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BY

JOHN WRIGHTSON, M.R.A.C., F.C.S.,

PROFESSOR OF AGRICULTURE IN THE NORMAL SCHOOL OF SCIENCE AND ROYAL SCHOOL OF MINES; EXAMINER IN AGRICULTURE TO THE SCIENCE AND ART DEPARTMENT; PRESIDENT OF THE COLLEGE OF AGRICULTURE, DOWNTON, SALISBURY;

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PREFACE.

THE object of this volume is to present the subject of root and fodder crop cultivation from an agriculturist's point of view. It is meant to follow my small work entitled *Principles of Agricultural Practice*, published a year ago, taking up the subject where it was then left, in order to deal with the cropping of land. Our farm crops are, however, too numerous, and their treatment too various, to be included within the limits of one small book, and the consideration of the cereal crops has therefore been further postponed.

I have treated exclusively of crops consumed upon the farm by live stock, and in so doing it may be at once admitted that there are some aspects from which these crops might be regarded which have been but briefly noticed. Among these I would especially mention the botanical, chemical, and structural aspects. Minute differences in the various plants have not occupied me, and the individuality of the plant has to a great extent been sunk in the "crop," viewed as an aggregate of individuals, to be reckoned in tons per acre rather than as botanical specimens.

Drs. Stebler and Schrötter's standard work, lately translated into English, purports to treat of "the best fodder crops." In this book many of the plants here discussed do not find a place, although unquestionably ranking among our best fodder crops. Similarly, in the work now introduced a choice has been made, but the ground covered is not the same as that occupied by Drs. Stebler and Schrötter. Here I have purposely excluded the plants which compose the chief ingredients of permanent pastures, which in the work referred to absorb the whole attention of the authors. The *graminiœ* form a group requiring knowledge of a highly specialized character. Methods of description, and the aid of the microscope and dissecting knife, would become necessary in describing them, which are scarcely within the province of the agriculturist, but belong to the domain of the structural botanist.

The study of grass land also pertains to pastoral life rather than to arable land cultivation, while all the plants here enumerated and described are essentially cultivated as crops with the direct aid of ploughing and other tillage operations.

The present work, like that issued last spring, embodies a course of lectures delivered to science teachers at South Kensington. It is intended to assist teachers in their labours, and to indicate the bounds within which a crop may be profitably studied by agriculturists. The subject has been taken up where it was left in '87, and the actual cultivation of crops naturally follows a treatise upon soils and tillages.

The subject of agriculture is a very vast one, and many volumes would be needed to cover the field. Having placed on record, in a form available for teachers, my views upon both land and crop cultivation, so far, at least, as root and fodder crops are concerned, I am free to proceed a step further in the task of explaining my subject by taking up other topics belonging to it.

There are some who may be disappointed that the cultivation of the potato finds no place in these pages. Dr. Gilbert some time ago remarked, that although botanically the potato is not a root, yet agriculturally it is to all intents and purposes a root crop. It must, however, be remembered that the potato is grown for sale, and that it is therefore an exhausting crop to the land. Being realizable, it compares with corn crops, and its cultivation is not consistent with the winter feeding of cattle and sheep. Although in some respects a fallowing crop, inasmuch as its cultivation tends to clean land, it cannot be viewed as a renovating crop in the same sense as turnips and mangel, which are consumed upon the farm.

The subject of manuring the root crop is more fully treated of than are some other points of management. The Rothamsted papers, as is well known, deal almost exclusively, in their relations to crop cultivation, on the effects of fertilizers, and the importance of this aspect must be my excuse for having treated it at very considerable length. I have taken the opportunity of reproducing certain results obtained by me in connection with the Cirencester Chamber of Agriculture, which have never yet been published, excepting in the columns of a local newspaper. These results are in themselves worthy of record, and were to have appeared in the journal of the Royal Agricultural Society. They have, however, been laid aside until now; and although in these days the "seventies" may appear somewhat remote, the results, having been obtained with great care, are in point of fact as valuable as though they had been arrived at more recently. Trusting that the present contribution to the subject of crop cultivation will receive the same kind indulgence which has been accorded to my previous work, I leave it to the reader, in the hope that he may find it useful to him, whether as a teacher, a pupil, or a practical agriculturist.

JOHN WRIGHTSON.

College of Agriculture, Downton,
May, 1889.

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FALLOW AND FODDER CROPS.

INTRODUCTORY

ADVANTAGES OF FALLOW CROPS.

BOOK-FARMING has always been viewed with a certain amount of suspicion by practical agriculturists. The real fact is, that those best qualified to practise the arts of the cultivator are naturally averse to take up the pen; and conversely, those who are most at home in the study are often most abroad in the field. The task of writing upon purely agricultural matters is therefore not one to be undertaken lightly, if the writer values the good opinion of farmer critics, who, he may be assured, will not spare his shortcomings and misdoings. Writers on agricultural subjects too often take refuge in science and theory, and leave the actual practice of agriculture to be dealt with in the field alone. They invade the domains of the chemist, the botanist, or the veterinarian; but with agriculture herself, as she is understood by the actual cultivator of the ground, they are distant and reserved. Our object is different. We shall in the succeeding pages devote ourselves assiduously to agriculture. While to some extent touching upon the several sciences which bear upon and explain the practices of agriculturists, we shall make agriculture, or, to speak more plainly, farming, our principal study. Following the lines already laid down in a previous work, we shall treat of crops in the same manner as we have already treated of soils, and endeavour to explain the underlying principles which should guide agriculturists towards the attainment of their numerous objects.

The subject of agriculture naturally divides itself into four principal sections—the soil, the growing crop, live stock, and economics. It is the second of these sections which claims our attention now, and on a future occasion the third and fourth sections may occupy us, and if so, we shall find them increasingly interesting. As we rise from the inorganic to the vegetable world, we find the conditions to become more complicated, and the problems more diversified. The step from the vegetable to the animal kingdom introduces us to still more intricate considerations; and finally, in dealing with agricultural economics, we find ourselves surrounded with a variety of complicated questions which form an important division of political economy.

The subject of agriculture is therefore seen to be almost as extensive as that of nature herself. It is the art of regulating natural production for the well-being of man. No plant or animal that can be utilized can be regarded as beyond the province of the agriculturist, and hence he is ever on the look-out for new objects whereon he may exercise his skill.

In taking farm crops as our subject, we shall restrict ourselves to those which are grown in Great Britain. This greatly simplifies our task, for the plants upon which the English farmer depends are comparatively few in number.

Even upon the continent of Europe the number of cultivated plants greatly exceeds our own. The vine, tobacco, maize, millet, hemp, haricot-beans, sugar-beet, and other crops swell the list, and render continental agriculture more complicated than our own. Still, for our present purpose, the list of English-grown crops is abundantly long, and we shall only be able to give a passing notice to many of them.

Our farm crops may be classified as fallow crops, corn crops and grass and fodder crops, and to one or other of these three classes may any of our cultivated crops be relegated. The most widely used rotations consist in alternating these crops in the order just given. Thus, in the Norfolk rotation, we find first a fallow crop, next a corn crop, then a grass or fodder crop, and lastly another corn crop.

Fallow crops are especially adapted for renovating exhausted land. It must not, however, be imagined that these crops possess any properties which specially fit them for this purpose. The renovating effect of fallow crops is due to the mode of their cultivation, and the uses to which they are put. A corn crop may be used as a renovator, while a root crop may be converted into an exhausting crop by reversing their usual destination. If the root crop, for example, is sold off the farm, and the corn crop is fed upon the land by sheep, or soiled in yards by cattle, the root crop becomes the exhausting crop, and the corn a restorer of fertility. The beneficial effect of the root crop is thus principally due to the fact that it is consumed upon the premises. There are, however, some other reasons why root crops are capable of acting as fallowing, or renovating crops. They require the land to be thoroughly tilled, cleaned, and manured before they can be sown with any prospect of success. They are, therefore, grown upon well-prepared land. In the next place, the root crop is for the most part sown in late spring and throughout summer, thus allowing of the cleaning and cultivation (fallowing) of the land during a protracted period between harvest and the following summer. The root crops are always grown in rows or drills, placed at wide intervals apart, allowing of the use of the horse-hoe and hand-hoe during their growth. Thus interculture preserves the condition of thorough freedom from weeds, and at the same time stimulates the growth of the plants. Finally, the consumption of the roots upon the land, especially if done by sheep, restores the fertilizing elements they contain to the soil, with the exception of the comparatively small proportion retained by the animals for the increase of their live weights. When, however, as is always the case, other stock foods, such as hay, corn, and cake, are fed with the root crops, a further addition of manurial substances is made, which much more than compensates for the nitrogenous and mineral matters extracted from their food by growing and fattening animals. The root crops, therefore, secure at once a high state of fertility and cleanliness in land; and as these are the two main objects of "fallowing," they are completely attained by their cultivation.

Not only are root crops well fitted to take the place of the bare fallow, but the following consideration will show that they are superior as a means of fallowing than the older fashioned bare-fallow.

On all light soils the treading of sheep is beneficial, in producing the firm and tenacious condition suitable for growing corn. In Norfolk, for example, corn could not be successfully cultivated on much of the sandy soils there prevalent but for the preliminary folding of sheep.

During recent years, Sir John Lawes and Dr. Gilbert have investigated the important subject of the waste of nitrogen in soils, owing to the dissolving action of the rain-fall upon nitrates, and their washing through into the deeper and inaccessible sections of the soil. They have shown that this waste is greater upon land which does not carry a crop, and that it is entirely arrested when the upper surface of the soil is permeated by a mat of root fibres. These seize upon, and hold nitrates, and fix them in the body of the growing plants, thus preserving them as food for animals, and finally retain them for further use in the form of fertilizing matters for the succeeding crop. Not only do the roots of growing crops absorb nitrates, but mineral matters; and by their penetrative powers they ransack the subsoil, and bring matter to the surface which was not previously available. Lastly, the mass of carbon and nitrogen they receive from the air by their leaves, and through rain, dew, and snow, must not be forgotten in estimating the superiority of cropped over naked fallows. The case in favour of the root crops is therefore a very strong one, and when all its aspects are considered, they fully account for the general adoption of their cultivation among farmers.

The great diversity of plants which may be employed for the attainment of the objects just mentioned has done much to banish the system of bare-fallowing. Crops may be selected suitable for an extensive range of soils, as will presently be shown, so that bare-fallowing need only be practised upon the most retentive soils, unless in conditions of soil and climate which must be viewed as exceptional.

Besides root crops, by which term are generally understood, the turnip, swede, and mangel, there are crops which allow of similar treatment, and whose cultivation is followed by precisely similar results. Among them may be mentioned rape, cabbage, kale, and kohl-rabi, which, although cultivated for their leaves, may conveniently be classed with the root crops. A third class of fallowing crops are known as forage crops, and includes vetches, clover, sainfoin, lucerne, &c. These crops, when consumed on the land, exercise similar functions as regards the future fertility of the land as the root crops. They are, however, not well adapted for cleaning purposes, and in this respect are inferior as fallowing crops, and are consequently often taken at a different period of the rotation, or are employed as "catch" crops, in which case they hold a subsidiary position, and only occupy the ground for a short time.

CHAPTER I.

BARE FALLOWS.

Origin of Bare Fallowing—The old Three-field Course—Lengthening Interval between Fallowings—Why Fallowing is Necessary—True Meaning of Soil-Exhaustion—Comparative Exhaustion—Bare Fallows on Clay Land—Expense an Objection—Process of Bare Fallowing—Data for Estimating Cost of Horse Labour—Cost of Food for Farm Horses—Cost of Litter and Accommodation—Other Expenses of Horse Keep—Summary of Expenses upon Farm Horses—Cost per Day of Horse Labour on Farms—Cost of Tillage Operations—Calculating the Cost of Tillages—Cost of Bare Fallowing.

THE "fallow," whether cropped or uncropped, occupies the first place in a rotation of crops. It is the foundation of successful farming, and consequently deserves our foremost consideration. I shall therefore proceed at once to the consideration of fallows and fallow crops, devoting a few pages to the time-honoured practice of bare-fallowing—a system which even in these days has many admirers and advocates. The term fallow is derived from the Anglo-Saxon *fealewe*, and seems to indicate the colour of the bare or unploughed land, and is apparently the same word as is applied to fallow-deer, in accordance with their earth-like colour. The practice of fallowing land is very ancient, and no doubt originated in necessity. After land has been cropped for a series of years it becomes foul with weeds, and exhausted of its available plant food, and a period of "rest" becomes necessary. Originally the time of rest or inactivity consisted in abandoning the ground for a period probably extending over many years, after which it was found to have recovered its powers of production. The art of systematic fallowing was understood by the Romans, and was introduced into this country during their occupation. It does not appear to have been practised in Scotland until the earlier part of the eighteenth century, when it is stated to have been first attempted by John Walker, tenant of Branston, East Lothian. The late Mr. J. C. Morton states that, "like all innovators and improvers, Walker had to endure for a time the contempt and ridicule of his neighbours;" but that "twenty years after its introduction the practice had become nearly general throughout East Lothian." According to the same respected authority, who, as a Scotchman by birth, and a nephew of the well-known scholar and divine, Dr. Chalmers, was likely to have special knowledge of this subject, we learn that "many are (1850) old enough to remember the wonderful improvement effected in Scotland through the introduction of the bare fallow system." Previously to the introduction of the bare fallow, the ordinary practice was to crop land repeatedly with grain, "until it ceased to produce enough to pay for seed, labour, and rent. It was then allowed to remain in grass until the operation of natural causes had in some degree repaired the former damage it had sustained, when it was again broken up, and the same scourging process resumed."

The earliest allusions to fallowing are found in Leviticus, when the Israelites were ordered to give the land complete rest every seventh year.

There is reason to suppose that fallowing was understood by the Teutonic races before they received the impress of Roman civilization. This is inferred from the original divisions of the common arable field of the Teutonic *gemeinde*, or Village Community, which were probably derived from the still more ancient institutions of India. A three-field system of cropping appears to have been practised even in the first century, "each field lying fallow once in three years, the community having rights of pasturage on the fallow, as well as on the stubbles of the land under the plough" (Morier, *Systems of Land Tenure*, Cobden Club, 1870). The same system was practised by the Anglo-Saxons in the management of their *Folcland*. How far we may assume that the triennial division of the Teutonic arable mark involved actual cultivation of fallows is doubtful; but it is scarcely likely that one year's rest, without cleaning or cultivation, would have sufficed to restore fertility.

After the accession of the Normans the cultivation of the land was chiefly left to the subjugated Saxons, who carried on their methods according to traditional usage. In the thirteenth century, according to Professor Rogers, "half the arable estate as a rule lay in fallow, called *warectatio* in the language of the time."

The length of time allowed to elapse between the fallowings varies with the quality of the land. In the thirteenth century a system of fallowing every alternate year was practised in some cases, but the far more general method was that of the old three-field course, still followed in some parts of this country. By this system one-third part of the arable land was under fallow, one-third part in wheat, and one-third part in spring corn—oats, barley, or beans.

This system of cropping is well adapted for poor stiff land, and poor cultivators, as the amount of capital required is small, and the return in the form of corn is large. In the county of Durham, where it is still practised, it was not long ago commonly considered that *three rents* was a sufficient amount of capital for a farmer to possess, or from £3 to £5 per acre.

On land of better quality an extra crop may be taken, as when a bare fallow is successively followed by wheat, beans, and oats. On land of still higher quality five years may elapse between fallowings, as, for example, the land is fallowed and then cropped with wheat, beans, wheat, and oats. On rich clay lands a fallow may be followed with five crops, and the interval between the fallowings extended to six years, as when fallow is followed with wheat, beans, wheat, clover, and wheat. The interval has sometimes been even still further increased, and in many cases an alternation of wheat, beans, wheat, beans, has been kept up for a long series of years without a fallow.

WHY FALLOWING IS NECESSARY.

A period of rest is not indispensable for lands. The Sabbath prescribed in the Levitical law had, we may be sure, an allegorical and mystical meaning, but it is a mistake to think that land requires periods of inaction in order to recruit its waning powers. The continuous and luxuriant growth of forests is an instance of the power of soils to maintain vegetation uninterruptedly. The increasing richness and productiveness of permanent pastures and of water meadows supply instances of the inexhaustible powers of the soil. Even the poorest soils will continue to grow grass, although side by side with such pastures the arable land may require to be bare fallowed very frequently. The continuous growth of wheat may be pursued year after year apparently in endless succession, provided that the fertility of the land is kept up by suitable fertilizers. The exhaustion of land is merely the exhaustion of plant food, and if this is prevented by applications of manure, growth may be continuous for any number of years.

The exhaustion of land is brought about by the constant removal of crops without adding a due equivalent in the form of manure, and is due to the removal of what is known as the available plant food. This available food occurs in very small quantities not easy to state in percentage. The practice of analysts is to pass all soils through a fine wire sieve, and to extract all mineral fragments which cannot pass through the mesh. This process leaves only the finest portions of the soil for examination, and of this a large proportion consists of alumina and oxide of iron, sand, and carbonate of lime. The total amount of potash after this treatment is usually from ·1 to ·5 per cent., although in some clay soils it rises higher. Phosphoric acid occurs often as a mere trace, or in many cases from ·10 to ·20 per cent. Nitrogen occurs in the proportion of ·10 to ·15, or in rich pastures of ·45 per cent. It must be borne in mind that a large proportion of these small percentages is unavailable for immediate use, and needs to be slowly liberated by the natural forces, aided by tillage operations. Besides these are the mineral fragments, which, by a slow process of degradation, are reduced gradually in the process of centuries, and no doubt in this way constitute a magazine of plant food which relieves us of any anxiety we might feel as to the ultimate exhaustion of a soil.

The term "exhaustion," as used by farmers, is relative rather than positive. A soil may be exhausted for wheat growing when it can still support barley, and land may be able to grow white turnips when it could not grow mangel-wurzel. Exhaustion does not infer the complete removal of available plant food, but only such a withdrawal of it as prevents remunerative returns being obtained. It is a condition of soil which relates only to the immediately available plant food, and consists in lowering the amount down to an unremunerative level. It will now be seen that two means are open to farmers for restoring the lost balance between the wants of a good crop, and the capabilities of a soil for supplying them—manuring and tillage. Manuring is a direct addition of extraneous fertilizing matter. Tillage operates by mechanically reducing the soil to a fine condition, and exposing new surfaces to the natural forces; this, acting upon the unavailable plant food, liberates it, renders it soluble, and accumulates it in the soil. It acts not only upon the mineral matter, but upon the organic matter, causing the formation of nitrates. This, then, is the secret of fallowing. Partly by the introduction of fertilizing matter, and partly out of the resources of the soil itself, the field becomes once more stocked with available plant food, and the land again becomes fertile. A virgin soil is simply a soil in which fertility has accumulated for ages, owing to the operation of natural forces upon its mineral parts, and the storing up of organic matter and organic nitrogen by the decay of successive generations of plants.

Most cultivated soils are, so to speak, on the margin of exhaustion. A single corn crop is sufficient in most cases to lower the amount of available plant food to such a degree as to need artificial help. In other cases, two corn crops taken in succession would serve to render further exhaustive cropping unremunerative, while in some few instances land will stand a more scourging succession of crops. It is this condition of approximate exhaustion which renders fallowing so effective in keeping up the standard of fertility. The margin of fertility is raised above what is needed for remunerative cultivation, and then, by the removal of crops, it is lowered so as to need further assistance. This standard of fertility varies with the crops grown. Thus around Biggleswade, where the soil is unusually rich, and is kept in high condition by heavy dressings of London manure and soot, corn crops are only taken when the ground is considered to be in an impoverished condition for the growth of potatoes, turnip seed, and vegetables removed for the London market. On ordinary farms corn growing can only be practised when the ground is at its best, after the consumption upon it of root and fodder crops. Thus exhaustion is a relative term, and the necessary amount of available plant food varies with circumstances.

