writers. In our early herbals—those of Dodoens and Gerarde—we find it figured and described, with full directions for its cultivation and use. At this period it was certainly known in this country as a garden vegetable, having been probably introduced, with so many of our vegetables, from Germany or the Low Countries, which were then further advanced than ourselves in the art of cultivation, and had no doubt derived it originally from Italy, or other countries more civilized than they were themselves. As a field crop they were but little known until towards the end of the last century, when we find mention made of them by Arthur Young, and also in some few of the surveys made for the Board of Agriculture at the beginning of the present, in which the descriptions and recommendations given would imply they were only newly introduced as a farm crop suitable for light soils. Since then their value has been better known to us; and we now know, by our improved tillage

¹ *Transactions of the Horticultural Society*, vol. ii. p. 348.

system, that they are suitable for cultivation in a far wider range of soils than was at first assigned to them; and from their excellent keeping properties, offer great inducements to the stock-keeping farmer to share with his other plants in the breadth set apart for his general root crop.

The varieties most recommended for farm cultivation are the

Altringham, a red coloured carrot, growing well out of the ground, with a broad head, convex or rounded at top, and tapering more sharply and abruptly towards the end. It is generally a profitable carrot to grow for sale, as its quality is equal to the garden varieties, and its produce much greater. It has a great tendency "to sport," although the roots grown for seed had been selected with the greatest care. This sometimes interferes with the crop.

Fig. 1.

Large Red, or *Orange Cattle Carrot*, is a coarser variety than the former, and only fit for cattle feeding; grows deep in the ground; somewhat thick at the upper part of the root, and gradually tapering to the end; colour lightish red, with rather a large centre or heart.

Long Red, or *Long Surrey* (fig. 1), is of a deep red colour and very small centre, grows deep in the ground, and is a thinner carrot than the foregoing variety, but of finer quality.

Short Red, or *Horn* (fig. 2), is a larger and coarser description of the *Early Horn* or *Dutch* carrot of the garden, and well adapted for field cultivation where the soil is too shallow for a deep-rooted crop. The root is thick, short, and of a conical shape, broad at the top, with a flat or hollow crown, and carrying but little stem. It grows well out of the ground, and is of excellent quality. A very similar variety, but somewhat

larger in size, and equally suitable to the same class of soils, has been lately introduced as James' Scarlet carrot. There is also a white variety of the Horn carrot, cultivated largely on the Continent, on soils too shallow for the ordinary varieties. This is known as the *Càrrotte des Vosges*.

Large White Belgian (fig. 3) is one of the best suited for general field cultivation. It grows well out of the ground, and

Fig. 2.

Fig. 3.

has a root thicker in proportion to its length than the other field varieties. It is very productive when grown under suitable conditions; and owing to the comparative shortness of its root, and its habit of growing well out of the ground, it can be more profitably cultivated than those which require a greater depth of soil for their growth. The lower part of the root is white; the upper part green, with a well-rounded top.

The *Yellow Belgian* is also a productive variety, of a finer quality than the preceding. The root, which has a deepish yellow tint, with a green top, is longer, but less thick than the white, and is better suited for the lighter than the stronger class of carrot soils.

Although the carrot is naturally a plant that requires a deep and light soil for its development, cultivation has so changed its habit of growth, and our greatly advanced mechanical methods of treating our soils has so altered their texture, that there are but few descriptions of soils under cultivation in this country in which some variety of carrots cannot be grown. At the same time we must admit, notwithstanding these improvements both in the nature of

the plant and of the soil, that soils of the lighter class are, *cæteris paribus*, more suitable than those of the heavier class; the medium description, which we should term loams, probably being those which, under ordinary circumstances, carry the most productive crops. In strong loams, those of an argillaceous character, the parsnip would be a more suitable plant than the carrot; and as these plants greatly resemble each other in all their agricultural characters, the parsnip, on such soils, offers itself as a ready substitute for the carrot. One necessary condition in all soils for the cultivation of carrots is depth; if this does not exist naturally, as is seen in the light sands or vegetable moulds which we meet with in the green sandstone formations in Bedfordshire, Surrey, or the alluvial or warped soils of the valleys of the Thames, Humber, &c., it must be effected by deep ploughing and subsoiling, or otherwise breaking-up and stirring the substratum to a sufficient depth. Unless this be done the carrot will either be stunted in its growth, if the subsoil be compact and hard, or if it be sufficiently pervious to allow the root to penetrate, a considerable portion of it will be broken off in the operation of lifting at harvest, and left in the ground. Deep cultivation is also of vital importance to the crop, as the tendency of the plant is to send down, at an early period of its growth, a long thin tap-root into the soil, through which it receives those supplies of food necessary for the development of its upper portions. And one of the great objects in our cultivation is to support in the plant this habit of reliance upon the tap-root for the supply of its wants, rather than to seek to increase its sources of supply by throwing out forks or lateral subordinate roots nearer to the surface.