ARE BARE FALLOWS NECESSARY?

Even at the present day there are advocates of the system of bare fallowing. Many writers have condemned it as unnecessary and expensive, and as a general practice we should certainly agree with them. On all lighter descriptions of soils bare fallows have long been banished in favour of cropped fallows. But in the case of very heavy clay soils, especially suited for wheat cultivation, there is much to be said in favour of the bare fallow. The cultivation is thorough, and the land is available for wheat-sowing at the season when the seed is best committed to the ground. A heavier crop of wheat is obtained after summer fallowing such land than after roots fed on—a system for which it is not suited. The stiffer the land the better is it adapted for summer fallowing; and if we take the case of a stiff clay out of condition by previous cropping, no better plan could be devised for bringing it into good order. The introduction of fodder crops for consumption in summer, such as cabbage, kale, and rape, have done much to diminish the area devoted to bare fallowing; but the critical nature of clay soils, and the difficulty of obtaining a tilth in the spring, will always cause a certain area of them to be treated according to this method.

THE PROCESS OF BARE FALLOWING.

The objects of bare fallowing are the thorough cleaning and conditioning of the land. The process begins with the treatment of a corn stubble in the autumn, and extends to the following August or September. During a whole agricultural year the land yields nothing, while at the same time labour is freely expended. The wheat crop which universally follows cannot be grown, and certainly will not be realized under an additional year, so that two years must elapse before the farmer is reimbursed for his trouble and expenditure.

When wheat was selling at 56*s.* a quarter the case was absolutely simple. Even a moderate yield of 36 bushels per acre meant a return in marketable grain of at least £11 per acre, while in favourable circumstances and under skilful management £14 per acre might be looked for. With wheat at 32*s.* the case is very different, as the money value of similar crops to what have been assumed above would only bring in from £6 to £8 per acre, amounts which leave a small, or possibly no, margin of profit after two years' toil. It might, in fact, be easily shown, that at present prices 50 bushels per acre of marketable wheat would be needed to clear expenses, a quantity which is too high to be relied upon by practical men. The inducements for continuing to bare-fallow certain soils appear to be, first, the difficulty of finding a better system, and secondly, the fact that the cost of bare fallowing ought not to be exclusively charged to the wheat crop, but divided between it and the succeeding crops which derive benefit from the process.

In the county of Durham, where bare fallowing is extensively practised, the work is begun in the winter and finished in August. The process consists in five ploughings, given at intervals of from one to two months. The land is also well dragged and harrowed between the third and fourth ploughings, and brought into a clean and well-tilled state for the reception of the seed. The "roasting" effect of the sun upon the clods in July is relied upon for cleaning, rather than weeding.

Many persons advocate autumnal cultivation for summer fallows, and continue the cultivation the succeeding spring and summer. There is much to be said in favour of such a system, but the objection is the press of work at that particular period of the year. Winter wheat and bean sowing, the sowing of fodder crops, and the preparation of such portions of a clay farm as are intended for potatoes, mangel, or root crops in the spring will claim first attention, and the bare fallows will probably be put off until these more necessary operations have been performed.

It is also clear that a rough condition of soil, such as is obtained by winter ploughing and spring cross-cutting, will be more likely to produce that complete dessication of the ground which is relied upon for clearing the soil of weeds. Good as the principle of autumn cultivation of fallows is, it is no doubt more fitted for root, or cropped, than for naked fallows.

The number of ploughings and other cultivations varies according to custom. Mr. Hannam in *Morton's Cyclopædia* recommends six ploughings. In parts of Kent one ploughing followed by cultivations is thought necessary.

Mr. Frank Solomon, Dartford, Kent, in a letter dated September '88, says—"Bare fallowing, I may safely say, is not carried on extensively in this county—only on the stiffer descriptions of soil; where the soil is lighter the fallows are always cropped with roots, rape, &c. A bare fallow is often taken after oats, or may be after 'seeds.' They plough even before Michaelmas if possible, then leave the ground till early in the new year, and then plough again (it may be across or by turning back the furrow). The ground receives about four more ploughings, and about a dozen or so harrowings and draggings, exposing couch and other weeds to the hot suns of July and August. The cost of such operations will be heavy, as each ploughing will cost from 16*s.* to 20*s.*" Again, "when we had some of our marshes here under plough the following was the rotation—

Fallow
Wheat
Beans
Wheat
Clover

but this fallow was only a 'bastard fallow,' because they took one cut of clover and then ploughed up in June or beginning of July. The land was immediately cross-ploughed so as to lay it up roughly, and it was left till September when it was ploughed again for wheat, which was sown early in October."

In Essex in more prosperous times nine ploughings have been not unfrequently given during bare fallowing.

Bare fallows are always dunged, and are limed at intervals of about twelve years. Chalk is sometimes used instead of burnt lime. The dung is applied before the final ploughing or seed furrow.

The land is best raised into rounded ridges, and this is done by twice "gathering," or ploughing around a set furrow instead of "splitting," or ploughing out between two set furrows. All efforts to lay stiff lands quite flat have failed, owing to the liability of the seed and young wheat to perish from water.

When the work is completed the ground should consist of a sufficient amount of firm soil to bury the seed, but there should also be a decided clod upon the surface which will crumble down upon the young wheat and prevent it from being "thrown out" by frost. Too fine or smooth a condition of soil should be avoided, and on no account ought the surface to be rolled in the autumn.

Another essential to success is, that all bare fallowing operations should be completed so as to allow of early seeding. Fallow wheat ought if possible to be sown in August, so that the young wheat may be peeping through the ground while harvest operations are still in progress. In the pleasant phraseology of the farmer, the young wheat should see the old wheat riding by on its way to the stack-yard. After sowing and harrowing in the seed, the plough should open up the furrows between the ridges, called water-furrowing, and grips should be dug by the spade in the lines of greatest depression, and the water-furrows connected neatly with such grips so as to form a system of surface drains. The previous underdrainage of lands suitable for summer fallowing is assumed in all cases, as the good and thorough cultivation of these soils cannot be carried out without this initial improvement.

COST OF BARE FALLOWING.

The costly nature of bare fallowing has already been alluded to. It appears necessary in this connection to enter upon the subject at some length, because the whole question as to the cost of tillages is involved in that of the cost of making a bare fallow. It will be necessary, in considering the cultivation of various crops, to speak of cost and returns; and it is impossible to do this if we do not clear up certain considerations of a fundamental character which control the question of cost. We are, I know, approaching a subject upon which a good deal of difference of opinion exists, and the conclusion arrived at may be adversely criticized. In the first place, it is evident that certain factors of the cost of crop cultivation, or of bare fallowing, are tolerably certain. Rent, rates, and tithe, although varying in each case, yet may be assumed without much difficulty. The cost of seed, of various manual operations, and even of incidental expenses, may be estimated with fairness, if not with accuracy. There is, however, a class of expenses upon which a considerable amount of doubt exists, namely, those connected with horse labour. Now if horses received wages, and found their own living, the case would be easy enough. If they could be regarded as hired, or, in other words, if they could be simply charged as if hired from a haulier or horsekeeper, we could readily estimate the cost of horse tillage. The case is, however, less simple. The farmer owns and maintains a number of horses, and the question before us is, in the first instance that of the actual cost of a horse to the farmer per working day or per year. This question has often been answered, but there is no doubt that the tendency of most estimates is towards exaggeration of the actual cost.

In laying before my readers an estimate of the cost of keeping an agricultural horse for one year, and the cost of a horse per working day to the farmer, I will assume the following data as reasonable.

First, that such an estimate is best made without complicating it with questions as to the manual labour associated with horse labour. The labour bill is one thing, and the cost of maintaining horses is another. Every farmer knows what he pays in labour, and this sum is readily converted into a per acre charge. To this it is required to add an estimate of the cost per acre of horse labour, and it will be best to keep the two accounts separate.

The items which together give us the cost of maintaining a horse are as follows—

(1) Food.
(2) Litter.
(3) Accommodation.
(4) Shoeing, and blacksmith.
(5) Harnessing.
(6) Depreciation and risk.
(7) Interest upon capital invested.
(8) Attendance.

Food.—That indefatigable collector and collator of agricultural facts, the late John Chalmers Morton, threshed out the question of cost of horse labour thirty years ago, in such a manner as leaves little to be desired. He tabulated no fewer than 115 methods of feeding adopted by standard authorities on farming matters, and found that, at prices then current, the average cost of feeding amounted to 8*s.* per week. Commenting upon the differences in the cost to individual farmers, Mr. Morton found them to be very considerable. "More than 100 per cent. in the cost of summer feeding, which averages 8*s.* per week, and varies from 5*s.* to 11*s.*; 70 or 80 per cent. in the cases given of autumn feeding, which costs on an average about 9*s.* 6*d.*, and varies from 7*s.* 6*d.* to 12*s.*; more than 100 per cent. in the case of winter feeding, which averages 6*s.* 4*d.*, varying from 4*s.* 9*d.* to 12*s.*; and 50 per cent. in the cost of spring feeding, which averages nearly 10*s.* per week, varying from 7*s.* 6*d.* to 12*s.*"

Taking a liberal system of feeding as our type, we should consider that the allowances of corn, hay, and green food would vary in different seasons, according to the following scale—

From June 1st to September 30th—

1 bushel of oats per week.
Cut green food, and grazing.

From Oct. 1st to May 31st—

2 bushels of oats per week.
1 peck of beans „ „
¾ cwt. of hay „ „
1 cwt. of mangel or swedes.

The above may be regarded as outside estimates as to quantity of food required, and it is upon these quantities that we shall calculate the cost of food. In Scotland, it is true, larger quantities are given, as, for example, when, as we read, "½ bushel of oats, and as much hay as he can eat" is the daily ration recommended. It must, however, be remembered that the half bushel of oats consists of undressed tartarian oats, probably not weighing over 36 lbs. per bushel. The Clydesdale horse needs liberal feeding, and the Scotch farmer calls upon his horses not only for a greater number of hours of labour, but also requires deeper ploughing than is looked for in most parts of England.

In reducing the above quantities of food to terms of money value, we are placed at an economical advantage, compared with Mr. Morton when he wrote 30 years ago. At that time he valued hay at 3*s.* a cwt., which may still be considered as reasonable. Oats were valued at 3*s.* per bushel, a price which cannot now be maintained as fair, when oats can be freely bought at 2*s.* Beans were taken at 5*s.* per bushel, but are now quoted at 4*s.* 6*d.* and less. Green food and roots are taken at 4*d.* per cwt. or 6*s.* 8*d.* per ton, a figure which may still be accepted as approximately correct. The grazing during the summer months may be taken at 2*s.* per week, if in addition to this charge we allow 3*s.* for the cut clover, vetches, or grass given during the week.

Our account for food will then stand as follows—

June 1 to September 30.

	Per week.		Per total period.		
	s.	*d.*	£	*s.*	*d.*
13 bushels of oats at 2*s.* ...	2	0	1	6	0
13 weeks' grazing at 2*s.* ...	2	0	1	6	0
13 weeks' cut fodder at 3*s.* ...	3	0	1	19	0
	7	0	4	11	0

October 1 to May 31.

	s.	*d.*	£	*s.*	*d.*
78 bushels of oats at 2*s.* ..	4	0	7	16	0
9¾ bushels of beans at 4*s.* ...	1	0	1	19	0
29¼ cwt. of hay at 3*s.* ...	2	3	4	7	8
39 cwt. of roots at 4*d.* ...	0	4	0	13	0
	7	7	14	15	8

The total cost for food is therefore £19 6*s.* 8*d.* per annum, and the average cost per week is seen to be 7*s.* 5¼*d.* We think that a close inspection of the above quantities and prices will satisfy any practical man that the allowances are liberal, and exceed what is usually given.

Litter.—I propose to sink this item entirely. We have charged market price for the corn, which amounts to more than half of the total cost of food, and yet the manurial residue remains on the farm. This residue is probably worth half of the cost of the beans, and one quarter the cost of the oats, or £3 5*s.* 0*d.*, a sum which would more than cover the consuming value of the straw used as litter. We are therefore justified in omitting straw used for this purpose out of our calculation.

Accommodation.—Under this head would be included rent of stables, and the expenses incidental to lodging a number of horses, such as a supply of combs, brushes, lanthorns, candles, buckets, forks, &c. Farmers are not, as a rule, accustomed to apportion rent to their buildings, or to charge their live stock with such an item. Rent is, in fact, almost always viewed as a *per acre* charge, and this being the case, it may be presumed to have already been discounted in the expenses incidental to the cultivation of the various crops consumed by the horses in their maintenance. Rent has been paid for the ground upon which the oats, beans, hay, clover, and roots were grown, and has gone into the costs of cultivation. I do not therefore see the necessity of charging rent a second time for stables. The unavoidable incidental expenses and repairs to buildings, and for the items already mentioned, must however be reckoned, and these we propose to include under a covering charge of £1 per head. This charge would cover such accidents as the pulling down of a rack, injury to a travis by kicking, &c.

Shoeing and blacksmith.—Shoeing may be contracted for at 13*s.* per horse; but in some cases, where land is sharp and horses are much upon the roads, it may rise as high as 20*s.* The whole blacksmith's work connected with the horses, including shoeing, repairing chains, keeping up ploughs, harrows, cultivators, &c., may be let at £2 per horse. This exceeds Bayldon's estimate by 10*s.*, but is below Morton's estimate, which places the total smith's expenses at £3 7*s.* 6*d.* per horse, including all smith's work on the implements. Confining ourselves strictly to what belongs to the horses, I think £2 per horse is fair.

Harness and saddler.—This Bayldon estimates at 10*s.* per horse, and Morton as high as 13*s.* 3*d.* As it is our object to disarm criticism, and produce an outside rather than a low estimate, we shall accept the higher figure.

Depreciation and risk.—Depreciation is unavoidable, even where the farmer adopts the system of selling his horses as they reach their maximum value. In such cases, it is true, the loss is shifted, but it is still to be incurred. The farmer who works out his horses suffers the full effect of depreciation; but the farmer who purchases young horses must work them lightly, and runs considerably more risk of permanently injuring or blemishing them. Looked at as a matter of cost, the two systems may be regarded as equal. The amount of depreciation depends upon the original value, which we will take at £40. If a horse is worth £40 at six years old, he will, if all goes well, be worth £25 at twelve, or have suffered an annual natural depreciation of £2 10*s.*; to this must be added a covering charge for risk of accident or death, which we should not put at less than £1, making a total charge under this section of £3 10*s.* per annum, to include farrier.

Interest.—Besides the above there is the constant charge of interest at 5 per cent. per annum upon a capital of £40 originally expended, or of £2 per annum.

Attendance.—As already mentioned, we prefer to consider the ploughman's wages as included in the pay-sheet on the manual labour account, which will be found to amount to 25*s.*, 30*s.*, or 40*s.* per acre, according to the locality, and the system of farming pursued. We shall by so doing be able to charge our crops or our tillage operations with a certain amount for horse labour, and a separate amount for manual labour.

Having now passed in review the various items which, taken together, make up the total cost of maintaining a farm horse, we summarize the same as follows—

	£	*s.*	*d.*
Food	19	6	8
Litter	...	...	...
Accommodation	1	0	0
Shoeing and blacksmith	2	0	0
Harness and saddler	0	13	3
Depreciation and risk, including farrier	3	10	0
Interest at 5 per cent. on £40	2	0	0
Attendance	...	...	...
	28	9	11

By stretching our figures a little we could have brought our total up to £30, but it would not be easy to make an estimate reasonably consistent with times prices, in which the cost of maintaining a farm horse could be placed at more than this sum. It is convenient to take £30 as a fair estimate, because by so doing we conclude that it takes about as much to maintain a farm horse as to purchase one of average quality. Also it is clear, that if two horses can till sixty acres of arable land of average tenacity, which is quite correct, then horse labour, as distinct from manual labour, will cost just £1 per acre.

It is also interesting to note, that according to this view the keep of a horse and the wages of a labourer bear a simple relation to each other. "It has long been the practice with farmers to value horse labour at the same rate as manual, the keep of a horse per week being about equal to the payment of a labourer" (Bayldon, *Rents and Tillages*, Morton's edition).

This estimate will be seen to be correct where the ordinary wages of a labourer are 11*s.* 6*d.* per week. Although in some districts higher wages are given, yet in a large number of the counties 11*s.* and 12*s.* represent not the earnings, but the standard wages of ordinary agricultural labourers.

We are now in a position to answer another question of importance with regard to tillages—the cost per day of a working horse to the farmer? The number of working days in a year varies according to the character of the soil. On stiff soils they are fewer in number than on light soils. Idle days and partially idle days, other than Sundays and holidays, are not very numerous, and are to some extent compensated for by the long hours of work during hay time and harvest. For practical purposes it has often been thought sufficient to deduct 65 days from the total of the days in the year, leaving 300 working days. This is probably more convenient than exact.

On light lands, where ploughing may always be done even after the heaviest downfalls of rain, 300 days may be taken as approximately correct.

In the case of stiff soils, which cannot be touched with horses for several days after continued rain, the case is very different. On such soils there are sometimes periods of several weeks in extent during which the horses are compulsorily idle, or are engaged in work of a make-shift character. On such soils it may be assumed that for at least three months in the year, say January, February, and part of March, the horses are better off the land. We may at least assume that one quarter of the year is unavailable for tillage operations. We shall in the case of clay lands therefore deduct

78 working days as unfit for tillage,
52 Sundays,
3 holidays,

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leaving 235 days, or, considering that some sort of work is contrived for the horses even in unseasonable weather, we shall take the number of working days at 250.

Here then we have two divisors—300 suitable for light soils, and 250 to be used in the case of heavy clay soils. It may be urged with some reason, that during periods of enforced idleness the rations of the work horses are revised and lowered, and this is quite true. During prolonged frosts, snow, or continuous rain, the corn may be discontinued, thus reducing the cost of maintenance very materially. Calculations of the kind before us are falsified by various circumstances, and we can well imagine a farmer questioning the conclusion that horse labour per horse per day is more expensive on clay soils than on light soils.

We may, however, fairly conclude that if 300 working days are made by a horse, the cost is clearly 2*s.* per day per horse, whereas if 250 working days are only available, then the cost per day is 2*s.* 4½*d.* The actual cost probably lies between these figures, and I should therefore feel disposed to use 2*s.* per day as a fair figure for estimating horse labour throughout the year in the case of light soils, and 2*s.* 6*d.* for the same purpose on heavy soils.

ACTUAL COST OF TILLAGE OPERATIONS.

As our wish is to find the cost of bare-fallowing, we shall at present assume the cost of horse labour per day upon the higher estimate of 2*s.* 6*d.* per day, as estimated for clay land. In Scotland and the Northern counties, where, it must be allowed, the greatest economy prevails in labour arrangements, one man is allotted to each team of two horses, and the wages of such a man may be taken at 15*s.* per week, or 2*s.* 6*d.* per day—the same, in fact, as the cost of one horse. We may further assume that when a field is ploughed several times during the fallowing process, one man and two horses will in many districts plough one acre in one day of eight hours. The cost of ploughing will then be represented by the wages of one man and the cost of two horses, the repairs to the plough being already included in the blacksmith's bill. The cost may be thus stated—

		s.	*d.*	
1 man	... ...	2	6	
2 horses	... ...	5	0	
	Total	7	6	per acre and per day.