This tendency to "fork" is frequently noticeable in unfavourable soils, or where they are either too shallow or contain large stones or other obstructions, and also

in badly tilled soils where the staple has not been sufficiently reduced, or where the manure has been placed too close to the surface, and too recently before the time of sowing. In shallow soils, the growth soon becomes stunted, the tap-root having no range downwards into the rich mineral stores of the subsoil, loses its vigour, and the plant usually throws out numerous smaller roots, in order to compensate for this loss of its usual purveyor; and where stones or other obstacles are met with by the root of the young plant, it either is stopped altogether in its growth, or the root is either encouraged to fork or is forced aside more or less abruptly; the tissues are unnaturally compressed and restricted in their development, and the root, owing to its irregular growth, is generally broken when being removed from its bed. In imperfectly tilled soils much the same conditions of growth are exhibited—the buried clods, or indurated lumps of earth, producing well-nigh the same effect as stones on the roots of the young plant, which always has an increased tendency to fork and throw out lateral roots when the manure, especially if it be in a fresh state, has been applied at the time of sowing. In that case the root is apt to extend itself in the direction where it finds the most ready supply of food, instead of following its natural habit of searching for it low down in the subsoil, which, indeed, is one of the properties that, both in a chemical and physical point of view, render the carrot such a valuable crop in our rotations.

This habit of deep growth renders another condition absolutely necessary in the soil, and that is freedom from stagnant water. As long as the tap-root can roam in a substratum of soil to which the rain-water can have regular access, it is always sure to meet with supplies of food suitable for its purpose, as the rain-water percolating through the surface soil carries with it not only the

proportion of air and carbonic acid which it always contains, but also some of the soluble matters of the surface-soil through which it had to pass. These are to a great extent arrested in the subsoil, while the rain-water, whose oxidizing and solvent powers are greatly increased by its additional constituents, assists materially in rendering the natural ingredients of the substratum more available and assimilable by the roots that penetrate it.

Besides these two *necessary* conditions in all carrot soils—depth and drainage—the tilth and general condition so important to the good cultivation of our other crops are equally desirable for this, though probably the carrot would be less injuriously affected by their absence, than either of the cruciferous crops already described would be. As a general farm rule, they should always be secured as far as possible, as they both have a strong and permanent bearing upon all our crops, from the earliest to the latest period of their growth; and it happens, therefore, fortunately, that both the carrot and the parsnip suffer less from the absence of that fine tilth so necessary for our other “root and fallow crops,” as, owing to the early season at which they are sown, a fine division of the soil can very rarely be obtained.

The proper place in the rotation for carrots is always admitted to be between two straw crops. The stubble of the preceding crop being ploughed in, assists beneficially in keeping the soil well open, and exposed to the weathering action of the winter season, while the deep tillage and general careful cultivation which the carrot crop receives, leaves the field in admirable condition for the crop that has to follow it. In this respect it is equally well suited with the turnip to act as a fallow and consuming crop to the straw or selling crop, and owing to its habit of growth in seeking its food ingredients from the lower strata of the soil, and

then abstracting from it materials of less value in a manurial or fertilizing point of view than the turnip removes (see analysis, p. 484), it draws, comparatively speaking, but little from the surface-soil, and leaves it in a better condition for the succeeding straw crop. On light, sandy soils it offers great inducements for cultivation, as on such soils its produce is generally more satisfactory than that of either turnips or mangolds, while the earlier period at which it is customary to get the seed in, reduces the pressure of labour at the usual turnip season.

No one questions the value and importance of our root crop to our present system of farming, and most of us have noticed the increasing tendency to disease and deterioration which our turnips have exhibited of late years—good and timely warning that we should not rely so entirely as we have done upon them for our necessary supplies, but should seek for another plant which should supply a deficiency, or in the event of entire failure be a substitute for them. In money matters we think it more prudent to divide our investments in different undertakings, where the success of one should balance the failure of another, than to trust all to the uncertain fortunes of a single one, however fair its prospects may be. If this is good policy in the counting-house, it surely is good policy on the farm, where the risks are greater, and the chances of success or failure less within our control. If we rely on the turnip for our root supply for winter food, and it fails us, as it has to a great extent done so often of late, from insect ravages or climatal causes, the whole of our farm arrangements are affected—our live stock must be diminished or kept on purchased food, and then our home-made manure suffers in quantity, or is produced at a higher rate of cost. But if, like prudent administrators, we invest our resources in two or more crops, differing as far as possible in their habit of growth, their food require-

ments, and susceptibility to climatal influences and insect injuries, we may calculate with far more security on the aggregate returns averaging one year with another the quantity which we may consider necessary to have for our winter supplies. As one of these auxiliary root crops, carrots are most valuable on a farm, and might in most cases occupy, very beneficially, a portion of the acreage destined for the root crop of the season. They precede in the field work both the mangold and the turnips, occupying the hand labour of the farm at a season when the demand for it is not very great; they are far less liable to insect injuries during their growth than the turnip, and are not affected by the dryness of a season, which so frequently produces mildew and stays its further growth; and when harvested and properly stored, will keep good in substance and in flavour, long after the turnips, and even the mangolds, have been all consumed. The only drawback to their cultivation is the extra labour they require in lifting, as, owing to the depth they grow in the soil, they have to be forked out separately, instead of being merely pulled up as ordinary roots. This adds somewhat to the expense of the crop, but at the same time is an excellent preparation for the succeeding straw crop, which without doubt derives great benefit from it.

In preparing the land for the carrot crop, every advantage should be taken of autumnal cultivation for the purpose of getting the field cleared of weeds, whether annual or perennial, before it is finally laid up for the winter. These points have been already alluded to, and full directions given at page 294, which we cannot do better than recommend to be followed on the present purpose. Indeed, it is even of more importance to the carrot crop than to most others, that the soil should have been well cleared of weeds, as, owing to the early period at which the young plants show themselves above the surface, and their ex-

treme delicacy of structure, it is very difficult in most seasons to get on the ground with the hoes at exactly the desirable time; and if not checked, the weeds speedily overpower them and considerably check their growth.

When the work of clearing has been satisfactorily accomplished, the proportion of farmyard manure allotted to the crop should be carted out and spread equally over the surface, and then covered in with a winter furrow as deep as the horse-power of the farm will allow. On most soils the subsoil plough can here be used to advantage, and as the carrot-break is usually only of a limited extent, it would not interfere much with the ordinary horse-labour of the season, and in the process of time a considerable portion of the farm would thus be worked, and a large additional amount of valuable soil be made available for the purposes of vegetation. In such cases the subsoil plough should follow immediately behind the ordinary plough, taking an equal depth, and thus stirring the soil well to the depth of 15 to 18 inches. By harnessing the horses of the leading plough "tandem fashion," instead of abreast, they both draw on the land instead of one traveling in the furrow, which would in this case do an injury, by treading down the soil moved by the subsoil plough. "Read's," or the "Tweeddale subsoil plough," with two good horses, will, with a depth two-thirds that of the furrow of the surface plough, follow close behind it, and get over the same amount of ground in the day. In Norfolk and Suffolk, where carrots have been longer and more largely grown as a field crop than in most other places, it is the custom to increase the depth of soil for this crop by means of stout forks, the labourers following the plough, and working on the bottom of the furrow. This operation acts upon the soil to the depth of about 15 inches, and costs, irrespective of the surface ploughing, about £2 per acre; whereas the work is as efficiently done by the use

of the subsoil plough for about 10s. to 12s. per acre. In Belgium and France, where carrots are largely cultivated, the same practice of stirring the subsoil, by forking below the plough-furrow, is always carried out previous to carrot sowing.

The manure applied should be always in a well-rotted condition, so that it may at once get mixed up with the soil, and have distributed some of its fertilizing ingredients through the mass before the seed is sown in the following spring. Indeed, it would be better for the growth of the plant if no manure at all were applied directly to it, provided the soil, by manuring for the preceding crop, were left in sufficiently high condition for supplying the requirements of a carrot crop. In this case the manurial substances would have become more intimately mixed up with the soil, and would offer less inducements for the formation of forks or lateral roots than where they were met with in the soil, collected together in the shape of solid masses of "green" or fresh dung.