When, as in Kent, Worcestershire, and other very stiff land districts, custom prescribes four horses and a driver, and the amount of work done equals only three-quarters of an acre a day, the cost will be

		s.	*d.*	
1 man	... ...	2	6	
1 boy	... ...	1	0	
4 horses	... ...	10	0	
	Total	13	6	per $\frac{3}{4}$ acre and per day,

or 18*s.* per acre.

A convenient rule for estimating the cost of tillage operations is based on the observation that 9 inches is the usual width of a plough furrow. If with a 9 inch furrow one acre can be ploughed in a day, then with a width of 18 inches double the amount can be accomplished at plough pace.* For every 9 inches in width of any cultivating implement drawn at plough pace one acre will be done. Thus in harrowing

* One acre 9 inches or a quarter of a yard wide = a total length of $4840 \times 4 = 19{,}360$ yards = 11 miles, the distance a horse walks in order to plough one acre.

with an implement 12 feet in width the amount done at plough pace would be—

$$\frac{(12 \times 12)}{9} \text{ in.} = 16 \text{ acres per day.}$$

The cost would be $\frac{1}{16}$ that of ploughing, or

$$\frac{7s.\ 6d.}{16} = \frac{90d.}{16} = 5\frac{10}{16}d. \text{ often taken at } 6d.$$

Where four horses and a driver are employed, the cost would approximate to 1*s.* per acre.

Rolling with a 7 foot roller drawn by two horses, would be done at the rate of,

$$\frac{7 \times 12}{9} = 9\tfrac{1}{3} \text{ acres per day.}$$

and the cost would be $\frac{7s.\ 6d.}{9\frac{1}{3}} = \frac{90}{9\frac{1}{3}} = 9\frac{9}{14}d.$ per acre.

Cultivating with a 4 foot cultivator drawn by four horses would be done at the rate of $\frac{4 \times 12}{9} = \frac{48}{9} = 5\frac{1}{3}$ acres per day, and would cost $\frac{15s.}{5\frac{1}{3}}$ = nearly 3*s.* per acre.

Thus the actual cost of tillages to the farmer may be arrived at with tolerable accuracy, and in using the data given due allowance must be made for differences in speed of travelling.

Drilling and rolling, for example, are more quickly performed than ploughing, not only on account of the greater width of the instruments used, but also the quicker pace at which the horses walk, sometimes one half quicker. Thus, in favourable conditions, a pair of horses may roll 12 or 13 acres a day, and four horses may drill 13 acres a day.

It has been observed, that in valuing tillages between incoming and out-going tenants, a somewhat different scale of remuneration must be adopted than has been above indicated, (1) because valuers are bound to take into consideration what is actually done in ordinary, and not very perfect practice, rather than what is done on the best possibly managed farms; (2) that some profit must be allowed to an out-going tenant on work done for his successor, who is somewhat in the position of a hirer of the horses and men of his predecessor. Valuing tillages is also controlled by custom, which sometimes places the value of the operations considerably higher than their actual cost. The valuer would put an extra shilling on ploughing done with the addition of the skim coulter; and he would also take into consideration the quality of the ground, and the depth or comparative efficiency of the work done.

The cost of making a bare fallow may thus be computed, on the assumption that two horse teams are employed—

	£	s.	d.
5 ploughings at 7*s.* 6*d.* each	1	17	6
5 draggings at 1*s.*		5	0
5 harrowings at 6*d.*		2	6
2 rollings at 1*s.*		2	0
Couching		5	0
Filling, carting, and spreading dung		7	6
Water furrowing		1	6
Rent, rates, taxes, and incidental expenses ...	1	15	0
	4	16	0

In Bayldon (Morton's edition, 1864) the cost of bare fallowing is given as follows, three horses being employed to break the stubble—

	s.	d.
First ploughing, Nov.	10	0
Second ploughing, March	9	0
Third ploughing, April...	9	0
Harrowings, May	3	0
Rolling	1	0
Fourth ploughing	9	0
Drawing on stetch (water furrowing)	1	6
Fifth ploughing	9	0
Sixth ploughing, August	9	0
	£3 0	6

Rent, &c. at per acre.

In the last estimate the values of the tillages rather than their prime cost is evidently given, and rent is not included. Five pounds per acre, including rent, is a general estimate as to the cost of making a fallow in the north of England, and in many cases is no doubt incurred.

In order to appreciate the cost of producing a crop after bare fallowing, an additional rent besides the cost of seed, sowing, harvesting, threshing, marketing, and interest and risk must be added, and these will bring the total amount expended before the wheat crop is realized up to at least £8 per acre. In order to throw the balance of this two years' cultivation on the right side, at the present low price of wheat, 40 bushels of marketable corn at 4*s.* 6*d.* per bushel, or a value of £9, would be necessary—a result which must appear to be above what is likely to be realized.

On the other hand, it must be remembered that a thorough cleaning and cultivation such as is involved in bare fallowing is beneficial to several succeeding crops, and that only a portion of the expenses should be charged to the wheat crop immediately following. It is very difficult to say how much of the cost should be apportioned to each crop, and many practical men would consider that the costs should be defrayed by the wheat crop, if farming is to be carried on profitably. To this latter conclusion, however, we cannot subscribe, as the work of fallowing is not undertaken solely for the succeeding wheat crop, but with a view to from two to four crops, each of which is substantially benefited. I would therefore suggest that half of the immediate cost of bare-fallowing should be charged against the wheat, and that the remaining half should be equally divided among the remaining crops of the rotation.

CHAPTER II.

ROOT CROP FALLOWS. TURNIPS AND SWEDES.

Outlay on "Roots" not necessarily Loss—Origin of Turnip Husbandry—Turnips not Generally Cultivated in 1707—Growing Turnips in Drills or Ridges—National Importance of Turnip Husbandry—Extraordinary Plasticity of the Cabbage—Constant Character of Flowers and Seeds—Common Turnips—Swedish Turnips—Yellow Turnips—Varieties of Turnips—Apportionment of the Root-Crop for the Requirement of the Farm.

THE advantages of substituting a root crop for the older system of bare fallowing have already been pointed out. One of these advantages undoubtedly is that the value of the root crop is, to say the least, a substantial and immediate "set-off" against the cost of fallowing. That the root crop is usually grown at a loss might at first sight appear a reason against its cultivation; but further consideration will show that the loss entailed by growing roots should really be looked upon as the cost of preparing land for future crops. Sometimes the root crop is grown at an actual profit, in which case the fallowing expenses are entirely abolished, and a margin of profit substituted for them. If such a happy result were general, farming could scarcely fail in being a profitable business; but as it must be regarded as exceptional, we do not expect the root crop to balance its account, but to leave a small debt upon the land to be defrayed by the succeeding barley, clover, and wheat. The root crop may thus be legitimately regarded as involving outlay, as probably involving an immediate loss, but at the same time an ultimate profit, and in any case, a saving upon the old dead or bare fallow.

The turnip has long been cultivated. "As long back," wrote the late Professor John Wilson of Edinburgh, "as we have any distinct records of agriculture to refer to we find information respecting this plant." Its cultivation was described by Greek and Roman writers, and it was grown in the gardens of the Religious Orders during the middle ages. When it was first distinctly introduced as a farm crop is not known with certainty. It is mentioned by Barnaby Googe in his *Whole Art of Husbandry*, 1586, by Gerardi in 1597, and by Parkinson in 1629; but none of these writers speak of turnips as a cultivated field crop. Ray, however, informs us that they were generally grown as field crops in 1686, so that we may reasonably infer that the turnip was introduced into field culture during the middle periods of the seventeenth century. Lisle, who began his observations in 1693, and continued them to his death in 1722, speaks of turnips as generally grown in his time, as the following quotations will show—"I had discourse with Mr. Pawlet of Leicestershire, who deals in great quantities of turnips—it was August the 7th, 1699; he says when turnips are sown after Michaelmas they are generally counted out of danger of the fly"! Yellow turnips, white turnips, red or blue, and long (? tankard) turnips are mentioned by Lisle, which indicates that yellow turnips were known before the introduction of the swede. "The Newtown men, who houghed my turnips this year (1707), having made it their business for many years to hough turnips, assure me that it is the best to hough turnips as soon as they have four leaves." Here is evidence that turnips were carefully cultivated many years before 1707 Again, "Going to Holt by Burbage, January 10, 1698, I asked a farmer whether white lightish land might not bear turnips, and he said by no means—the black sandy earth or reddish sandy earth were the best." That folding sheep on turnips was not very widely adopted at the commencement of last century in Hampshire is to be inferred from the following extract from Lisle—"Having in November (anno 1707) a good crop of turnips for the winter feeding of my flock of sheep, I had a desire before I entered on the doing of it to consult a farmer's shepherd, who had *for many years* used his sheep to turnips. I understood from him, as also from others, that turnip feeding was apt to breed wind in the sheep and gripings; but to prevent this evil, they agree it is necessary to give the sheep some dry meat in the evenings, though coarse." "Farmer Biggs said that he was confident if it was a hard winter 300 sheep would eat twenty-five to thirty tons of hay. Farmer Crapp said he had often given thirty tons to that number of sheep." "Mr. Slade of Tilshade tells me that they allow a ton of hay for every score of sheep they winter on their downs." The general practice at this time in Hampshire, Wilts, and Dorset appears to have been to rely on hay chiefly as winter food for sheep and cattle. "Mr. Gilbert of Madington was telling me (Lisle) the way of husbandry about him, near Salisbury, was to fold on their wheat after it was sowed till St. Luke's-tide, which is the middle of October; then to draw off their flocks for a month to fold their sheep-leases, and then on the barley-fallows."

Jethro Tull, who wrote in the early years of the last century, and was closing his career as an author about 1730, says, "As far as I can be informed, it is but of late years that turnips have been introduced as an improvement in the field."

Turnips were at that time sown broadcast. The important invention of the drill by Jethro Tull, author of *Horsehoeing Husbandry*, about the period when turnip cultivation was spreading, must be regarded as an event of prime importance in the history of the turnip.

In 1730 Charles Viscount Townsend having noticed an improved system of turnip cultivation while Ambassador Extraordinary to the States-General of the Netherlands, introduced the same system on his estate at Rainham, Norfolk. The progress of the new cultivation is so well described by the late Professor Wilson, that we do not hesitate to quote the passage *in extenso.* Turnips "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 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 upon his own farm. Its introduction, it appears, was marked by the general distrust with which farmers sometimes view any innovation on old customs that does not originate with one of their own class. 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." The Swedish turnip, or *rutabaga,* was not introduced until 1775-80, when a parcel of seed was brought from Gottenberg, and its superior feeding value and great hardihood soon made it popular. The revolution which the introduction of the turnip effected in the art of agriculture has never been eclipsed by any later improvement. It is unquestionably the greatest event in the history of modern agriculture. The great movement which set in towards the close of the last century of the improvement of our breeds of cattle, sheep, and horses by Bakewell and the brothers Colling could scarcely have been successfully carried out without the turnip, and hence the history of our improved flocks and herds is intimately and vitally connected with the rise and progress of the cultivation of suitable material for winter feeding.

The benefit to the nation from the general adoption of turnip husbandry cannot easily be estimated. It is principally owing to this cultivation that we are supplied with fresh butcher's meat during the entire year. Before the introduction of the turnip, salt beef, with its concomitant evils of scurvy and other forms of disease, was the rule. It would have been impossible without the turnip to have maintained the flocks and herds necessary for the maintenance of our present population.

There are about 2,300,000 acres of turnips, swedes, and mangel grown in Great Britain every year, giving employment to tens of thousands of men in their cultivation, and in the tending of the millions of sheep and cattle which subsist upon them. The profitable employment of capital in the cultivation of turnips must also be included in the advantages accruing from their husbandry.

The turnip is the cultivated form of the *Brassica Rapa*, a plant which is described in Hooker and Arnott's *British Flora* as an inhabitant of borders of fields and waste places. It belongs to the natural Order *Cruciferæ*, and to the same genus as the cabbages, raddishes, and mustards, as well as the wallflower, charlock, and Jack-by-the-hedge (*Sisymbrium Alliaria*, Sc.). The order is principally distinguished by its cruciform flowers, its tetradynamous stamens, and its seed being formed in a long or short pod, the valves of which open from a central *septum.*

All the cabbages possess the disposition to vary from the normal type in a marked degree. This tendency towards *variation* may be exemplified by almost innumerable examples. The principal parts of a plant into which it may be divided are the flowers, which eventually develop into fruit and seeds, the leaves, stem, branches, and root. All these parts may in the genus *brassica* be modified in a remarkable manner. An abnormal development of the flowers, coupled with a temporarily arrested condition of growth, gives us the cauliflower, broccoli, and major. The leaves may by cultivation be induced to assume an imbricated character, so as to form a solid head or heart, or they may be grown so as to form an open-headed cabbage or kale. The leaves are sometimes deeply dissected and curled, giving curly greens, or they may be developed into small heads springing from the axils of leaves, known as Brussels sprouts. Various descriptions of cabbage are known from each other by the form and comparative roughness or smoothness of their leaves. The stem or stalk of a cabbage has been modified by an abnormal development of cellular matter, forming the useful esculent kohl-rabi. The root has been developed by cultivation of some of the genus, with the result of producing various descriptions of turnips.

The swede turnip is only a cultivated variety of smooth-leaved summer rape, just as the turnip may be regarded as botanically identical with rough-leaved summer rape. These singular variations belong to the *genus*, and not to any one species. Thus we should not expect varieties of cabbage from any other species but *B. oleracea,* or of turnips from any species of the genus but *B. rapa.* The plasticity of the cabbages is certainly a remarkable fact, in which they excel any other of the genera which will come under notice in the following pages. It is worthy of attention, that while flowers, leaves, stem, and root are all capable of such extraordinary modifications, the seed remains constant in form. It is, indeed, difficult to distinguish rape, cabbage, kale, kohl-rabi, and swede seed from each other, and although turnip seed is smaller and rather reddish in tint, the whole group are so similar that it requires some experience to identify any of them. Similarly, the flowers are in all the crops just named of the same light yellow colour and general outline and symmetry, showing close relationship in spite of the effects of cultivation. The artificial character which has been induced by cultivation and selection is only kept up by the exercise of the greatest possible care in the choosing of parent plants. All of the species breed freely together, a fact which has caused botanists to doubt whether they are specifically distinct, and hybridization is certain to take place through the agency of bees, unless great care is taken to keep the stocks sufficiently far apart.

Such is the interesting and useful genus of plants to which the turnip, swede, rape, kale, cabbages, and kohl-rabi all belong. These constitute, in fact, our root crops, and some of the group can scarcely be properly so designated, as they are grown rather for their foliage than for their roots. There is only one other principal member of our root-crops which is not included in the cruciferæ, namely, mangel wurzel, and two less important plants, which will deserve distinct notice in a later chapter, namely, carrots and parsnips.

Turnips and swedes compose 81·9 per cent. of the root crop of England and Wales, and 99·7 per cent. of the root crop of Scotland, and have therefore evidently a right to our first consideration. As has already been mentioned, the turnip was known long before the introduction of the swede, and according to Lisle, yellow turnips were also known before the swede was brought from Sweden. The intermediate class, known as yellow turnips, may in some of its varieties (and possibly in all) be the result of hybridization between swedes and white turnips. Certain it is, that in appearance and qualities they are very generally intermediate between the two distinct species *Rapa* and *Campestris*.

These three descriptions of turnip—the swede, yellow, and white—are each represented by numbers of varieties or sorts suitable for various soils, climates, and purposes. Some of these are distinct in character, while others are less characteristic, and appear to be named to distinguish the seedsmen who are responsible for them rather than for personal identification of the root designated.

Before giving a list and general description of some of the best known varieties of these plants, I will point out the leading differences by which each group is characterized.

Turnips.—All turnips have rough leaves of vivid or vine-green colour, which readily allow water to dry off them. The colour of the leaves enables us to recognize a field of turnips at a considerable distance. The proportion of leaf to root is high in turnips, and was found by Dr. Gilbert to be from 329 to 600 of leaf to 1000 of turnips.

Turnips are not furnished with a "neck," the top or haulm growing from the root without any scarred stalk, as in the swede. With the exception of the sorts known as tankards, and certain special forms, as the grey-stone, the horizontal axis of the root is longer than its vertical axis. In other words, the root is flat rather than oblong, and this fact has given rise to the Latin expression *depressa* as descriptive of the shape of turnips.

On cutting into a turnip the flesh (except in the case of yellow turnips) is of a beautiful glistening white colour, rivalling snow in purity. The flesh is also soft, giving the characteristic name of "soft turnips." Turnips are much more watery than swedes, and contain only 8 per cent. of solid material.

Among the general characteristics of turnips, which are not visible but well known to farmers are the following—

Turnips will thrive upon thinner and weaker soils than swedes. They are as a rule quick in growing, and early in maturing; they are easily injured by frost (unless in the case of late sown turnips, which are hardy); they are of less value than swedes for feeding purposes, but are better fitted than swedes for stock feeding during the early winter. As a rule they are later sown and earlier ready for use than swedes.

Swedes.—All swedes have smooth, waxy leaves of blueish green or *glaucus* tint, collecting dew and rain in globules or spherical drops upon their surface. The proportion of leaf to root is much lower than in white turnips, being, according to Dr. Gilbert, from 69 to 78·5 of leaf to 1000 of root. The leaves spring from a well defined neck. The general form is cylindrical rather than spherical, *i. e.* the vertical axis is longer than the horizontal axis. The flesh of the swede is of pale yellow or cream colour, crisp and hard. The proportion of dry matter is 11 per cent., and the percentage of sugar is almost double of the amount contained in white turnips, or about 7 per cent.

Swedes require fairly good land, and do well upon stiff loams. They must be sown early, and they continue to grow late into the winter. They are very hardy, and are of high value for feeding purposes, especially in the later weeks of winter.

Yellow turnips.—This class of turnips are in many respects intermediate in character between swedes and white turnips. The leaves are rough, and do not retain globules of water after rain or dew. The form of the root usually approaches that of the white turnip, and they have no neck. The flesh is yellow, and intermediate both in hardness and in nutrient properties between the white turnips and swedes. Thus in the proportion of dry matter and sugar—

		Dry Matter per cent.		Sugar per cent.
White turnips	...	8	...	3·5 to 4·5
Yellow turnips	...	9	...	4·0 to 5·0
Swedish turnips	...	11	...	6·0 to 7·0

Yellow turnips are also intermediate with regard to the time at which they are best sown, and at which they are consumed by stock. They require a better soil than turnips.

We must now review some of the principal cultivated varieties of turnips, beginning with swedes.

Common Purple-top Swede.—This swede, although described by the late Professor Wilson in his book on "our farm crops," is now merged in improved stocks which have sprung from it. Its colour is a dull purple on the exposed portion of the root, and buff underneath.

Skirving's Purple-top Swede is a very well-known variety introduced by Mr. Skirving of Liverpool in 1837-8. Since then it was again brought out by Mr. Skirving as an "improved" variety. The Improved Skirving purple-top swede is of oblong shape, grows higher out of the ground than the older sort, is early in maturing, and keeps well when stored. It is less hardy than other varieties, and is liable to "run to neck" during the autumn. Both of these faults are due to its tendency to early maturity, and would probably be avoided by sowing it somewhat late. This swede retains its position in all seed catalogues of the present day under the names of the 'Liverpool,' and 'Skirving's Liverpool,' as well as by the original name above given.