The field having been duly cleaned, manured, and laid up with a high-shouldered winter furrow, needs no more attention until seed-time in the spring, which should not be left later than the end of March, as the carrot is a more hardy plant than either the turnip or the mangold, and can with safety be left longer in the soil for the purpose of increasing its produce. At this early period of the season it is rarely advisable to touch the field with the plough previous to sowing; a good turn or two with the grubber or cultivator across the line of ploughing will be sufficient to break up any part of the old furrow slice that may still hold together, and to mix up the manure in the soil, while the fine winter tilth on the surface, so necessary for a successful seed-bed, is left undisturbed. Dry weather, of course, is desirable for this operation, and as we have the choice of time during the whole month, a few days' delay

for the sake of suitable weather is always good policy. At the same time, in this, as in all other of our field operations, we should never throw away a chance, by neglecting to take advantage of even a single day of weather suitable for our work. A farmer early with his field work has always a labour balance in hand, whereas with a late or dilatory farmer it is always against him.

At the same time that arrangements are being made for getting the land in order for the reception of the seed, some little preparation of that is required before it should be placed in the soil. The seed of the carrot differs from all our other farm seeds in being covered with stout short hairs, which are attached to the outer surface or skin of the seed, and prevent it to a great extent from coming in direct contact with the substances of the soil in which it may be placed. In the course of time the hairy attachments absorb moisture, and convey it to the inner part of the seed, which then sets up the germinative process, and the growth commences; but as this necessarily depends upon the conditions under which each seed is placed in the soil, the germination is very irregular, and in some cases does not take place at all. There is also a great difficulty in separating the seeds, which being very depressed, nearly flat indeed in shape, are held together by their hairy envelopes, and thus an equal distribution in the drill is rendered well-nigh impossible.

To overcome these two obstacles, it is customary to mix the seed required, which is usually from 2 lbs. to 4 lbs. to the acre, with moistened sand, in the proportion of two bushels to each acre to be sown. This should be done with proper care, so that the quantity of seed per acre should be equally distributed through the mass, which can readily be secured by adding the sand in small quantities at first to the seed, and mixing them together intimately with the hand, taking care that no lumps of seed remain

adhering together. When the mass is thoroughly mixed up it should remain so for a week or ten days, being occasionally turned over with a shovel, and watered if necessary, to keep it in a proper condition of moisture. By this process of preparation each seed is separated from the others, and brought into contact with a moist surface, the germinative process is set up previous to its being deposited in the soil, where it continues its functions, increases its growth, and speedily shows itself above the surface.

In all our cultivated crops the quality of the seed is a matter of great importance, but in none other is attention to this point so much demanded as in the carrot crop. The same conditions are required as have already been given, page 19, and to these we must now add another—that the seed be *quite fresh—the produce of the preceding year's plants*. If due care and precaution have not been exercised in the selection, the produce is sure to be unsatisfactory, either from the plants throwing up seed stems, instead of forming roots, or from the roots formed being forked and fibrous, instead of straight and plump.

Owing to the delicate and fragile stem which the carrot possesses in its early growth, it is very difficult to distinguish the exact line of drills at the time of hoeing, which should be commenced as soon as possible, to protect the young plant from its more vigorous companions, the weeds. In order to mark this out clearly, it is recommended to add to the prepared seed, at the time of sowing, a small quantity—say a few quarts to the acre—of any tail or inferior corn in store, which by its more vigorous and erect growth, speedily indicates the line of sowing, and preserves it from any injury from the hoes. Carrots should always be sown by the drill, and as they are essentially a fallowing and cleaning crop, the distances between the rows should be such as to admit the free use of the horse-

hoe during the full period of their growth. Their habit of growth, however, does not require the amount of space recommended for the other root crops; from 15 to 18 inches would admit the horse-hoe, and at the same time give sufficient width for the plants to have full access to the air and light.