Laing's Improved Purple-top differs from other varieties in having large entire cabbage-like leaves, which by their spreading, horizontal habit of growth speedily cover the soil between the drills (Wilson). The habit of this swede is to bury itself for the most part in the ground. It is suitable for good land and a south country climate.

Sutton's Champion was introduced by the well-known Reading firm thirty-two years ago. It is globular in form, domed in shape, preventing the lodgment of water, has a very small neck, and deep yellow flesh of good quality. The merits of this swede have been well tested in competition in the leading agricultural shows.

Sutton's Crimson King swede is described as a hardy, heavy cropping swede, remarkably easy to draw.

Webb's New Emperor, Webb's Imperial, Carter's hardy Prize-winner are examples of carefully selected and excellent swedes, and to these the following may be added as well recognized by the farming public—*Lord Derby, Bangholm,* a popular Scotch variety, *Queen of Swedes,* a bronze-topped variety, *Westbury Swede, Marshall's Purple-top Swede, Purple-top stubble Swede,* which may be sown until the end of July. Of the green-top varieties the best known are *Hartley's Green-top,* largely grown in Yorkshire, *Green-top Swede,* and *Green-top yellow Swede.*

White swedes are peculiar for their white flesh, and are very hardy. There is a purple and a green-top variety. Tankard swedes are also offered in most catalogues.

Among the best-known varieties of yellow turnips the following are worthy of especial notice—

Dale's Hybrid was introduced into cultivation by Mr. Dale of Libberton West Mains, in 1822-3. It grows well out of the ground, which makes it somewhat sensitive to frost. It is described by Messrs. Sutton in their latest catalogues as one of the heaviest cropping turnips in cultivation, and of rather light yellow flesh with green top.

Fosterton Hybrid is an old favourite, and may be described as a green-top yellow, with somewhat darker tinged flesh than the Dale's Hybrid.

Purple-top and Green-top Aberdeen, or *Bullocks,* are much esteemed in Scotland and the north of England. They are suitable for early sowing, but do not always succeed in the south of England.

Old Meldrum Green-top is another yellow turnip, which possesses very similar qualities to the two last-named varieties.

Among other esteemed sorts of yellow turnips may be mentioned Sutton's *Favourite turnip, Webb's Green-top Scotch, Carter's Champion Green-top Hybrid, Orange-jelly* or *Golden Ball,* suitable for sowing on stubbles, *Palmer's Yellow,* the *Border Imperial,* the *Tankard Yellow Turnips,* and the *Golden, Green-top Yellow.* Sutton's *Favourite Yellow* was obtained by crossing the *Gordon Green-top Yellow* and the *Border Imperial,* and was introduced in 1882.

The number of white-fleshed turnips in cultivation is larger than that of swedes or yellow turnips.

The Pomeranian White Globe is a very quickly-growing and early turnip. It is the best sort for providing early keep in late July or August, and forms an excellent crop when it is intended to feed it off in anticipation of wheat. The Pomeranian White Globe is pure white in appearance, and is a handsome, clean-growing root.

The Common White Globe is very similar to the last, but is somewhat slower, later, and hardier.

The Green Globe is an excellent hardy, and free-growing turnip, suitable for winter-feeding, and when sown late it is capable of standing as much frost as a swede.

The Green Round is a flatter shaped turnip than the Green Globe, and is a general favourite. An excellent stock of the same variety is known as *Stratton's Hardy Green Round.*

Among others may be mentioned the *Lincolnshire Red Globe,* a free-growing, very hardy turnip; the *Improved Red Paragon,* the *Greystone,* the *Red, Green,* and *White, Tankards,* the *Purple-top Mammoth,* and the *Early Six-weeks,* or stubble turnip.

The above list of cultivated turnips might have been extended, but in a work of this description it is not necessary to enumerate every cultivated variety, especially as many of them are very similar in appearance and qualities. The practical question as to what sort of turnips to select ought to be determined rather by consultation with the best farmers of the district than by what is recorded in books or catalogues. The great variety of soils, and the variations of climate in every locality, give preference to certain descriptions of roots; and their peculiarities are best appreciated and met by the experience of those who have long resided under those special conditions.

Practically we should recommend in the first place a few acres of Pomeranian White Globes, to be followed by common White Globes, which might again be succeeded by Green Globes for later use. White turnips are better than swedes for sheep and cattle in the autumn, being cooler and lighter of digestion. A few acres of a good yellow turnip, such as the Favourite, the Green-top Scotch or Dale's Hybrid, will be found useful after the early turnips are finished, and these again may be succeeded with the main breadth of swedes, which may be followed with sowings of Stratton's Green Round, Early Six-weeks, or Stubble turnips. A fair apportionment of the various kinds of roots upon 400 acres of arable land, interspersed with a fair proportion of pasture, would be:—

12	acres of Mangel-wurzel.
15	acres of early sown White Turnips.
10	acres of Rape.
8	acres of Cabbage.
10	acres of Yellow Turnips.
30	acres of Swedes.
15	acres of Late Turnips.
100	acres.

Much must depend upon the character of the soil, as well as upon the amount of live stock in arranging the acreage of the various root crops.

The general principle, not always followed, is that white turnips should be used first, yellow turnips next, and swedes last. Such a succession would give a supply of food for stock from August to May, and it is after this that mangel-wurzel arrives at its highest value, and furnishes a capital food during the hot months of June and July.

Farming is, however, so full of exceptions as to what may be called sound practice, that we occasionally see mangel-wurzel being fed by sheep in September and October, with a view to getting in wheat after it, and white turnips left over until spring, both of which deviations must be puzzling to a novice.

Early-sown white turnips, arriving at maturity in August and September, are certainly not fitted for withstanding any hardships in the way of frost, and should always be fed off early, as already recommended.

Late-sown white turnips are much hardier owing to their being young, full of vitality, and well protected by their abundant leaves, which fall over the roots during frosty nights and protect the roots. Such late-sown turnips will continue to grow up to February if the weather is mild, and yield excellent food for ewes with lambs.

Yellow turnips form a good introduction to swedes, and may be viewed as a connecting link between the two distinct classes of white turnips and swedes. They are also esteemed for ewes and lambs, as they stimulate the flow of milk and are more wholesome than swedes for nursing sheep.

As a mainstay for spring-feeding the Swedish turnip holds a strong position. From January 1st to the end of April they are in perfection, but after the commencement of May they begin to turn soft and flaccid and to lose their "nature." They are much better suited for heaping or storing than either white or yellow turnips, and their nutrient properties are higher.

CHAPTER III.

TURNIP CULTIVATION.

Root Crops for Various Soils—Preparation of the Land—Cleaning Land—Broadcasting Turnips—Drilling on the Flat—The Northumberland System—Time for Sowing—Seed and Sowing—Width between Drill Rows—Size of Roots affecting Quality.

TURNIP cultivation was formerly restricted to what was called "turnip land." These were soils of light, friable, and dry character, underlaid by a subsoil which favoured the free percolation of water, suitable for carrying sheep during the winter months. Such soils are to be found by the sides of rivers where they form haughs or holmes of sandy, loamy, or clayey character. They are characteristic of the upper chalk, which may be considered as sheep and turnip land *par excellence.* They are found on the upper green sand, and still more extensively on the brashy soils of the lower oolite, whether found in Lincolnshire (the heath), Northampton, Oxfordshire, Gloucestershire, or Somersetshire (the Cotteswold hills). They also abound in the fertile plains and table-lands of the New Red Sandstone. The light soils of the millstone grit gives excellent turnip soil, and, as associated with the early history of turnip cultivation, the first-rate turnip growing district of North Northumberland may be mentioned, formed by the blending of material from the trappean basis of the Cheviots with the mountain limestone soils extending from their lower slopes.

Turnip, or, to speak more correctly, root and forage crop, cultivation, has become much more general now than in the older time when the cultivation was confined to turnip soils. A vast amount of attention has been bestowed upon forage crops, including both roots and leafy esculents, and they are now so numerous that suitable kinds may be selected for all descriptions of soil, from the stiffest to the lightest. We shall examine many of these crops in due course, but may in this connection indicate them as forming part of a series, by the aid of which all soils may be made to support crops suitable for live stock:—

White turnips for the lightest sands.

White and yellow turnips for light loams.

White, yellow, and Swedish turnips, mangel-wurzel, and rape for clay loams.

Mangel, rape, kale and cabbage for clay soils.

Early sown turnips, cabbage, kale and rape, for summer consumption on clay soils.

Carrots on even stiff description of clays, and for deep sands and loams.

This list might have been made fuller by the introduction of several other fodder crops, but we shall confine ourselves chiefly to those which are usually classed with the root crop.

PREPARATION OF THE LAND.

The successful cultivation of the turnip crop depends upon a large number of circumstances. Among these one of the most important is the judicious preparation of the seed-bed. It is not possible to prescribe one system of cultivation which will be suitable for the varying conditions of soil and climate, but certain principles may be laid down which will greatly assist the farmer in arriving at his object—the growth of a good crop.

The turnip crop as a rule follows wheat, and it is with wheat, or at all events corn stubbles, that we have to deal. Stubbles may be clean or foul, and land may be stiff or light, so that our attention may be directed to one of the four following conditions of land:—

A foul stubble upon strong land.
A clean stubble upon strong land.
A foul stubble upon light land.
A clean stubble upon light land.

It is not easy to imagine a case which cannot be included in this simple classification, unless it be that of wet lands; but as roots cannot be successfully grown on such lands, we shall not consider them.

I shall take these cases in the order given, only premising that the first is the most difficult, and that each is easier to cope with than the preceding one. If then we master the difficult case of preparing a foul and stiff piece of land by rendering it fit to grow a good crop of roots, the remaining cases may be treated of with greater brevity.

1. A foul stubble will be covered with an abundance of herbage composed of couch-grass, black-bent, thistles, docks, crowfoot, rest-harrow, coltsfoot, charlock, &c. For our present purpose the blacker we paint the picture the better. The field may be considered as having only recently come into our hands, and we may be supposed to have, to use a colloquial expression, our work set. The land too is stiff and expensive to work, and the aspect of things is not promising.

Weeds as viewed by a farmer are divided into classes. Deep-rooted weeds, such as thistles, bur-docks, docks, coltsfoot, knapweed, nettles, bindweed, and red-shank. Stoloniferous, as couch and bent; and surface weeds, such as ground-ivy, chickweed, speedwell, &c.

When a field is covered with surface weeds only, it is not considered foul, as such weeds are easily destroyed by ploughing them under. Foulness is chiefly associated with the prevalence of the deep-rooted weeds and couch-grass, and it is with the eradication of these persistent enemies of good farming that we have chiefly to deal.

It is some comfort to know that these weeds are weakest immediately after harvest, when they have been shaded by a growing crop for several months. Also, it is satisfactory to find that these two or three months after harvest are particularly well adapted for the cultivation of clay land. No time should therefore be lost in attacking these vegetable pests at advantage, and whether we employ steam or horse cultivators is a less important consideration than that no time should be lost.

When steam cultivating instruments are available they are valuable aids towards the accomplishment of our object, and they possess the advantages of thoroughness and of rapidity. It is, however, necessary to be careful not to cultivate deeply, but to set the implement so as to move the ground not more than three inches in depth. Cross cultivation is also to be recommended, *i.e.* two cultivations given at right angles so as to insure the whole of the ground being moved. An equally thorough but less rapid course is to plough thinly with a steel broadshare fixed upon an ordinary plough, or "Broad-shares" or "Parers," specially designed for the work, may be used.

Raftering, or half-ploughing, is a third system, which although old-fashioned is effective upon very foul land. There are cases in which land is so full of roots and weedy herbage that the mass is difficult to deal with, and seriously impedes the cultivating implements. In such cases there is an advantage in raftering, as by this means only half the foul surface is disturbed at once, and after this "coat" of couch is removed we may proceed to get out a second. Raftering is also employed as a means of killing weeds, by turning over one half of the land upon the remaining half, and thus sandwiching the weeds. This method of dealing with weeds requires time to operate, and its advocates would probably prefer to wait until the spring of the year before resuming cleaning operations.

The preliminary work then consists in moving, whether by steam power or otherwise, the top three inches of the soil. The second part of the work is performed by four-horse drags or harrows, which are used to break up the soil, and by their tines to drag out the weeds and leave them upon the surface. Rollers and two-horse harrows follow, and the chain harrow usually completes this part of the process.

When the weeds are well brought to the top, and are shaken free from the adhering soil, the final operation consists in raking them together with horse-rakes, couch-rakes, or collecting them with forks, and they are then either burnt in small heaps on the surface, and the ashes spread, or they are carted off the field and made into compost heaps.

We have imagined our field to be very foul, and therefore it may now be necessary to plough again about three inches in depth, and to repeat the rolling, harrowing, and cleaning, in order to collect and destroy a second crop of couch. This ought to suffice, but we have in some stubborn cases found it necessary to go over parts of a field even a third time. When female labour is abundant, hand picking of the remaining strings of couch is an excellent plan, but in these days few farmers are willing to incur this extra expense.

Dry weather is absolutely necessary for the successful carrying out of these operations, and if a wet period intervenes, the work is stopped and sometimes suspended until the spring. Dry weather is also of assistance in killing the weeds, while in showery weather they retain their vitality and are more difficult to master.

When the farmer is satisfied that he has well cleaned his field (we are considering the case of strong land), his best course is to cart on from sixteen to twenty loads of long dung, and after spreading it upon the surface, to plough it in with as deep a furrow as it is in his power to give. This ends the process so often spoken of as "autumn cultivation," and when accomplished the land may be left to the pulverizing effects of the winter.

If the weather is dry in January or February, it is a good plan to cross-cut or cross-plough the field, and afterwards to rely upon cultivators, drags, and harrows to produce the necessary tilth. Three ploughing are, however, often found to be necessary, and a third furrow should be given rather than lose mould or earth.

Late spring ploughing should be avoided if possible, as it only buries the fine tilth produced by frost, and dries the land too much. In droughty seasons over-ploughing has often been the cause of a deficient root crop. The application of dung in the spring upon land of this class is also to be done with caution, and is on the whole better avoided, as it renders the soil hollow and "lets in the drought," thereby undoing the beneficial effects of the manure. The essentials of success are a fine, moist, and clean condition of the soil, and when these are secured and the land is enriched by proper fertilizers, we have done all in our power to secure the necessary conditions.

2. When land of the description we are dealing with is clean, the work is rendered much more simple. The preliminary cleaning operations are unnecessary, although on most land it will be advisable to "fork" the stubble, that is, to look them over fork in hand, and dig out stray patches of couch. After this has been done the dung is carted on, and the deep winter furrow is at once given.

3. The cleaning of a foul stubble upon light land differs chiefly from the system already described in the fact that autumnal cultivation is not so imperatively demanded. Light lands, it is true, may be cleaned in the autumn, but where a farmer occupies land of various qualities, he will do well to concentrate his autumn cultivation upon the stiffer soils of his holding, and those which are intended for mangel-wurzel and potatoes. Turnip land will not be so soon wanted for sowing, and the preparation of the seed-bed may very well be put off until the new year. Light lands are not of the same critical nature as clays, and the number of weeks in which they may be tilled exceeds the days upon which clay lands can be worked. In the case of light lands which have become foul, the system of raftering already mentioned will be found effective. After raftering, the field may be left until the first dry weather of early spring gives the opportunity for thorough dragging, rolling, harrowing, and couching. The land may then be ploughed, and the remaining weeds brought to the surface and got rid of as already described. The too frequent ploughing and working of very light land is liable to dry it and to injure its yielding powers. It may in fact be considered as a principle in light land management, that provided it is clean, the less it is tumbled about, the better prospect will there be for an abundant crop.

4. The simplest case of all is the preparation of a clean light land stubble for roots. Unfortunately the combination is a rare one, chiefly because light lands soon run wild with weeds. When light land is clean it will in many cases appear desirable to take a fodder crop, such as rye or trifolium, before the roots, and after this crop has been fed off the cultivation of the turnip is exceedingly simple, consisting of one ploughing, followed with a sufficient number of harrowings to secure a pulverized seed-bed. It is upon land of this description that a system of root growing

practised by a well-known Scotch agriculturist might be followed. His plan was to plough the stubbles after harvest, and to let the furrow alone until the afternoon before he proposed to drill his turnips. He then ploughed and dressed down as much land as he could "make" into turnips on the succeeding morning. He was thus engaged in the afternoons ploughing up land, and in the mornings in raising and splitting drills and sowing, or, as the Scotch farmers call it, "making turnips." This plan may appear to some readers to be rather impracticable, but the general principle of letting the land alone from the autumn ploughing to the eve of sowing turnips is worthy of attention. The farmer who practised this method assured me that he never lost a yard of plant by following it, while his neighbours who were for ever working their land were troubled with patchy crops. Such a system could only be carried out upon clean land of friable nature.

I must once more insist upon the necessity for securing the conditions essential for the successful growing of root crops, which may be summed up by stating that the soil must be rich, deep, fine, moist and clean. A soil which may be described in these five monosyllables is, if favoured with a suitable season, certain to produce a heavy crop. Take away any one of them and a poor crop will as certainly be the result. All tillages should be used with these ends in view, and having said so much I pass on to the consideration of the next point, namely—

METHODS OF SOWING.

The three modes of sowing turnip-seed are broad-casting, drilling on the ridge, and drilling on the flat.

With reference to these three methods the first is the oldest, but is seldom now used. Broad-casting turnips was universally followed by turnip growers before 1730, when Tull invented the drill. Since then drilling has gradually extended, until it has superseded the older plan. Hoeing, or *houghing,* as Lisle calls the operation, appears to have been practised in conjunction with broad-casting, and we are informed in a passage already quoted that it cost 10*s.* per acre nearly 200 years ago. It was evidently a tedious piece of work, and has been greatly simplified by the method of drilling turnips in rows. Few agricultural practices are to be entirely condemned, and although at first sight that of broad-casting turnips might be regarded, and properly so, as antagonistic to the very objects of root fallowing, yet there are circumstances in which it may still be recommended. I refer especially to the latest sowings, when turnip cultivation is pushed beyond the middle of August, and when all that can be reasonably expected is a supply of hardy green food in the spring. In such circumstances turnip-seed may be sown at the rate of 1½ to 2lbs. per acre, with the broad-cast barrow, upon a finely harrowed surface, and gently harrowed and rolled in. If not sown too thickly they will make small heads, and cover the ground better than if they had been drilled—in which case they would have been crowded in the row, while they would have had too much room laterally. It might even be urged with reason that after the 1st of August, or as soon as the best system is clearly to sow but not to single, then we may resort to broad-casting. The broad-casting of turnip-seed may also be done with advantage upon land carrying a bean crop. The seed germinates, but the young plants make little progress till after the beans have been harvested, and they then yield a crop of late turnips useful for sheep.

The drill system was invented by Tull, who did not scruple to advocate drills from 3 feet to 6 feet apart. It is the general system in the Midlands and southern counties, and must be regarded as firmly established. This system involves the use of a Suffolk drill, and the seed is run into the soil in rows, by means of coulters, placed from 14 to 24 or more inches apart. Two classes of drills are employed for the purpose—dry drills and water drills, and both have their advocates. During the extremely dry summer of 1887, it was noticed that the dry or ash drill gave better results than the water drill—the seed not being encouraged to germinate so rapidly, but more gradually, and in accordance with the limited amount of moisture available. In using the dry drill, the superphosphate or other artificial manure is mixed with ashes produced by the burning of weeds, and after the substances are well incorporated, they are transferred to the drill, and deposited with the seed. In the case of the water drill, a tank takes the place of the receptacle for manures, and water is used as the vehicle for distributing the fertilizer. The water is lifted by means of dredging wheels, furnished with buckets arranged around their periphery, and the water with its manurial matter in suspension and partly in solution is precipitated down tubes, and finds its way through the coulters into the ground. From 200 to 800 gallons of water are used per acre, and the amount is regulated by a valve, which when fully open allows the whole of the liquid to run through the coulters into the ground, but when shut to run back again into the tank. The water drill was invented by Mr. Chandler, a North Wilts farmer, and is much used in the southern counties, but has never made its way north of the Humber.

There is but little to describe in the method of drilling on the flat. The ground is brought into a proper condition of fineness, and is rolled in front of the drill, and harrowed afterwards. It is a rapid, efficient, and simple method of sowing, open to some objections, which are not of a serious nature, and possessing some advantages over the next system to be described. As to the objections, it must be allowed that turnips sown upon the flat require more time before they can be either horse-hoed or hand-hoed than if sown on the ridge. They cannot be touched until they are sufficiently large to escape from being buried by the horse-hoe. They must at least be visible, while on the ridge system weeds may be hoed both by horse and hand-hoes before the turnips appear above ground—the ridge in itself being a sufficient guide. Neither are they so easy to hoe as when grown on the summit of a ridge, from which the soil is more easily drawn away. On the other hand, a greater amount of moisture is retained by a flat surface than by one which is corrugated with drills, as in the raised ridge system. It is this consideration, more than any other, which has determined the practice of southern farmers, and left the Scotch and north country men in possession of their own characteristic method—the ridge system.

The credit of the Northumberland system of drilling turnips upon raised ridges or drills formed by the plough, and then split over dung, appears to rest with Mr. Dawson of Harperton, Kelso, who, according to Donaldson, conceived the idea of "sowing the turnip-seed on narrow ridges." This happened about 1760, and the field is still shown where Mr. Dawson first put his brilliant idea into practice by drawing turnip-drills or ridges with his own hand. This mode of cultivation soon extended upon the fine turnip soils and suitable climate for this moisture-loving root found at the base of the Cheviot Hills. From thence it spread into Scotland, and southwards into Durham and Yorkshire, and is now almost universal north of the Humber.

The Northumberland system of sowing turnips possesses many advantages, and its only disadvantage is found on dryly situated soils, on which situations the system is accused of favouring undue evaporation from the surface.

Undoubtedly the heaviest crops of turnips are grown on ridges, but this is probably largely due to the fact, that when the ridge system prevails, the climate is highly favourable to the maximum development of turnip crops. Among the most patent advantages of the system are the following:—First, the best land is focussed by the ridge system, and the depth of good soil immediately under the seed is increased. Wherever two furrows are thrown towards each other, for example, in the centre of a ridge of wheat, there vegetation is always most luxuriant. On the other hand, wherever furrows are thrown from each other, as in the open furrows between ridges, there is always evidence in the condition of the crop of poverty of soil. These conditions are repeated in every ridge in the raised ridge system—the good land is concentrated for the use of the young plant, and the hollows between are for the time denuded of the best earth.

Secondly, the dung and artificials are concentrated by being placed in the bottoms of the raised ridges, and in the process of splitting, their position is reversed, so that they lie immediately under the apex of the newly formed drill. The young turnip therefore germinates in a seed-bed of good soil, underlaid by moist fertilizing matter, and the *initial* growth is consequently strong, which is an important point in estimating the future growth of the crop.

Thirdly, the hoeing of the crop is more easily carried out, and may be earlier commenced than in the alternative system of sowing on the flat.

Fourthly, the horse-hoeing restores the normal level condition of the field, so that the repetition of ridge and hollow, which is characteristic of the system in its early stage, disappears during the growth of the crop, and the root-fibres are able to seek their nourishment in a mass of loose and fine soil, extending laterally from row to row.

Sowing on the ridge implies, in the first instance, the previous cultivation of the ground, that is the obtaining of a fine condition of tilth before the ridges are raised. The ridglets are not to be pictured as consisting of compact furrows turned towards each other, but as loose soil in a state of complete tilth, thrown together so as to form continuous, sharply-pointed drills. The perfection with which this is accomplished by a good ploughman is admirable, and the precision of the system is one of its best points.

The *modus operandi* may be thus described. The field having been ploughed two, three, or four times, according to circumstances, and brought by repeated dressings into a fine state, is rolled. Two teams are then told off to raise ridges, commencing next to a fence. If the fence is straight, the work follows the direction thus indicated. If not, a few shorter rows, known as "butts," are struck, until a straight line is obtained from end to end of the field.

After a sufficient number of drills have been raised, the dung-carts appear, and the manure is placed in small heaps, usually in every third ridge. It is then spread carefully in the bottoms between the ridges, and the work is completed by splitting the ridges over the dung. Thus the work proceeds; the ploughmen raising ridges as they go up the field, and splitting ridges as they return; the usual plan being to keep some thirteen or fourteen ridges free for the operations of dunging and spreading. Two teams thus employed will raise and split four acres of twenty-seven-inch drills in one working day. The speed of the teams is the measure of the amount done, and the remainder of the force of men, women, and horses, should be so balanced that the whole work proceeds without interruption.

Bearing in mind the arrangement of the work, the following schedule will assist the reader in forming an idea as to the system and its cost:—

		s.	d.
2 teams raising and splitting ridges at 8*s.* each ...		16	0
4 carts with 4 horses carting dung at 3*s.*		12	0
3 men filling dung at 2*s.* 6*d.*		7	6
2 boys driving at 1*s.* 6*d.*		3	0
6 women spreading manure in drills at 1*s.* 3*d.* ...		7	6
1 man sowing artificial manure		2	6
$\frac{1}{3}$ time of 1 man (foreman) and horse drilling turnips ...		2	6
Total cost per day	£2	11	0
Total cost per acre		12	9

The drill employed for sowing seed on the ridge is known as the Northumberland two-row turnip drill. It is provided with two concave metal rollers, which precede the coulters, and flatten and smooth the tops of the ridges. It is also furnished with a light wooden roller, which follows the coulters and covers the seed. The two-row drill does not deposit any manurial or fertilizing matter, but seed only.

TIME FOR SOWING.

The root crop, viewed as a whole, is sown during the entire spring and summer. From April onwards to the end of August some member of this group may be seasonably committed to the ground. Thus by judicious selection of the description of root to be sown, the work of providing winter's food may be carried on during a protracted period, and if the season is past for one description of root crop, a substitute in some later variety can be readily provided. Including mangel-wurzel, for the purpose of exhibiting a complete series, the best periods for sowing the root crops may be thus enumerated:—

Mangel-wurzel; March, April, and early May.
Early white turnips; May and early June.
Swedes; May, June, and early July.
Main crop white turnips; June and early July.
Main crop yellow turnips; „ „ „
Late turnips; Late July, August, and early September.

The period for sowing must be allowed a fair share of latitude to meet peculiarities of season and local climate. As a general rule early sowing is to be recommended, although it is not always that extreme earliness in sowing is successful. Frosty nights are occasionally destructive to early-sown root crops. The "fly" is often particularly prevalent in early summer; and lastly, early-sown swedes are often attacked with mildew. Still the risks are worth running, and every one who has noticed the large size of swedes which have been sown among mangels, either as chance seeds or purposely, must be convinced that the whole of a long season will be made use of by this crop.

The season varies considerably between the north and south of Great Britain. In the north early sowing prevails, while in the south later sowing is customary. On high lying and exposed situations early planting is preferred, while on better soils and in valleys sowing may be postponed for a month longer.

The period of sowing affects the hardihood of root crops. Early sown and completely matured roots are more liable to injury from frost than later sown ones. A late sown white turnip, full of leaf and vitality, will resist lower temperatures, than a mature swede, thus falsifying the general conclusion, which is nevertheless true, as a rule, that swedes are hardier than white turnips.

QUANTITY OF SEED.

There are something like 100,000 turnip-seeds to 1 lb., and as the number of turnips per acre, 18 inches apart both between the rows and in the rows, is 19,360, it follows that 1 lb. of seed is amply sufficient to seed an acre. Many good farmers sow 1 lb. of seed, but 2 lbs. or even 3 lbs. are more ordinary quantities as a safeguard from the attacks of the turnip-fly. Even 4 lbs. have occasionally been sown when the fly is particularly active ; but such a quantity must not only be regarded as unusual, but extravagant, and even as positively prejudicial to the crop. Too thick a "plant" is liable to become over-crowded, and to interfere with the growth of the individual seedlings, and besides it renders singling difficult and expensive. Much must depend upon the season, as in moist and showery weather less seed will be found sufficient than in hot and dry summers.

Another controlling circumstance will be found in the distance apart of the rows, for it is evident that if 1 lb. of turnip-seed is enough in the case of rows 28 inches apart, one-half more seed would be required when the rows are 21 inches apart. Lastly, the size of the individual seeds may be considered as affecting the question of quantity of seed. Thus 1 lb. of turnip-seed will contain as many individuals as 1½ lbs. of rape or cabbage-seed.

DISTANCES BETWEEN THE ROWS.

The distances between the rows of swedes and turnips, varies with:—

The description of the root cultivated.

The quality of the land.

The time of sowing.

The climate of the district; or of the individual field.

The more favourable the circumstances the wider may the intervals be. Thus, it is safe to predict that on good land in high condition, early in the season, and in a cool and moist locality, the maximum space may be left between the rows. And as these conditions become less favourable to full development, the rows should be drawn closer together. The distances fixed upon will vary from 30 down to 15 inches, and these and every intermediate distance may be considered as reasonable in varying circumstances.

When the ridge system is employed, it is not practicable to plough drills narrower than 25 inches apart; but when the Suffolk drill is employed the spaces between the coulters may be made to vary from 16 to 25 inches.

Narrow drilling finds more favour in the south, and the minimum distance is generally adopted in the dry climate of the Eastern counties.

The weight per acre of a crop greatly depends upon the full development of the individual roots, and a crop of large turnips is not only heavier, but may be many times heavier than a crop of somewhat smaller roots. Take, for example, a swede of 6 inches in diameter as against one of 4 inches in diameter. Supposing these swedes to be spheres, and of equal density, the six-inch swede would represent a crop 3·38 times heavier than that produced of the 4-inch swedes. That is, while the smaller swedes might yield 12 tons per acre, the swedes one-half greater in diameter would yield 40 tons to the acre. This result is arrived at by the rule that the contents of spheres are to one another as the *cubes* of their diameters. The extraordinary records as to weight per acre is thus easily accounted for, as a slight increase in size of the roots, almost imperceptible to the eye, may make a difference of many tons per acre. In the case of a heavy crop of swedes, one inch in diameter in large roots would scarcely carry the impression of the ten or more tons per acre difference.

That overgrown turnips, swedes, and mangel-wurzel are of lower value than those of more moderate size is well known to both farmers and chemists. The late Dr. Voelcker wrote in 1877 :—"It is perfectly well known to stock-feeders that a ton of sound, solid, juicy, sweet-tasting swedes is worth a great deal more for feeding and fattening purposes than the same weight of watery, big, and comparatively tasteless roots." Again—"White turnips not unfrequently contain from 92 to

93 per cent. of water; and even in swedes and mangolds I have found, occasionally, as much; whereas good, fully-matured swedes or mangolds seldom contain more than 88 per cent. of water, and frequently less. In such watery mangolds the proportion of dry or real feeding substance in 100 parts weighs only 7 lbs., whilst good roots contain 12 lbs. of dry food in every 100 lbs., or, in other words, 10 tons of the more nutritious mangolds are worth about 17 tons of the watery roots."

The remarks just made on the proper distance between the rows are of great importance in connection with the quality and feeding properties of the produce. This is clearly shown by results obtained in the growth of sugar-beet by M. Ladureau, and quoted by Dr. Voelcker:—

Distance apart of rows.	Yield per acre.			Sp. gravity of juice.	Percentage of sugar.
Inches	Tons	cwt.	qrs.		
10	28	0	0	1055·5	11·62
12	27	12	3	1055·0	11·21
14	27	15	3	1050·0	10·48
16	25	1	3	1051·0	10·61
20	25	5	2	1046·0	8·97

It is interesting to note that the roots grown nearest together not only gave the highest percentage of sugar, but the greatest weight per acre, thereby combining both quantity and quality. Although it may be objected that an experiment conducted upon sugar-beet grown in France does not of necessity apply to swedes grown in England, yet we may safely conclude that the same principle holds good; and, to once more quote the late Dr. Voelcker, we may say with him, "I believe it is not a good plan to plant swedes too wide apart." The general question of composition and quality of swedes and turnips will again come before us in the next section.

CHAPTER IV

MANURING OF THE ROOT CROP.

Root Crops Exhausting to the Soil—Turnips Dependent on the Condition of the Soil—Exhausting Effect of Root Crops—Effect of Liberal Treatment upon Roots and the Succeeding Crop—Benefit from Folding Sheep on Turnips—The Best Application for Turnips—Value of Rothamsted Experiments—Cirencester Chamber of Agriculture Experiments—Practical Directions for Manuring—Injurious Actions of Guano—Injurious Action of Nitrates—Summary of Results—Effect of Climate on Manures—Importance of Farm-yard Manure Illustrated by Effect on Mangel—Importance of Farm-yard Manure on the Root Crop—Methods of Applying Fertilizers.

No class of crops is more dependent upon a liberal supply of plant food than the root crops. The large weight per acre grown, and the exceedingly short time in which the growth takes place, are quite sufficient reasons to account for the importance of liberal treatment. Mr. Warington gives, in his little work entitled the *Chemistry of the Farm*, a tabular statement showing the amount of various constituents of plant food removed from an acre of land in pounds by various crops. If we place side by side the amounts of nitrogen and of ash constituents taken from an acre of land by average crops of turnips, wheat, barley and clover hay, the exhausting nature of turnips will be rendered apparent. Dr. Gilbert recently pointed out the fallacy of supposing turnips and swedes to be renovating crops, or restorers of fertility, and shows that so far from this being the case no crops will more quickly collect and remove the superfluous plant food out of a soil than swedes or turnips. The practical fact that root crops do assist to keep up and increase the fertility of a farm, is not due to any inherent power in the plants to absorb nitrogen from the air—or to collect it, like clover does, from the lower sections of the soil—but simply to the fact that they are consumed upon the land.

TABLE SHOWING THE AMOUNTS OF VARIOUS PLANT FOODS IN LBS. REMOVED FROM ONE ACRE OF LAND BY AVERAGE CROPS.

	White turnips 17 tons.	Swedes 14 tons.	Wheat 30 bushels.	Barley 40 bushels.	Clover hay 2 tons.
	lbs.	lbs.	lbs.	lbs.	lbs.
Nitrogen ...	71	74	33	35	102
Potash ...	108·6	63·3	9·7	9·8	87·4
Lime ...	25·5	19·7	1·0	1·3	86·1
Magnesia ...	5·7	6·8	3·7	4·0	30·9
Phosphoric acid	22·4	16·9	14·3	16·2	25·1

Reference to the above table clearly shows that although the turnip crop when consumed on the farm restores material drawn from the soil, it is capable of scourging land much more effectually than cereals, if carried off the farm.

That turnips or swedes grown without manure soon exhaust a soil of its available plant food, is well shown in the following case of Norfolk white turnips grown consecutively on the same land without manures, and is taken from results obtained at Rothamsted :—

	Tons.	cwts.
1843	4	3¾
1844	2	4½
1845	0	13¾

When grown in rotation at intervals of four years without any manures, a similar effect has been observed, the first crop apparently securing and carrying away with it all the available fertility.

In opposition to these results the effect of heavy dressings of farmyard manure upon the root crop, especially when made by fatting animals receiving liberal allowances of cake, is very marked, and the benefit is propagated in the following crops, fully bearing out the principle known to all good farmers, that "one good crop begets another." This fact is accounted for by the known effect of the decaying roots and residues of crops upon their successors. Once establish a vigorous growth, and the land becomes stocked with vegetable matter, containing not only nitrogen but inorganic matter in a state of organic combination, the decay of which furnishes available plant food in abundance to the next crop. This is one of the principal effects of the root crop, especially when in addition to the natural residue of root-fibres the entire crop is consumed upon the land by sheep.

The effect of dressings of 12 tons per acre of farmyard manure upon the root crops is shown by the Rothamsted results obtained in 1843-5.

	Tons.	cwts.
1843	9	$9\frac{1}{2}$
1844	10	15
1845	17	$0\frac{3}{4}$

If the reader contrasts these amounts with those obtained from unmanured land, the effect of farmyard manure upon the root crops will be made evident.

The statement made at the commencement of these remarks, that no crops are more dependent upon fertilizers than root crops, is very clearly shown by the rotation experiments at Rothamsted. In these experiments the four-course system is adopted, and roots are grown every four years. One half of the area under roots is entirely stripped of all produce, while upon the other half of the area the root crop is consumed upon the land by sheep. We are at present dealing with the denuded portion only. This portion is divided into three parts—(1) an unmanured portion;

(2) a portion in which superphosphates were applied to the root crops only, at intervals of four years; (3) a portion manured with complex mineral manures also applied to the root crops only.

Looking at these results we find, as might have been expected, a rapid falling off in produce in the portions from which all the crops were removed. But this falling off is much less evident in case of the barley and wheat occupying the second and fourth years of the rotation, than in the roots and clover crops.

PRODUCE OF ROOTS (OMITTING THE TOPS OR LEAVES) GROWN WITHOUT MANURE, AND REMOVED FROM THE LAND.

	PER ACRE. Tons.	cwts.
1848	3	5½
1852	1	6
1856	1	12
1860	0	1
1864	0	8¾
1868	Failed.	
1872	1	14½
1876	0	17½
1880	0	14
1884	0	5

Thus it is seen that upon exhausted land roots cannot be grown even at intervals of four years.

On the portions of root land which received superphosphates applied during almost the whole period at the rate of 200 lbs. of bone ash dissolved with 150 lbs. of sulphuric acid, the effect of the fertilizers employed is evident, although not satisfactory from a commercial point of view. The superphosphate thus applied evidently reacted upon the crop, enabling it to extract constituents from the soil to an injurious extent, as is seen by studying the table recording the yields of barley after roots. The larger turnip crop produced by means of superphosphate leaves the land in a truly impoverished condition, and the consequence is a serious reduction in the subsequent barley crop. Thus the conclusion is inevitable, that a root crop raised by applications of superphosphate of lime, and removed from the field, is exceedingly exhausting to the soil.

PRODUCE OF ROOTS (OMITTING THE TOPS OR LEAVES) MANURED WITH SUPERPHOSPHATE, AND REMOVED FROM THE LAND, AT INTERVALS OF FOUR YEARS.

	PER ACRE.	
	Tons.	cwts.
1848	11	$5\frac{3}{4}$
1852	11	3
1856	6	16
1860	1	$9\frac{1}{2}$
1864	3	8
1868	Failed.	
1872	8	$10\frac{5}{8}$
1876	9	$8\frac{1}{4}$
1880	9	$19\frac{1}{2}$
1884	8	$13\frac{3}{4}$

On the third portion the turnips were grown with a complete manure, during the third to eleventh courses, composed of the following ingredients:—

300 lbs. sulphate of potash.
200 „ „ soda.
100 „ „ magnesia.
200 „ bone ash.
150 „ sulphuric acid.
100 „ sulphate of ammonia.
100 „ chloride of ammonium.
2000 „ rape-cake.