It is generally found beneficial to drill in with the seed some manurial substances, in order to afford the young plant at starting a supply of food, which it would not so readily meet with in the surface soil after its exposure to the solvent powers of the winter's rain. For such purpose Peruvian guano is the best fertilizer that can be applied; and if about double or treble the quantity of good field or coal ashes can be obtained to mix with it, the double purpose is served of diluting the concentrated manure, and of securing round the young plant a loose and permeable soil, which will induce a more vigorous growth, and aid its general powers of development. As soon as the young plants are fairly up, and the line of drilling marked out by the cereal plants, the horse-hoes may be sent in, provided the condition of the soil and the weather be suitable, and the spaces between the drills cleared of weeds. In about three weeks or a month after sowing, and the young plants have acquired a growth of about 3 inches high, they should be "bunched out" with a narrow-bladed hoe, taking a 4 to a 6 inch cut, and leaving spaces untouched about half that width all along the drills. The plants left should then be singled out by careful children, in the manner described at page 303, for turnips, care being taken to leave the healthiest and most vigorous plants, so that they may stand at about 6 to 9 inch distances in the drill.

With the exception of hoeing, which should be well followed up as long as a weed remains on the surface, the crop needs no more attention until harvest time. This

generally takes place at the end of October or the early part of the following month, when most plants have ceased to grow, and offer no inducements for being allowed to remain longer on the field. This part of our field work, however, should never be left too late for the sake of adding to the produce by the tardy growth of a few days at this season of the year. It is far better to sacrifice this doubtful gain, whatever it may be, than to lose the chance of harvesting the crop in favourable weather; for not only is it stored in better state for keeping, but the field is cleared under conditions far more favourable for the succeeding grain crop. The operation of lifting the carrots is more laborious and expensive than the other root crops. Owing to their habit of growth, they have to be forked up separately, and this absorbs labour, according to the nature of the soil and the quality of the crop. On light sandy soils of the eastern counties, of course the work is easier than on the stronger loamy soils of the midland and western districts; in all cases, however, it is important that strong tools and stout hands be employed, so that the whole of the roots be extracted from the soil, and not broken off and left behind, as is too frequently the case under careless management. As this is frequently done by piece-work, at so much per acre, it is desirable to provide proper forks for the purpose, so that no excuse may exist for not doing the work well. A fork with an ordinary handle, and with two prongs only, about 12 to 14 inches long, made of proportionate stoutness, and set at about 3 inches apart, with a "tread" or shoulder on each side sufficiently wide for the foot, has been found to do the work efficiently on even the strongest soils. From 12s. to 30s. per acre may be calculated as the expense of forking and topping alone. The cost of filling will also be determined by the quantity on the ground. The tops may be spread over the surface and picked up by sheep, who readily eat all the fresh green

portions: in such cases it is always advisable to give some dry food, such as hay, straw, or corn, at the same time in the racks or feeding troughs. In lifting the crop, a man and his wife or child work profitably together, the man using the fork to displace the root from its bed, and the wife or child aiding the operation by grasping the stem of the plant, drawing it out of the raised soil, and then topping it and throwing it into the heap arranged for carting. This divides the labour economically; the man has not to alter his erect position to pull out the root, and the root, by being pulled out vertically, has less chance of being broken than when carelessly drawn out by the side-wrench of the single workman.

As carrots stored are generally intended for late consumption, it is desirable before carting them off the field to give them a few days' exposure, if the weather be favourable, for the purpose of drying their surface, and getting rid of a small proportion of the water they contain. This is effected readily by placing them in small heaps on the ground, and covering them over with a layer of tops, so as to protect them from the dews and morning frosts so common at this period of the year. Their surface being smooth, but little soil usually is attached to them, so that no necessity exists for cleaning them previous to storing. The storing should be effected, under ordinary circumstances, in the manner already described for mangold-wurzel (page 441), which, if properly carried out, will keep the stock of carrots fresh, and in good condition for feeding, until the next crop is harvested.

As more care is required in the proper selection of seed for the carrot than for most other crops, owing to the diminishing vitality of the seed when kept longer than a year, and to its greater tendency, when not carefully grown, to produce seeding or forked plants, it is most important that in growing the seed all precautions should