This is at once a complex and liberal dressing, containing everything that the plant could require, and calculated to keep up the fertility of the land, in spite of the fact that the produce was constantly removed. Under the influence of this complex and liberal admixture, root crops varying from 15 to 16 and even 20 tons per acre were obtained, with the exception of those grown in the droughty years 1860, 1864, and 1868, which were unfavourable to plants of this description. Before leaving this part of our subject it will be well to glance at the effects of these various treatments upon the following crop of barley.

This crop was grown under three conditions; (1) after swedes unmanured and entirely removed; (2) after swedes manured with superphosphate and also removed; (3) after swedes receiving a very heavy and complete manure already described, and also removed. In the first case the root crop was so insignificant (see p. 66) that the land might almost be considered as having been bare fallowed rather than cropped. The removal of 5 cwts. or even 30 cwts. of roots could not exert any palpably injurious effect, and to this consideration we must attribute the very fair crops of barley, and even of wheat, which were obtained during the eleven courses of cropping during which this experiment has been carried out.

It is also interesting to note that while the turnips and swede plant found it impossible to live under such conditions, the cereals were able to draw nourishment from this partially exhausted soil, and to maintain an average of $31\frac{5}{8}$ bushels of barley, and of $26\frac{1}{4}$ bushels of wheat, even upon a starvation system. This, as already stated, must be accounted for on the ground that the root crops in this case resolved themselves into a series of bare fallowings.

The case of a series of swede crops grown with the aid of 200 lbs. of bone-ash, and 150 lbs. of sulphuric acid converted into superphosphate, is very different. Here the swede crop was able to develop and draw from the soil to a degree detrimental to the succeeding crop. Hence, although at first sight the treatment is more liberal, the whole effect is expended upon the greedy root crop, and the average yield of barley is reduced to $26\frac{7}{8}$ bushels.

Lastly, when the complicated liberal dressing was applied every four years, not only was the root crop abundant, but the average of the barley crop was pushed up to $40\frac{1}{4}$ bushels per acre, proving the importance of maintaining land in high condition if it is desired to produce good root crops.

It is at this point that objection is taken by some agriculturists to the root crops as both expensive and entailing expense. Why, we are asked, keep up the fertility of land in order to enable it to grow a class of crops not in themselves profitable? It must, however, be kept in view that in ordinary farming the conditions are different from those which accompany a strict system of experiments such as those just cited. A period for cleaning land is necessary, and this the root crop allows of. The system of feeding the root crop on the land, or at least on the holding, not only restores the fertilizing matter accumulated from the soil, but returns it in a condition in which it is immediately available for future plants. Instead of an exhausting crop it becomes a renovating or restorative crop, and the mass of root fibres left in the soil no doubt tells favourably upon the fertility of the soil as truly as does the consumption of the bulb itself. The maintenance of a large head of sheep upon the lighter description of soils is found to be so inseparably connected with their successful cultivation, that the root crops become in turn essential, simply because the maintenance of sheep would not be practicable without them.

The interdependence of barley upon roots, and wheat upon clover, is a fact which cannot be lightly passed over, and it is for the objectors to the present system of farming, to propose a better system of profitably cultivating our extensive wolds and downs.

Phosphatic manures produce a striking effect upon cruciferous crops, such as turnips, rape, and cabbage. As already shown, phosphatic dressings so stimulate the growth of turnips and swedes as to cause them to draw severely upon the soil for the remaining constituents both mineral and nitrogenous, and thus accelerate exhaustion.

In ordinary farming this effect is obviated by the application of farm-yard dung, and by the consumption of the turnips with imported food upon the farm. No evil consequences therefore follow, and the turnip crop is usually raised by applying superphosphate, either alone or in combination with dung.

The effect of additions of other mineral substances, such as potash, soda, and magnesia to superphosphate, do not give a sufficient increase to warrant their recommendation, and such small effects as they have been observed to produce have been under conditions of exhaustion artificially produced under consecutive and continuous cropping. The effect of potash, gypsum, or sulphate of soda and magnesia will be found to be practically *nil* where farm-yard manure is applied, and where the crops are consumed upon the land. Ammonia salts and nitrate of soda, although producing an increase of leaves, do not greatly increase the yield of bulbs. Their effect when applied alone on exhausted soils is trifling, but where there is an abundance of available mineral food an increase is no doubt effected by their application. This increase is, however, not commensurate with the expense, and the wiser system is to employ superphosphates in root cultivation, and hold back the ammonia salts and nitrate of soda for application on the cereals or grasses. The following table exhibits the actual effects of various dressings applied to swedes during fifteen years (1856—1870) at Rothamsted by Sir John Lawes. The crops are small, owing to the fact that an exhausting crop was grown year by year, and that the roots and leaves were carted off the land. The lightness of

TABLE I. SWEDISH TURNIPS; FIFTEEN SEASONS, 1856-1870.(1) Roots and Leaves carted off the Land.

Plots.	Series 1. Manures as under; no Cross-dressing.	Series 1. Roots.	Series 1. Leaves.	Series 2. 5 years, 1856-1860. 3000 lbs. Saw-dust. 328 lbs. Nitric Acid. 10 years, 1861-1870. 550 lbs. Nitrate Soda. Roots.	Series 2. Leaves.	Series 3. 5 years, 1856-1860. 200 lbs. Ammonia-salts. 10 years, 1861-1870. 400 lbs. Ammonia-salts. Roots.	Series 3. Leaves.	Series 4. 5 years, 1856-1860. 200 lbs. Ammonia-salts. 3000 lbs. Sawdust. 10 years, 1861-1870. 400 lbs. Ammonia-salts. 2000 lbs. Rape-cake. Roots.	Series 4. Leaves.	Series 5. 5 years, 1856-1860. 3000 lbs. Sawdust. 10 years, 1861-1870. 2000 lbs. Rape-cake. Roots.	Series 5. Leaves.
		T. cwts.	T. cwts.	T. cwts.	T. cwts.	T. cwts.	T. cwts.	T. cwts.	T. cwts.	T. cwts.	T. cwts.
1	Farmyard Manure, 14 tons	6 4	0 17	7 9	1 2	8 8	1 4	8 16	1 9	8 0	1 4
2	Farmyard Manure, 14 tons, and Superphosphate	6 7	0 16	7 13	1 3	8 5	1 5	8 14	1 9	7 16	1 2
3	Without Manure, 1846, and since	0 11	0 3	0 19	0 4	0 13	0 3	3 6	0 14	3 8	0 13
4	Superphosph., each year; Sulph. Potass, Soda, and Magnesia, 1856-60	2 16	0 8	5 2	0 16	4 12	0 14	6 12	1 6	5 8	0 17
5	Superphosphate, each year	2 12	0 9	4 13	0 18	3 16	0 15	5 16	1 7	5 0	0 19
6	Superphosphate, each year; Sulphate Potass, 1856-60	2 7	0 7	4 11	0 14	4 5	0 13	6 6	1 2	5 3	0 16
7	Superphosph., each year; Sulph. Potass, and 36½ Amm.-salts, 1856-60	2 12	0 7	4 13	0 14	4 12	0 14	6 15	1 4	5 9	0 17
8	Unman. 1853, and since; previously part Unman.; part Superphosph.	1 3	0 4	1 13	0 5	1 2	0 5	3 19	0 18	3 14	0 19

Series 2–5: Each Plot manured as Series 1, and Cross-dressed as under—

NOTE.—"Sulphate of Ammonia" is estimated to contain 23 per cent. Ammonia, and "Muriate of Ammonia" 27 per cent. "Ammonia-salts," in each case, equal parts Sulphate and Muriate of Ammonia of commerce; and the mixture is estimated to contain 25 per cent. Ammonia. The 328 lbs. Nitric Acid (Sp. gr. 1·35), mixed with sawdust, and used as a cross-dressing on the Plots of Series 2, from 1856-1860, were estimated to contain Nitrogen = 50 lbs. Ammonia.

(1) The crops of 1859 and 1860 failed, and were ploughed in; but, as the manures were applied, and there would be accumulation within the soil for the succeeding crops, the average produce is calculated as for 15 years, that is, the produce of the 13 years is, in each case, divided by 15.

the crops need not be considered as detracting from the value of the results. The effects of the various manures are indeed all the more strongly brought out by the partial exhaustion of the soil and the isolation of the plots from a mixed system of manuring such as that usually employed by farmers.

The effect of farm-yard manure in increasing the yield over the unmanured portion deserves notice, and the comparatively small increase obtained where heavy dressings of ammonia salts and nitrate of soda were cross-dressed over certain portions of these plots is also striking. The small effect of superphosphate is accounted for by the consideration that general exhaustion of the field was the inevitable consequence of the system pursued of growing consecutive crops of swedes. The conclusion already arrived at with regard to the inadequate results of ammonia salt and nitrate of soda as a dressing for swedes in comparison with the effects produced of farm-yard manure, is still further supported by the considerable effects which, in the above table, is seen to accompany the application of heavy dressings of rape-cake and sawdust, which no doubt produced a very similar effect to dung.

INFLUENCE OF CONDITION AND QUALITY OF THE SOIL UPON EFFECTS OF FERTILIZERS.

The Rothamsted experiments in this country give the best answer as to the actual effects of various fertilizers upon our farm crops. The length of time during which the same crops have occupied the same plots have produced a state of tension with regard to the requirements of the crops which has rendered the soil exceedingly responsive to any change which may be introduced in the system of manuring employed. This prepared or sensitive condition of the plots, the precise condition of which has been carefully regulated for forty years, is of immense value, when it is wished to actually test the effect of a fertilizer by the system of cross-dressing pursued. It is true the effect may be registered in a small yield per acre, but it is nevertheless accurate and measurable, and practical suggestions may be deduced of the highest value. Still, it must be allowed that the artificial condition of soil induced by long-continued experiment constitutes a difficulty in the way of the practical application of the Rothamsted results to land subjected to the complex system of manuring adopted where heavy stocks of sheep and cattle are maintained, and a rotation of crops is practised. The effects of fertilizers in such cases is masked and obscured by previous manuring, and the consequence is a degree of uncertainty as to results which is puzzling to the uninitiated.

As a general rule, the poorer the ground the greater is the effect of manuring. These effects are, however, still further obscured by the nature or the artificial condition of soils. Thus, soils abounding in nitrates are scarcely likely to respond to further additions of nitrates, and soils of calcareous character are not likely to be greatly benefited by dressings of lime. Hence the various opinions expressed by farmers as to the merits of fertilizers, and the disappointment which often follows the adoption of certain suggestions based on the experience of others. Sometimes the most approved manurial substances produce no effect, and at other times an excessive result, according as particular constituents of plant food abound or are wanting.

The higher the condition of a field, the more difficult is it to find a manure which really tells in an increased produce; and consequently the more likely is the unmanured portion to produce as good a result as the dressed portion.

The conclusion is well illustrated by a series of experiments undertaken by myself with the co-operation of members of the Cirencester Chamber of Agriculture, from 1868 to 1876. These experiments were chiefly upon swedes, and the

TABLE IV. GENERAL RESULT OF EXPERIMENTS UPON SWEDES, 1873.—NUMBERS AND WEIGHTS OF SWEDES PER PLOT.

	Earl Bathurst.		Mr. Swanwick. R. A. Col.		Mr. J. Smith.		Mr. E. Bowly.		Rev. T. Maurice.		Mr. L. D. Little.		Mr. Price. F. Y. M.		Mr. Price. No F. Y. M.		Mr. Iles.		Mr. W. J. Edmonds.		Mr. Marshall.		Mr. O'Dwyer.		Average Results.	
	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.
1 Peruvian Guano 3 cwt. per acre.	676	3·4	85	2·79	357	4·35	556	2·35	253	3·	181	3·1	414	3·11	407	3·14	552	2·1	652	2·6	816	1·77	474	1·42		
	678	3·4	551	3·23	504	3·53	455	2·53	296	2·27	142	3·33	409	3·35	409	2·7	669	2·25	667	2·63	835	1·7	414	1·6		
Average	677	3·4	568	3·	430	3·94	505	2·44	274	2·64	162	3·2	411	3·23	405	2·92	605	2·18	659	2·61	825	1·73	444	1·51	497	2·73
2 Dissolved Peruvian Guano.	695	3·3	589	3·04	403	4·17	550	3·08	275	3·88	187	3·7	455	3·4	685	2·76	502	2·25	684	2·61	776	2·01	541	1·55		
	642	3·5	585	3·4	527	3·71	679	2·18	284	3·38	193	3·6	783	1·75	353	2·8	575	2·17	754	2·3	783	1·93	527	1·68		
Average	668	3·4	587	3·22	465	3·94	614	2·63	280	3·63	190	3·6	619	2·58	519	2·78	538	2·20	719	2·45	779	1·97	534	1·61	542	2·83
3 Mineral Superphosphate 3 cwt. per acre.	647	3·1	778	1·91	807	2·44	838	2·35	897	1·85	807	1·71	877	1·94	864	1·86	912	1·7	755	1·92	999	1·44	758	·85		
	701	2·8	785	2·17	791	2·26	783	2·26	913	2·15	684	2·02	795	1·75	866	1·4	942	1·62	673	1·86	1032	1·48	744	1·0		
Average	674	2·95	781	2·	799	2·35	810	2·4	905	2·0	746	1·86	836	1·85	865	1·63	927	1·66	714	1·89	1015	1·46	750	·92	818	1·9
4 Min. Superphos. 3 cwt. Peruvian Guano 3 cwt.	676	3·4	687	2·94	734	2·74	627	3·16	614	2·64	330	3·	761	2·28	719	2·38	703	2·1	728	2·47	863	1·95	679	1·57		
	667	3·6	676	3·19	599	3·5	647	3·15	506	3·1	333	3·4	790	2·08	587	2·6	734	2·21	708	2·8	893	1·8	649	2·0		
Average	671	3·5	681	3·06	666	3·14	637	3·16	560	2·87	332	3·2	776	2·18	653	2·49	718	2·15	718	2·63	878	1·87	664	1·78	662	2·67
5 Min. Superphos. 3 cwt. Organic matter ½ cwt.	707	3·0	763	2·03	750	2·34	773	2·57	829	2·13	668	1·76	894	1·82	850	1·28	908	1·6	720	1·92	877	1·8	752	·95		
	671	3·3	768	2·16	801	2·38	826	2·46	913	1·8	734	1·7	687	2·9	892	1·5	917	1·75	665	2·2	909	1·75	756	1·2		
Average	725	3·15	765	2·1	775	2·36	799	2·5	871	1·96	701	1·73	790	2·36	871	1·39	912	1·67	742	2·08	893	1·78	754	1·07	727	2·0
6 Min. Superphos. 3 cwt. Nitrate of Soda ½ cwt. Potash Salts ½ cwt. Organic matter ½ cwt.	656	3·5	804	2·0	756	2·6	795	2·54	806	2·16	578	2·22	862	1·82	858	1·82	907	1·97	741	2·15	914	1·64	742	·98		
	688	3·2	761	2·4	672	2·52	783	2·4	939	2·	640	2·14	836	2·17	861	1·45	928	1·98	704	1·97	897	1·77	741	1·12		
Average	672	3·35	783	2·2	714	2·56	789	2·47	873	2·08	609	2·18	849	1·94	859	1·63	917	1·97	722	2·06	905	1·7	742	1·05	787	2·1
7 Organic matter ½ cwt. Nitrate of Soda ½ cwt. Potash Salts 1 cwt.	701	2·4	765	1·7	702	2·61	745	2·	576	·16	621	1·53	800	2·	851	1·5	817	1·07	734	·82	910	·95	615	·46		
	710	2·1	732	2·1	771	2·37	789	1·46	660	·44	640	1·1	811	1·95	807	1·4	899	·92	743	1·0	877	1·17	614	·36		
Average	705	2·25	748	1·9	737	2·44	767	1·73	618	·3	630	1·3	806	1·97	829	1·45	859	1·49	738	0·9	898	1·0	614	·41	744	1·43
8 Unmanured.	701	1·8	692	1·7	813	2·02	803	1·55	666	·34	625	1·64	783	2·01	900	1·4	854	·81	835	·5	950	1·12	348	·35		
	695	1·6	740	1·46	783	2·24	813	2·02	475	·3	657	·7	583	2·85	887	1·1	746	·8	612	·78	977	·85	468	·16		
Average	698	1·7	766	1·58	828	2·13	808	1·78	571	·32	641	1·67	683	2·45	893	1·25	800	·8	723	·64	963	1·5	408	·25	732	1·33

TABLE V. GENERAL RESULT OF EXPERIMENTS UPON SWEDES, 1874, UNDERTAKEN BY MEMBERS OF THE CIRENCESTER CHAMBER OF AGRICULTURE.

Dressings per Acre.	Earl Bathurst, Oakley Park.	Rev. T. Maurice, Harnhill.	Mr. E. Parson, Coates.	Mr. Arkell, Dean Farm.	Mr. W. J. Edmonds, Southrop.	Mr. Stevens, Ranbury.	Mr. Brain, Quenning-ton.	Mr. Hawkins, Oaksey.	Average of the Eight Sets.
	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.
1 Mineral Superphosphate 3 cwt. per acre.	10 9 72	10 0 0	12 14 32	11 10 100	10 16 28	9 13 44	10 18 84	13 9 52	
	10 13 4	9 3 44	12 14 12	14 1 108	11 5 60	9 17 76	10 10 0	11 6 28	
	Average	Average	Average	Average	Average	Average	Average	Average	
	10 11 38	9 11 78	12 14 22	12 16 48	11 0 100	9 15 60	10 14 42	12 7 96	11 4 4½
2 Mineral Superphosphate 3 cwt. and Nitrate of Soda 1 cwt.	10 17 56	6 14 32	10 5 40	14 8 64	12 3 44	6 0 10	8 19 72	10 10 40	
	11 18 104	8 15 60	10 10 0	11 16 108	13 3 4	5 9 12	7 0 0	11 0 100	
	Average	Average	Average	Average	Average	Average	Average	Average	
	11 7 109	7 14 102	10 7 76	13 2 86	12 13 24	5 14 67	7 18 99	10 15 70	9 19 50¼
3 Mineral Superphosphate 3 cwt., Dissolved Guano 2 cwt., drilled together.	12 10 0	11 18 104	12 13 24	15 4 32	11 18 84	8 11 48	11 6 108	11 5 80	
	12 18 84	10 7 56	15 0 0	15 12 36	12 2 76	12 16 28	9 16 8	10 9 72	
	Average	Average	Average	Average	Average	Average	Average	Average	
	12 14 42	11 3 24	13 16 68	15 8 34	12 0 80	10 13 94	10 11 58	10 17 76	12 13 14
4 Mineral Superphosphate 3 cwt., Dissolved Guano 2 cwt., sown broadcast separately.	13 3 4	8 18 84	12 11 108	14 8 84	13 1 8	10 1 28	10 9 32	12 14 72	
	12 0 80	10 18 24	14 5 0	15 6 108	12 17 16	10 8 24	11 0 0	12 19 72	
	Average	Average	Average	Average	Average	Average	Average	Average	
	12 11 98	9 18 54	13 8 54	14 17 96	12 19 12	10 4 82	10 14 72	12 17 16	12 16 18
5 Mineral Superphosphate 3 cwt., Nitrate of Soda, 1 cwt., Organic matter ½ cwt., Potash Salts ½ cwt.	10 13 84	10 5 0	10 0 0	13 14 72	10 18 84	3 15 0	8 5 20	9 10 0	
	7 6 88	7 9 12	9 10 80	15 18 4	11 16 16	8 18 84	6 13 64	5 2 96*	
	Average	Average	Average	Average	Average	Average	Average	Average	
	9 0 30	8 17 6	9 15 40	14 16 38	11 7 50	6 6 98	7 9 42	7 6 48	9 7 44
6 Patent Bone Superphosphate 3 cwt.	9 7 56	5 4 92	12 0 0	9 12 16	7 2 76	7 9 32	7 0 80	13 10 40	
	8 13 4	7 17 96	10 3 44	8 10 60	7 18 4	7 1 88	8 14 72	12 6 8	
	Average	Average	Average	Average	Average	Average	Average	Average	
	9 0 30	6 11 38	11 1 78	9 1 38	7 10 40	7 5 60	7 17 76	12 18 24	8 18 34
7 Unmanured Plots.	6 8 84	2 1 8	10 8 44	2 9 92	2 1 88	3 5 0	3 14 52	11 8 4	
	5 11 28	0 14 36	4 10 20	2 1 8	2 0 0	3 7 56	8 10 0	14 9 12	
	Average	Average	Average	Average	Average	Average	Average	Average	
	6 0 0	1 7 78	7 9 32	2 5 50	2 0 100	3 6 28	6 2 26	12 18 64	5 3 89¼

* This Plot was re-sown—hence a large number of roots and little weight per acre.

TABLE VI. GENERAL RESULT OF EXPERIMENTS, 1874, UNDERTAKEN BY MEMBERS OF THE CIRENCESTER CHAMBER OF AGRICULTURE, SHOWING INCREASE OVER UNMANURED PORTIONS PER ACRE.

Dressings per Acre.	Earl Bathurst, Oakley Park.	Rev. T. Maurice, Harnhill.	Mr. E. Parson, Coates.	Mr. Arkell, Dean Farm.	Mr. W. J. Edmonds, Southrop.	Mr. Stevens, Ranbury.	Mr. Brain Quenning-ton.	Mr. Hawkins, Oaksey.	Average increase in the Eight Sets over unmanured plots.
	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.	T. cwt. lbs.
1 Mineral Superphosphate 3 cwt. per acre.	4 9 72	8 12 34	5 5 0	9 5 50	8 15 40	6 7 16	4 16 58	+0 10 100	
	4 13 4	7 15 78	5 4 92	11 16 58	9 4 72	6 11 48	4 7 86	—1 12 36	
	Average	Average	Average	Average	Average	Average	Average	Average	
	4 11 38	8 4 0	5 4 102	10 10 110	9 0 0	6 9 32	4 12 16	—0 10 80	6 0 27
2 Mineral Superphosphate 3 cwt., Nitrate of Soda 1 cwt.	4 17 56	5 6 66	2 16 8	12 3 14	10 2 56	2 13 94	2 17 46	—2 8 24	
	5 18 104	7 7 94	3 0 80	9 11 58	11 2 16	2 2 94	0 17 86	—1 17 76	
	Average	Average	Average	Average	Average	Average	Average	Average	
	5 7 109	6 7 24	2 18 44	10 17 36	10 12 36	2 8 39	1 16 66	—2 2 106	4 15 78
3 Mineral Superphosphate 3 cwt., Dissolved Guano 2 cwt., drilled together.	6 10 0	10 11 26	5 3 104	12 18 94	9 17 96	5 5 20	5 4 82	—1 12 96	
	6 18 84	8 19 90	7 10 80	13 6 98	10 1 88	9 10 0	3 13 94	—2 8 4	
	Average	Average	Average	Average	Average	Average	Average	Average	
	6 14 42	9 15 58	6 7 36	13 2 90	10 19 92	7 7 66	4 9 32	—2 0 100	7 9 36½
4 Mineral Superphosphate 3 cwt., Dissolved Guano 2 cwt., sown broadcast separately.	7 3 4	7 11 6	5 2 76	13 3 34	11 0 20	6 15 0	4 7 6	—0 3 104	
	6 0 80	9 10 59	6 15 80	13 1 58	10 16 28	7 1 108	4 17 86	+0 1 8	
	Average	Average	Average	Average	Average	Average	Average	Average	
	6 11 98	8 10 88	5 19 22	12 12 46	10 18 24	6 18 54	4 12 46	—0 1 48	7 12 40½
5 Mineral Superphosphate 3 cwt., Nitrate of Soda 1 cwt., Organic matter ½ cwt., Potash Salts ½ cwt.	4 13 84	8 17 34	2 10 80	11 9 22	8 17 96	0 8 84	2 2 106	—3 8 64	
	1 6 88	6 1 46	2 1 48	13 12 66	9 15 28	5 12 56	0 11 38	—7 15 80	
	Average	Average	Average	Average	Average	Average	Average	Average	
	3 0 30	7 9 40	2 6 8	12 10 100	9 6 62	3 0 70	1 7 16	—5 12 16	4 3 66½
6 Patent Bone Superphosphate 3 cwt.	3 7 56	3 17 14	4 10 80	7 6 78	5 1 88	4 3 4	0 18 54	+0 12 88	
	2 13 4	6 10 18	2 14 12	6 5 10	5 17 16	3 15 60	2 12 26	—0 12 56	
	Average	Average	Average	Average	Average	Average	Average	Average	
	3 0 30	4 13 92	3 12 46	6 15 100	5 9 52	3 19 32	1 15 50	—0 0 40	14 56½
7 Unmanured.	(6 0 0	1 7 78	7 9 32	2 5 50	2 0 100	3 6 28	6 2 26	12 18 64)	

TABLE VII. GENERAL RESULT OF EXPERIMENTS UPON SWEDES, 1874.—NUMBERS AND WEIGHTS OF SWEDES PER PLOT.

Dressings per acre.	Earl Bathurst, Oakley Park.		Rev. T. Maurice, Harnhill.		Mr. E. Parson, Coates.		Mr. Arkell, Dean Farm.		Mr. W. J. Edmonds, Southrop.		Mr. Stevens, Ranbury.		Mr. Brain, Quenning-ton.		Mr. Hawkins, Oaksey.		Average of the Eight Sets.	
	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.
1 Mineral Superphosphate 3 cwt.	724	1·62	881	1·27	853	1·66	868	1·4	911	1·33	640	1·7	784	1·5	673	2·2		
	649	1·82	858	1·25	827	1·72	787	2·0	942	1·33	716	1·5	758	1·5	651	1·9		
Average	686	1·7	870	1·26	840	1·6	828	1·7	926	1·33	926	1·6	771	1·5	661	2·0	813	1·6
2 Mineral Superphosphate 3 cwt., Nitrate of Soda 1 cwt.	650	1·87	758	0·92	635	1·81	786	2·1	748	1·15	409	1·6	695	1·4	534	2·2		
	694	1·91	544	1·8	587	2·0	739	1·8	859	1·7	482	1·2	538	1·4	574	2·1		
Average	672	1·89	651	1·3	611	1·9	762	1·9	803	1·76	446	1·4	616	1·4	554	2·15	639	1·7
3 Mineral Superphosphate 3 cwt., Dissolved Guano 2 cwt., drilled together.	637	2.2	668	2·0	653	2·17	776	2·2	836	1·6	429	2·2	636	2·0	534	2·3		
	651	2·2	642	1·8	777	2·16	786	2·2	911	1·48	754	1·9	494	2·2	670	2·0		
Average	644	2·2	655	1·9	715	2·16	781	2·2	873	1·5	591	2·0	565	2·1	552	2·15	672	2·0
4 Mineral Superphosphate 3 cwt., Dissolved Guano 2 cwt., sown broadcast separately.	772	1·9	850	1·17	812	1·7	903	1·8	805	1·8	745	1·5	668	1·7	570	2·5		
	743	1·8	956	1·27	798	2·0	799	2·15	888	1·6	632	1·8	673	1·8	667	2·2		
Average	757	1·85	903	1·23	805	1·8	851	1·9	846	1·7	688	1·65	670	1·75	618	2·35	767	1·8
5 Mineral Superphosphate 3 cwt., Nitrate of Soda 1 cwt., Organic matter ½ cwt., Potash Salts ½ cwt.	596	2·0	745	1·5	471	2·36	820	1·9	780	1·5	275	1·5	592	1·5	534	2·0		
	475	1·7	513	1·6	494	2·14	702	2·5	865	1·5	566	1·7	460	1·6	592	1·0		
Average	535	1·88	629	1·55	482	2·26	761	2·17	823	1·5	420	1·6	526	1·55	563	1·5	592	1·8
6 Patent Bone Superphosphate 3 cwt.	756	1·38	813	·7	746	1·8	831	1·3	787	1·0	731	1·15	702	1·1	681	2·2		
	615	1·58	690	1·3	746	1·5	814	1·17	862	1·0	638	1·2	573	1·7	560	2·4		
Average	685	1·48	750	1·0	746	1·6	823	1·23	825	1·0	684	1·17	638	1·4	620	2·3	722	1·4
7 Unmanured	684	1·0	284	·81	541	2·15	706	·39	560	·4	540	·1	575	·7	598	2·1		
	573	1·0	497	·32	706	·7	457	·5	599	·3	598	·6	703	1·3	682	2·3		
Average	628	1·0	390	·4	624	1·3	582	·4	580	·35	570	·35	640	1·0	640	2·2	582	·9

great differences of results obtained upon various descriptions of soils was very marked. Tables II., III., and IV contain evidences of the fact that the natural quality and condition of the soil has much to do with the effect of a dressing. The experiments embodied in these tables were conducted in 1873 upon twelve farms in the neighbourhood of Cirencester. These farms were of very different character, and in various degrees of fertility, and in order to make this plain, a brief description of each soil is given.

Earl Bathurst's experiments were conducted on good sheep land, lying in the Great Oolite, and enriched by long-continued high farming. The experiments upon the Royal Agricultural College farm were carried out upon somewhat heavy land in good condition. Mr. J. Smith's farm was better known to the public when under the management of the late Mr. Charles Lawrence, for many years a member of Council of the Royal Agricultural Society. This land is not only of natural good quality, but was in high condition, and it will be seen that the unmanured portion gave as good a result as some of the manured plots. The late Mr. E. Bowly, as a breeder of shorthorns and of Oxford Down sheep, was a liberal manager, and Siddington is known to be a fertile farm, resting on the corn-brash of the Lower Oolite. Here again the unmanured plots yielded such fair results that no manure could produce a startling increase. The Rev. T. Maurice, J.P., farmed poor glebe at Harnhill, Cirencester, and in this case the unmanured plots yielded an exceedingly poor crop, averaging only 1½ tons per acre. Here, as a consequence of the poverty of the ground, very large increases were obtained from the use of artificial fertilizers. This is the best condition of land for indicating the *maximum* effect of manures. Mr. L. D. Little, of Northcote, Cirencester, farmed land of fair quality, but in low condition, and here the same general principle is indicated. Mr. Price, of

Quenington, undertook a double series of experiments, one being carried out upon land dressed with farm-yard manure, and the other upon adjoining land without dung, and these results are of great interest, as showing that artificial manures exert a greater effect when used upon unmanured than upon manured land. Mr. Iles of Reevy, and Mr. J. Edmonds of Southrop's experiments indicated poor land upon which artificial dressing produced an excellent effect. Mr. Marshall of Poulton farms land of stronger character, producing 8½ tons per acre of swedes without dressings, and satisfactory increases from the use of the dressings employed. Mr. O'Dwyer, who at the time rented some miserably poor land near Sapperton, showed that on his farm the swedes could not grow without artificial help, and that even with such assistance the crops were very light.

The varying capabilities of these soils to grow swedes without assistance is shown below, and the extraordinary divergence in the results as indicated in increase over unmanured plots is shown in Table II. The unmanured plots were 24 in number, and gave a general average yield of 8 tons 8 cwt. 74 lbs. per acre.

RESULTS OBTAINED WITHOUT ARTIFICIAL DRESSINGS.

		Tons	cwts.	lbs.		No. of plants per plot
Mr. Smith	obtained	15	3	14	without dung	828
Earl Bathurst	,,	12	0	4	,, ,,	698
Rev. T. Maurice	,,	1	10	80	,, ,,	571
Mr. Iles	,,	5	16	18	,, ,,	800
Mr. Marshall	,,	8	9	102	,, ,,	963
Mr. Price	,,	14	9	53	with dung	683
Mr. Price	,,	9	0	75	without dung	893
Mr. Edmonds	,,	4	0	30	,, ,,	723

In all these cases the same seed was used, and the same general climatic conditions existed, and the extraordinary differences must be attributed to the natural quality and condition of the land.

With the assistance of Messrs. Reeve, of the Bratton Iron

Works, Westbury, I contrived a liquid manure drill adapted for our purpose. It, in general form, resembled the ordinary drill, but by some three or four alterations we were enabled to sow more exact quantities, and to clear the drill completely out upon every plot of one-twentieth part of an acre, and this without any delay or difficulty. A suitable man was found to undertake the work of drilling the swedes upon every farm, so that by the use of this implement, travelling as it did from farm to farm, we were enabled to secure a more uniform method than if each farmer had been left to follow his own devices. Messrs. Proctor and Ryland, of Birmingham, were also communicated with, and courteously offered to supply their own manufactured manures free of cost, and others, which they did not manufacture, at prime cost. These manures were mixed, weighed, numbered, labelled, bagged, addressed, and forwarded to the various gentlemen who were willing to undertake experiments, and hence a regular system was introduced, which enabled us to start upon a new and improved footing. A circular was also issued inviting attention to, and co-operation with, our scheme. I adhered to the principle which has always been my motto, viz. Repetition and Control. Perhaps the high expectation which I at one time formed has been a little damped, but in any true investigation we must accept the answer which nature makes to our questions, even although apparently these answers may be contradictory. It might have been more satisfactory if we had found that in this district a certain and absolute effect always followed the use of a particular dressing or a particular treatment. Such is not the case, and the tendency of our investigation is more and more to doubt the utility of those general recommendations to a certain course of practice with which agricultural periodicals and journals teem. Published reports of experiments, however interesting in themselves, and however satisfactory as showing an appreciation of science on the part of the experimenter, must be looked upon with a degree of suspicion when they are presented before us as guides for our practice. The results about to be recorded clearly place agricultural experiments upon another and new footing. They cease to appear in the light of general guides for the agricultural public. No longer must we examine tables of experiments with a view to finding the best manure for swedes, wheat, or clover—or rely upon the testimony of our market acquaintances and farming friends for prescription for manures. Each for himself must endeavour by strict experiment to find the best fertilizing substances for his own particular farm. What, then, becomes of the system of conducting agricultural inquiry, involving frequent repetition and control? Firstly, it enables us to come to the above important conclusion; secondly, it affords the interesting spectacle of simultaneous effects, and those exhibit to us the varied character of soils; thirdly, repetition alone can bring out those effects of season, which will in one year frequently reverse the verdict of the preceding one; fourthly, it opens up a question of deep importance, requiring much more delicate investigation than is possible to agriculturists alone, and which requires the aid of agricultural chemists. I allude to the inquiry into reasons why such differences as these experiments demonstrate exist. Why do we find one soil able to give 15 tons of swedes without manure of any sort, while another can only produce its 17 cwt., albeit with a regular plant? Why do we find a decrease from the use of superphosphate in one instance, compared with an overwhelming increase from its use in another case? Why do we find a clear dictum in favour of one manure furnished by one series of experiments completely reversed by another? The answers to these questions are perhaps beyond our knowledge, but that they are *bonâ fide* questions, founded upon true experience, cannot be doubted for a moment by those who follow me through the results of previous years. These experiments also show us the difficulties which must beset the practical solution of the question of tenant-right, for how can we assign a general or universal value to a particular fertilizer, when perhaps this fertilizer, while exceedingly effective on one farm, is without effect upon another? Lastly, at the risk of repetition, I must enforce from experience the importance of each farmer testing the value of artificial manures upon his own farm for himself. Such tests are essential, for it seems altogether unreasonable that we should spend hundreds of pounds upon artificial fertilizers, upon land which could well afford to do without them. On the other hand, such tests would stimulate the purchase of still larger quantities where a marked effect was observable. While we find these varying and even contradictory results brought out by experiment, we also are able to trace certain effects which run through the entire series of trials. When such is the case we have evidence of extraordinary strength, which may be taken as a guide for future practice.

UNMANURED PLOTS.

These were 24 in number, distributed over various parts of the district. They give a general or average yield of 8 tons 8 cwt. 74 lbs. per plot. Some of these received moderate dressings of farm-yard dung. The season being propitious, and the plant being for the most part regular, this yield may be taken as indicative of what land without the help of artificial fertilizers will yield. Taking 25 inches as the width between our drills, and 15 inches as the distance between our plants, we ought to find 836 plants upon each plot of one-twentieth part of an acre. The average number of plants was actually 731, and, allowing for difference of space in hoeing, the plots carried a fair plant. The immense difference which existed between the yield of these plots is well worthy of attention, and is shown by the table already given, p. 81.

PERUVIAN GUANO,

as is well known, diminishes the number of plants, and sometimes in a most marked degree, halving and quartering their number. This was, however, not always the case, and guano gave the heaviest crop in more than one series of experiments. I attach great importance to this result. It has been borne out by previous experiments, and shows that although guano is not in general favour in our southern counties, yet there are soils which it suits, and this is particularly the case in wet seasons.

DISSOLVED PERUVIAN GUANO

was used with still greater success, and when compared with the dressing of ordinary guano, always, with one exception, gave a better result. Taking the entire twelve series of experiments, the average yield, after a dressing of dissolved Peruvian guano, was 1 ton 5 cwt. greater than after the use of ordinary Peruvian guano.

GUANO AND SUPERPHOSPHATE MIXED.

This dressing was accompanied by a considerable increase in crops over cases in which either manure was used separately. It was also accompanied by a great increase in the number of plants. When compared with guano alone, superphosphate gave an average number of 818 plants over the entire series, the dressing in question gave an average of 662 plants, while Peruvian guano used alone yielded an average of only 497 plants. The average weight of plants raised with superphosphate alone was 1·9 lbs.; that of plants raised with superphosphate and guano mixed was 2·67 lbs.; while the weight of an average plant raised by Peruvian guano was 2·73 lbs. Hence, we see that the tendency of guano, whether used alone or mixed with superphosphate, is at once to lessen the number of plants, while it increases the average weight of each root. This fact was conspicuous to any one who examined the plants before they were weighed, and seems to show that while guano destroys the vitality of seed with which it comes in contact, it stimulates strongly the growth of the survivors, so that although much fewer plants are left, they frequently yield a crop which rivals in weight that grown by the milder superphosphate. It is worth consideration how far guano may be applied in some way which will prevent its direct contact with the seed. For example, superphosphate might be drilled, while a moderate addition of guano might with advantage be incorporated with the soil previous to sowing.

SUPERPHOSPHATE.

The effect of superphosphate alone was singularly various. In one case, upon land which had received farm-yard manure, a deficiency in crop followed the use of superphosphate when compared with farm-yard manure alone. A second case gave only 1½ tons increase over the unmanured plot; and in other series this dressing gave 5, 8, and even 14 tons increase per acre over unmanured plots. In other words, there are farms in which superphosphate has been applied without any effect, and there are others in which the entire crop is apparently due to its use!

MINERAL SUPERPHOSPHATE MIXED WITH ORGANIC MATTER.