be taken to insure satisfactory results. The roots should be selected at the time of "lifting," and only such as are symmetrical in shape, free from disease or injury, with a sound head, and single stem well set on with a narrow neck, should be taken. The tops should be cut off about 1 inch from the crown of the root, and they should then be removed and planted at once in the piece already prepared for them, or they may be kept in a dry place, either in sand or otherwise, properly protected, until the spring, when they may be planted at about 2 feet distances apart in the row and in the drill. The spot appointed for their reception should have been previously prepared by deep digging and the application of well-rotted manure. Under favourable circumstances the roots speedily resume their functions when placed again in the soil. A round and fistular seed-stem is speedily thrown up, carrying branching and vigorous shoots, terminating in umbels, which, as the flowers fade away and the seeds begin to ripen, contract somewhat in size (circumference), and assume a form depressed in the centre and resembling a "bird's nest." The seed is usually ready for gathering about the first or second week in August, and as it ripens very irregularly, it requires to be gathered by hand, which is usually performed by children, who cut off the ripened umbels and carry them off in small baskets with which they are provided. When the seed has grown on a large scale the stems are severed with a hook, and the whole plant left in the field in small bundles until ready to be carted home, when it is either stacked or threshed out by the flail in the usual manner. This, although more expeditious and less expensive in labour, is, after all, perhaps, the least remunerative, as the seed is very unequally matured, and requires to be gone over with the flail three or four times before it can be all separated, and when on the floor presents a far less even and marketable

sample than that harvested in the preceding manner. Those who are particular in regard to their seed, especially where grown for home sowing, always select those seeds growing on the *outer edge* of the umbels, the rest being prepared in the usual way as a market sample.

In the light-soil districts of Belgium and Holland, where carrots are cultivated to a far greater extent than with us, it is a common practice to grow them mixed with a crop of rye or of flax. In the former case the rye is sown early in the autumn, so as to root well before the winter sets in, and thus come early to harvest the following year. In the spring, the carrot seed is sown broadcast as late as the growth of the rye will admit of the harrows being used to cover in the seed. This germinates and continues its growth until the rye is ready for cutting, which usually takes place about the second or third week in June. It is then mown with a cradled scythe, care being taken not to cut it so close as to injure the top of the root of the young carrot plants, which by this time have acquired a size about the thickness of one's finger. The field is cleared as quickly as possible of the stooks, the harrows are sent over the ground to disturb the surface and to drag up the roots and stubble that are left, while the remaining weeds are carefully removed by the hand. The liquid manure cart follows with a good supply of rape cake mixed up with "purin," and in a few days the young plants, which had been mown down by the scythes of the harvest-men, begin to show themselves again, and by the end of the autumn are in a condition to yield a weighty crop of roots, which, when forked up in the usual manner, leaves the land in excellent condition, both chemically and mechanically, for the succeeding crop of corn. When sown down with flax the carrot has a better chance, the land being better prepared, in higher condition, and better attended to during the growth of this crop than with rye.

The flax is ready for pulling about the middle of June. This operation is far less injurious than that of mowing to the young carrot plants, which, as soon as the field is cleared, immediately occupy the entire surface with their own foliage, and generally prove a productive crop.

In this country carrots have been frequently grown as an intercalary crop with beans, either a row of beans and of carrots alternately all over the field, or two rows of beans and then two or more rows of carrots, as may be thought best either for the growth of the two plants or for the requirements of the farm. For this method the field is usually prepared in time for early bean sowing, either laid up in ridges or left on the flat, the two crops being sown at about the same time and in the same manner. The object, however, is not so much to favour the growth of the carrots as of the beans, which have, by the wider intervals between them, more access to light and air, both of which act so beneficially on all vegetable growth. Carrots have also been sown advantageously in alternate rows with mangold-wurzel. By this practice the more erect-growing and smaller top of the carrot leaves an increased space between the rows for the development of the wide-spreading leaves of the mangold.¹

Under favourable conditions of soil and cultivation, the carrot is generally a very productive crop. It is less liable to disease and insect injuries than most of the root crops—is sown earlier, before the pressure of labour is felt, and may be left with safety in the field until the others are safely got up and stored. The only drawback attached to their cultivation is the extra care and expense attending their removal from the soil. This, however, should

¹ In 1852 a paper was read at a meeting of the Botley Farmers' Club, "On the Cultivation of Carrots," the details of which are given in the *Agri. Gaz.* for 1852, p. 90. Details are also given in the volume for 1851, p. 218, of the culture of carrots on poor soils.

not all be charged against the carrots, as this extra labour bestowed upon them entails a benefit on the succeeding straw crop. From 20 to 30 tons to the acre may be taken as a fair return on average soils, where deep tillage and liberal manuring have preceded the crop. In the neighbourhood of large cities carrots generally are a very remunerative crop, as there is almost always a ready sale at very satisfactory prices for any portion that may not be required for home consumption. Of late years magnificent specimens have been exhibited at our winter shows at Birmingham and London. At the former place the year before last (1858), carrots were exhibited nearly 20 inches in circumference, and weighing from 12 to 13 lbs. each. They were grown on a light soil of the new red sandstone formation, but the details of the mode of cultivation¹ adopted presented no points which have not already been alluded to here. The total weight of the crop per acre was estimated at 28 tons. If, however, we could always secure the roots the above size, or even half of it, we should, according to the table given, p. 305, have a yield greatly exceeding that quantity.

The *diseases* to which the carrot is liable do not appear to have excited much attention, as, with the exception of the tendency to throw out lateral roots or forks, due to degeneracy of seed or unsuitability of soil, and a disease noticed by Dr. Russek,² of Berlin, some few years ago, we seldom hear of any injuries being sustained, save those inflicted by some of the numerous insects that infest this plant during its long career in the soil.

The *insects* infesting the carrot crops are well-nigh as numerous as those attacking the turnip, though they are free from any single one that commits such wholesale de-

¹ *Roy. Agri. Soc. Jour.*, vol. xix. p. 574.

² Monthly Report of the Berlin Academy for January, 1852. Details of the paper are given in *Agri. Gaz.*, 1853, p. 484.

vastation as the *Haltica nemorum*, or “common turnip-fly.” No sooner, however, does the young plant appear above the ground, than it is liable to be eaten off by the slugs and snails (see p. 385) so plentiful at that time of the year. As soon as the tap-root is formed, the maggots of the crane-fly (*Tipula oleracea*, see p. 386) commence their work by eating through the root just below the crown, and effectually arresting its further growth. These, in some seasons are very destructive, entire drills disappearing from their attacks. The young plants, too, suffer considerable injury from the “carrot plant-louse”—*Aphis dauci*—which, by generating in the crown of the root, effectually destroys the plant. Later in their growth, the grubs of the “carrot-fly”—

1 and 2. Larva of *Psila rosæ* (natural size and magnified). 3 and 4. Do. appearing from the galleries excavated in the carrot. 5 and 6. Form of pupæ (natural size and magnified). 7 and 8. The “carrot-fly” (natural size and magnified).

Psila rosæ—make their way to the root, which they penetrate, and then form long galleries through its tissues, by which the circulation of its juices is interfered with, the functions of the roots arrested, and a general injury done to the plant. This is soon shown by its altered appearance; and if the root is taken up, the injury sustained shows itself by the ochreous or “rusty” appearance of the part affected, from which the name of “rust” has

been commonly applied to this form of disease. If left in the ground, decomposition speedily ensues, and other insects, delighting in diseased vegetable tissues, then assist in completing its destruction. Amongst these may be named the well-known millipede, the *Polydesmus complanatus*, and a centipede, the *Scolopendra electrica*, which frequently is found with it in the soil, always ready to attack any of our root crops which have been injured, either by disease or by insect attacks.

The caterpillar of a beautiful butterfly—the *Papilio machaon*, or “swallow-tailed butterfly”—is found feeding on the leaves of the carrot and other allied species about the end of June or July, where the eggs had been deposited by the female about a month or six weeks previously. This insect, however, like many others we could name, appears to become more scarce every year, as draining and improved cultivation effects a physical change on the surface. Formerly it was abundant in districts where it now would be searched for in vain, its present range being apparently confined to the fen districts of Lincolnshire, Huntingdon, and Cambridgeshires.

When grown for seed the umbels often appear distorted, and a number of fine small vegetable galls are found attached to them, the result of the punctures of the “carrot gall-fly”—*Callimome dauci*; and as the flower-heads become more matured they are subject to the attacks of three other moths—the “common flat-body moth,” *Depressaria cicutella*, the “purple carrot-seed flat-body moth,” *D. depressella*, and the “gray carrot-blossom flat-body moth,” *D. daucella*—each of which is capable of inflicting great injury on the seed-vessels, and of thus materially affecting their yield. The flowers and capsules, and even sometimes the leaves, are eaten off by them, the head being enveloped in a silk-like web, in which they remain and change to the pupa state. Happily the cater-

pillars of these moths are themselves kept in check by two ichneumon parasites, the *Ophion vulnerator* and the *Cryptus profligator*, which destroy them in vast numbers.

These are all very fully described by Curtis,¹ who recommends the usual application of lime, soot, or salt, or all combined, as the most efficient remedy against the attacks of the slugs, &c. To all descriptions of “aphides” tobacco-water is a certain and immediate check. The millipedes and centipedes, and grubs of the “crane-fly,” are much relished by the various insectivorous birds, partridges, rooks, starlings, &c., that frequent our fields, who are always on the look-out for them; while the safest plan to arrest the progress of “rust” is to remove the infected plants directly they are noticed, or to dress the land as soon as possible with spirits of tar in small quantities, which appears to be obnoxious to the “carrot-fly.” In all cases deep ploughing and careful eradication of weeds will go far towards limiting materially the ravages of the insects named—the first by exposing those that lie in the soil to the notice of the birds feeding on them, and the last by destroying the breeding and rearing places, which *preserve* the stock during the interval, whatever it may be, until another crop of the same plant appears in the field.

The *chemistry* of the carrot has been the subject of investigation on the Continent as well as at home. The proportion of top to root is about 20 to 25 per cent—one part to four or five parts. The proportion of water in the root appears to be from 85 to 88 per cent., and in the tops from 75 to 80 per cent.; and the average percentage of ash (mineral matter) in the root was found to be .904 (six specimens examined), and in the tops 4.12 per cent.

The composition of this mineral matter was determined by Messrs. Way and Ogston to be as follows:—

¹ *Farm Insects*, p. 402.

	Roots.	Tops.
Potash,.....	32·44	7·12
Soda,	13·52	10·97
Lime,.....	8·83	32·64
Magnesia,	3·96	2·92
Peroxide of Iron,.....	1·01	2·04
Phosphoric acid,	8·55	1·67
Sulphuric acid,	6·55	6·20
Carbonic acid,	17·30	17·82
Silica,.....	1·19	4·56
Chloride of Sodium,.....	6·50	13·67
	99·94	99·97

The results show that, although the carrot will grow and be a productive crop on soils where neither mangold nor turnips could be profitably cultivated, its mineral requirements from the soil differ but little, either in ingredients or in quantity, from those required by the other crops. This power of development, which renders the carrot so valuable a crop on poor light soils, provided they be of sufficient depth, is due to the mode in which the plant sends down its tap-root into the soil, from the depths of which it abstracts its necessary supplies of food-materials, and brings them up to the surface elaborated into the form of a nutritious, fleshy root. In deep sandy loams its tap-root has been found penetrating to a depth of 10 to 12 feet; and even in the soils of the upper beds of the lower oolite it has been traced threading the brashy surface of the subjacent rock to a distance of 3 to 4 feet from the thick part of the root, the diameter of the broken end indicating that its range had been far greater than had been traced. Assuming an equal weight of produce per acre from a crop of turnips, of mangold, and of carrot—that is to say, of 20 tons of roots and 4 tons of tops from each—Messrs. Way and Ogston calculated that the amount of mineral matters abstracted from the soil would be respectively as follows:—

	Turnips.	Mangold.	Carrots.
	lbs.	lbs.	lbs.
Potash,	140	133	134
Soda,	33	70	103
Lime,	90	21	197
Magnesia,	14	22	29
Phosphoric acid,	45	21	39
Sulphuric acid,	50	22	57
Chloride of Sodium (salt), ..	57	160	85

The *organic* composition of the carrot has been investigated by Horsford and Voelcker, who have given us somewhat different results, due probably to the fact that one operated on carrots grown on the Continent, while the other experimented on the ordinary carrot of our fields. The proportions of constituents are thus given:—

	Horsford.	Voelcker.
Compounds containing nitrogen (flesh-formers),	1·48	·604
Compounds destitute of nitrogen (heat and fat producers),	11·61	10·185
Ash (mineral matters),	·81	·723
Water,	86·10	88·488
	100·00	100·00

These analyses—and we would take that by Dr. Voelcker, as giving the most correct estimate of our field carrots—show that carrots are better suited for fattening than for flesh-forming purposes. For milk-giving animals they are well adapted. They are excellent for cows, who eat them with great avidity, and with perfect freedom from any chance of giving a bad taste to their milk. They are given, too, to horses with great benefit; about 1 to 2 stones a day during the spring months always improves their condition and appearance. In London and other large cities a ready and very remunerative sale always exists for them for such purposes.

n/-

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