This dressing was suggested as a means of conferring upon mineral superphosphate a composition akin to that of bone superphosphate. It was thought that organic matter containing nitrogen added to mineral superphosphate might be beneficial, since it is generally allowed that bone superphosphate is a more effective manure than mineral superphosphate. This addition of organic matter has usually been accompanied with an increase of crop, insomuch that in 1871 nearly a ton per acre upon an average was gained over the entire series of experiments then instituted (see Report of Cirencester Field Experiments, February, 1872, page 9). Also, the Rev. T. Maurice said in the discussion that the organic matter with superphosphate seemed to have given the best results, and Professor Church was called upon to explain its effects. The past season has once more, although in a less marked degree, shown the advantage of this manure, the average over the entire series giving nearly 4 cwt. additional swedes over and above the crop obtained by superphosphate alone. The results upon some farms was much more distinctly favourable, while in others no comparable difference could be detected. Having tried organic matter with superphosphate, it was again suggested by Professor Church that a mixture of nitrate of soda, potash, salts, and organic matter should be added to superphosphate, thus giving a highly nitrogenous and fairly general dressing. Without entering into the pecuniary aspect of this question, I may say that so far as an increase in the crop was concerned this addition was attended with considerable success. Subsequently we shall follow the results obtained upon each series of experiments, but for the present I must be content with stating that over the entire series an increase of 15 cwt. per acre was obtained by this means, in comparison with superphosphate alone. The number of roots on each plot was upon an average slightly diminished, that is by some 40 plants out of 818, but this diminution of plants as compared with the superphosphate plots was as nothing compared with the diminution after the use of guano. The average weight of the plants was considerably augmented, insomuch that where superphosphate plants average 1·9 lbs., the plants grown by this mixture average 2·1 lbs. It was also thought fair that while adding nitrate of soda, potash salts, and organic matter to superphosphate, the same mixture, minus the superphosphate, should be compared with the result from unmanured ground. That has been done with the general result of an increase of 17 cwt. 75 lbs. over unmanured ground, which result is eminently satisfactory as it accounts for the increase of 15 cwt. over the superphosphate plots just recorded. Without detracting from the value of general results founded upon an extensive series of experiments, I assign a greater value to the results obtained by each experimenter. The agriculturist is naturally anxious to know what is the best treatment for his own land. An average result is about as valuable to him as the average rate of mortality may be supposed to be to a man in fixing his own prospects of longevity. General results of experiments and general statistics as to life are no doubt both of interest, but to the individual his own peculiar circumstances and requirements are of infinitely more value. I shall not therefore attempt to work out any more general truths, but proceed to point out, with the help of the accompanying tables, the results obtained by the various gentlemen who undertook these experiments.

EARL BATHURST'S RESULTS.

Reference to the printed Tables, II. III. IV., will show that in these experiments the unmanured plots gave an average of 12 tons per acre upon land which may be spoken of as free working and of fair quality, and in good condition. The previous treatment consisted of vetches fed off by sheep, followed with turnips, manured with superphosphate, and fed on the ground. Then followed barley and seeds, mown and fed; and in 1871 the seeds were fed early in the spring, afterwards mown for hay, then dressed with about 12 loads of farm-yard manure per acre, ploughed up and sown with wheat. The wheat was dressed with 20 bushels of soot per acre, and the field was subsequently autumn cleaned and cultivated. In 1873 the field received one ploughing and the usual amount of harrowing, rolling, and quitch-picking. The experimental swedes were sown on May 30th, and received an ordinary after-cultivation, and were pulled, cleaned, and weighed upon November 15th. The plots carried a good and uniform plant, and the experiment was altogether very satisfactory. The duplicate plots bore each other out with uniform consistency, and gave average results very little differing from either plot considered separately. Guano gave the best results, and the very excellent yield of close upon 21 tons per acre. Thus, the use of 3 cwt. of guano per acre gave an increase of 9 tons of swedes, while the use of 3 cwt. of superphosphate alone gave only 6 tons 6 cwt. of swedes. Guano produced roots of 3·4 lbs. each, whilst superphosphate yielded plants of 2·95 lbs. each, showing a considerable advantage, other things being equal, of guano over superphosphate. The addition of Peruvian guano to superphosphate was not in this case advantageous, and, in fact, guano with superphosphate gave in weight per acre a result almost identical with guano alone. The addition of organic matter to superphosphate was attended by the very marked increase of 1 ton 4 cwt., supporting the conclusion arrived at in 1871. Lord Bathurst's results in 1873, so far as guano, superphosphate, and superphosphate with organic matter are concerned, are very accordant, and speak clearly in favour of the addition of organic matter and nitrogen to this soil. This is still more clearly pointed out by plots six and seven, where nitrate of soda, potash salts, and organic matter were applied in conjunction with superphosphate, and also without superphosphate. Comparing superphosphate alone with the same substance in combination as already explained, we find an increase of over 2 tons from the addition of the nitrate of soda, potash salts, and organic matter. These three substances applied in plot 7 give of themselves an increase of 2 tons 7 cwt. on the unmanured plots, thus once more showing the advantage of this dressing, and of the importance of nitrogen in addition to superphosphate upon the Oakley Park field. It is worthy of remark, that in the series in which guano exerted so beneficial a result, the number of plants where guano was used alone and in combination remained the same as in the case of superphosphate and unmanured plots. Lastly, the capabilities of this land in answering to the whip in the case of swedes is very observable, and an extra 8 or 9 tons produced from a moderate dressing shows the wisdom of investing in suitable artificial manures on this soil.

MR. SWANWICK'S RESULTS.

The unmanured plots in this case yielded 10 tons 1 cwt. 18 lbs. per acre. The land is somewhat thin and brashy, but is of fair quality, free working, and in fairly good condition. In the years 1870-71 it was in seeds ploughed up and sown with wheat without farm-yard manure. The swedes were sown May 29th, and throughout the season were characterized by a vigorous growth and a good general plant. As the next neighbour to Oakley Park farm, the results one might expect to be somewhat similar, and they are so to a considerable extent, although the manures have not as a rule been so effective. Guano gave an increase of 5 tons 3 cwt. 4 lbs. over the unmanured plots; while dissolved Peruvian guano gave an increase of 6 tons 16 cwt. 8 lbs., thus showing for the first time what is almost invariably the case, viz. the superiority of the dissolved over the undissolved guano. Mineral superphosphate gives the increase of 4 tons 4 cwt. over the unmanured plots, once more showing that guano can even in this district sometimes give a better return than superphosphate. The diminution in the number of plants owing to the use of guano is very marked; for while mineral superphosphate gives its 781 plants, averaging 2 lbs. each, guano gives 568 and 587 plants, averaging 3 lbs. and 3·2 lbs. each. Again, nitrogen appears suitable, as in the case of Earl Bathurst's results, and this is borne out by reference to plots 4, 6, and 7. In the first-named a marked increase is observable from the addition of guano to superphosphate (see tables), although a considerable diminution in the number of roots is at the same time noticeable. In plot 6, the addition of nitrate of soda, potash salts, and organic matter to mineral superphosphate at once raises the produce 1 ton 1 cwt. per acre, and that this is due to the addition of nitrate of soda, &c., to superphosphate is rendered evident from plot 7, where alone these supplementary substances gave a decided increase over the unmanured plots. Plots 2, 4, 6, and 7, in both the Oakley Park and Mr. Swanwick's series, point distinctly to the advantage of guano and nitrogen, both when used alone and added to superphosphate. The dissolved guano upon Mr. Swanwick's farm also gave a satisfactory result when compared with ordinary guano. The chief difference observable between these two series are (1) that Mr. Swanwick's field appears to have responded less distinctly to the dressings than the Oakley Park field; and (2) that on Mr. Swanwick's farm guano, although still favourable, considerably reduces the number of roots per acre.

MR. JOSEPH SMITH'S RESULTS.

Mr. Smith occupies land still further removed from Oakley Park than that occupied by Mr. Swanwick. Oakley Park farm may be fairly said to lie on the Cotswolds; Mr.

Swanwick's field is just off the hills, and Mr. Smith's field is distinctly off the Cotswolds, and is of a stiffer and deeper quality. The land on which Mr. Smith's swedes were grown was the previous year in wheat. The stubble was ploughed six inches deep about November; was ploughed again about March; then dragged and harrowed, and was not manured with dung or any other substance either for wheat or for the experimental roots. Nevertheless this field is not only naturally richer than either of the last examples, but it was also in higher condition. The history of the farm for the many years previously is well known. It was occupied by Mr. C. Lawrence, who cultivated according to the rules of high farming, and left much condition in the soil. It is by this assumption that I am able to explain a very remarkable result from the use of manures on this farm, during a season in which these fertilizers might be supposed to exert a high average effect. The chief point of interest in these results is found in the high yield per acre given by the unmanured plots. An average of over 15 tons per acre without manure, while it indicates a high fertility for swedes, also offers a bar to any startling increase from the use of artificial fertilizers. Accordingly, the manured plots exhibited an extraordinary uniformity, both among themselves and when compared with the unmanured plots. In no case do we find a greater increase than three tons per acre, and that is only forced from the land by the heavy application upon plots 4, viz. 3 cwt. of mineral superphosphate and 3 cwt. of Peruvian guano. Mineral superphosphate only increased the yield by a ton and a half, dissolved Peruvian guano by 1 ton 1 cwt., and ordinary guano gives a positive loss. That even these effects are due altogether to the manures applied is a little doubtful, for plots 6, in which superphosphate with certain additions before mentioned is employed, give a comparatively low increase, and reference to plots 7 will show a curious identity when the nitrate of soda, potash salts, and organic matter were applied without any superphosphate at all. In both cases the increase is 1 ton 2 cwt. 10 lbs. I am inclined, then, to conclude that on this farm the effects of even the most suitable dressings were very slight. The effect of guano was on the whole scarcely beneficial, and certainly not remunerative, while its use was accompanied with a great diminution in the number of plants. This point will again claim our attention. Glancing at these three neighbouring farms, I would submit the following explanation of the gradual decrease in effect of the dressings applied. No. 1, in fair condition, answers quickly and distinctly to the dressings applied; No. 2, in higher condition, and approaching a stiffer quality, answers less quickly, and requires the heaviest dressing (No. 4) to produce a large increase; No. 3, in the highest condition and naturally of stiff and rich character, scarcely answers, except to the heavy dressing of 3 cwt. of mineral superphosphate and 3 cwt. of guano. It may also be suggested, that during the cold and wet season of 1873, the gradual increase of clay passing from Oakley Park to Chesterton may have produced a less favourable condition for the action of artificial manures. The result, however, is not encouraging to the investment of money in artificial manures upon this farm.

MR. EDWARD BOWLY'S RESULTS.

This series of experiments was not instituted under such favourable circumstances as the last three. The weather was wet, and the land was wet at the time of sowing, and for a long time Mr. Bowly was in doubt as to whether the plots should not be re-sown. The final result was, however, a fair plant and a fair crop. As is usual, the swedes followed wheat, and received a dressing of dung. The results of Mr. Bowly's experiments will be seen in column 4, Tables II. and III. The unmanured plots gave the high average of 12 tons 18 cwt. 14 lbs. per acre, and knowing the large head of stock maintained by Mr. Bowly, and that for so many years, I am inclined once more to attribute the somewhat low effects of the dressings applied to a high condition of soil. Guano alone was in the case of both plots directly prejudicial, and as usual their prejudicial effect must be attributed to a loss of plant, as will be seen by an examination of Table IV. Dissolved guano in both cases increases the crop, though scarcely to a satisfactory extent, and in conjunction with this fact it is worth while to remark that a greater number of plants stood their ground upon these plots than upon the guano plots (see Table IV). Superphosphate gave again a better result, but still only the moderate increase of 3¾ tons, which compares unfavourably both with Lord Bathurst's and Mr. Swanwick's results. But I again repeat, that this is probably due to a higher condition of land at Siddington. The mixture of guano with superphosphate in plots 4, forces another ton per acre from the unwilling soil, as was also the case upon the rich soil of Chesterton farm. This may appear strange, when guano alone gives a minus result; it will, however, be noticed by reference to Table IV., that while guano alone lowers the number of plants in a very marked degree it does not do so to nearly the same extent when combined with superphosphate. This fact may be traced throughout the entire series of experiments, as is shown by the tables. This fact must be taken in conjunction with another, viz. that the sulphated guano also exhibited a less destructive effect upon plants than ordinary guano. I would suggest that in the case of a mixture of mineral superphosphate with Peruvian guano, a partial sulphating of the guano through admixture with the superphosphate takes place. Likewise, the increase noticeable in the plots 4, viz. nearly five tons per acre, is represented by adding together the increases of plots 2 and 3, which are also, taken together, nearly five tons per acre. Hence, dissolved Peruvian guano and mineral superphosphate applied separately give a united result just equal with mineral superphosphate and guano mixed together. The addition of organic matter to superphosphate gave an increase of crop, as has frequently been observed: as, for example, in the case of Lord Bathurst's experiments, and others which will be shortly mentioned. In conjunction with my remarks upon guano, I would also draw attention to the results of plots 6 and 7. Plots 6 show some advantage from the addition of nitrate of soda, potash salts, and organic matter to superphosphate, and yet the nitrate of soda, potash salts, and organic matter alone give a minus result. There is, therefore, a parallel between plots 1 and 4 and plots 7 and 6. In both cases the nitrogenous manure applied alone gave negative results, while in combination with superphosphate a positive good was effected.

THE REV. T. MAURICE'S RESULTS.

Passing from what I have spoken of as the high-condition farms of Chesterton and Siddington, we next find the Rev. Mr. Maurice's experiments, conducted upon land which for swedes at least seems to be in a poverty-stricken state. The field was in sanfoin for six or seven years. In 1871 it was sown with rape without manure. This crop failed, and bearing in mind the close relationship, if not identity, which exists between swedes and rape, I think this fact is of importance as showing a want of constituents for either crop. Some mustard was then harrowed in, and this together with the rape produced very little keep, but what there was was fed by sheep not folded. The field then had a moderate dressing of farm-yard dung, and was planted wheat in the autumn.

This crop was harvested in 1872, and was then cultivated for swedes. The soil is stated by Mr. Maurice to be of the average quality of the stone-brash of the neighbourhood, and has generally grown fair crops of swedes. I presume, however, that these fair crops of swedes were always assisted by artificial manures. The extraordinary point in this series is regularity of plant upon the unmanured plots, representing crops of 1 ton 17 cwt. 76 lbs., and 1 ton 3 cwt. 84 lbs. per acre. This affords a great contrast to anything we have yet examined, and shows at once the wide difference between Chesterton land, which will grow without manure 15 tons of swedes, and the land under consideration. This field also gives by far the best instance of the profitable application of artificial manures, and when contrasted with experiments already described, shows as conclusively the wonderful difference of effect of the same manure upon different soils. Nothing comes amiss to this field, just as almost anything is food to a hungry man. The results are given in Tables II. and III., to which I ask attention. Looking at Tables II. or III., column 5, we soon come to the conclusion that superphosphate pure and simple was by far the most successful application. The guano plots, No. 1, exhibit once more very beautifully the struggle between the two aspects of this manure, first, as a destroyer of seeds, and secondly as a promoter of plant growth. A gain of 5 tons 7 cwt. per acre over the unmanured plots illustrates the beneficial action of guano upon this soil, while a comparison with superphosphate plots shows it off to disadvantage. A glance at Table IV. throws light upon this point. There were 274 roots only on the guano plots, and 905 on the superphosphate plots. The dissolved guano plots again bear out this remark, and add their proof to the truth of this view, while the much larger increase due to dissolved guano is also in accordance with previous conclusions. The effect of superphosphate has been already mentioned, but I must here take the opportunity of noticing the extraordinary effect produced by this manure in this case. The entire crop seems due to it, and an increase of upwards of 14 tons per acre throws every other result into the shade. Mr. Edmonds has obtained 8 tons increase from the use of superphosphate, but there is no intermediate number between that and the magnificent increase obtained by Mr. Maurice. That the effect is due to superphosphate may readily be shown by comparing this result with plots 4, 5, and 6, in which it will be seen that corresponding numbers give overwhelming proof as to the advantage of this substance. Plots 4 again show the extreme susceptibility of this field to the destructive action of guano on the seed. There is in these plots an average of 506 plants instead of 905. No wonder, then, that guano and superphosphate together give a less weight per acre than superphosphate alone. All endeavours, so to speak, of the guano to form a crop are foiled by the unfortunate "murder of the innocents" at the commencement of the season. I take this opportunity of calling attention to the results of 1871, where guano gave more favourable results to Mr. Maurice than superphosphate. This I explain from the fact that at that time we did not bring the guano into close contact with the seed, and therefore the struggle between guano as a destroyer of seed, and guano as a promoter of growth, did not occur, and I am inclined to think that if the guano had been applied this season a little less directly to the plant, Mr. Maurice would have had a larger increase from guano than from superphosphate alone. It is sufficient to call attention to the fact that with the destruction of well-nigh half the plants, the survivors are still able to give a result little short of the superphosphate plots. Plots 5, 6, and 7 do not speak favourably of organic matter, or of the addition of nitrate of soda and potash salts to superphosphate, although in 1871 they gave good results in a neighbouring field upon the same farm. Referring again to guano, I cannot but see in it essentially a "strong" manure. Brought near the seed it destroys it, but supposing the seed to escape, guano will always develop a splendid root. Surely it is worth while to attempt to apply this substance so as to avoid its dangerous and utilize its beneficial qualities.

MR. L. D. LITTLE'S RESULTS.

Driffield adjoins Mr. Maurice's farm, and I therefore take this series next. This land is in a higher state of natural fertility for swedes than the last, although it is considerably lower than any of the other series yet examined. The unmanured plots carried 6 tons 16 cwt. 88 lbs. per acre, and this naturally lowers the increase from the use of manure much below Mr. Maurice's standard. The whole lesson from these experiments is strictly Conservative, bearing out thoroughly the old dictum, that 3 cwt. of superphosphate is the best dressing for swedes. Observe the distinctly injurious effect of guano as well as nitrate of soda, in the reduced yield in every case in which these substances have been added. Observe, also, the strong objection of the land to guano in any form, dissolved, mixed, or pure, and the fall in the number of roots from 746 in the case of superphosphate to 162 and 190 in the case of guano alone, and of 332 in the case of guano mixed with superphosphate. Still notice that this destruction of plants is to some extent checked by dissolving the guano and by the addition of superphosphate. I can scarcely upon this farm uphold the idea that guano may be used with good effect.

MR. PRICE'S RESULTS.

These are interesting as having been carried out upon land in two conditions: first, without farm-yard manure; and secondly, upon an adjoining land dunged. Previous to the experiments, then, the land had not been dunged for some time. One portion was manured with 12 single horse-loads of ordinary farm-yard manure in January, 1873, and the other portion received no manure. In both cases the stubble was first broken up by the plough, and the manure was ploughed in about February, and all was again ploughed in the spring, worked down and sown. The swedes were hand-hoed three times, but were not horse-hoed. The soil is described as thin stone-brash, clean, and in ordinary condition, calculated to grow four or five quarters of barley per acre. The whole portion devoted to the experiments was of even quality, but the near proximity of trees unfortunately diminished the yield upon three or perhaps four of the plots. First let us contrast the entire manured series with the unmanured. Table II. reveals that 5½ tons was at once the result of farm-yard manure upon the unmanured plots, and throughout the series it will be seen that the manured portion, that is, the dunged portion, always gave a better crop than the undunged portion. It will, however, be further noticed, that the effects of artificial manures upon the dunged portion is much less marked than upon the undunged portion. In other words, the application of farm-yard manure diminished the effect of subsequent dressings. The dunged portion yielded a very trifling increase from the further application of artificial manures, thus, guano gave a decrease, dissolved guano gave a decrease, superphosphate gave a decrease, superphosphate with guano gave a very slight increase of 12 cwt. 97 lbs.; superphosphate organic matter the insignificant increase of 7 cwt. 85 lbs.; superphosphate with nitrate of soda, potash salts, and organic matter gave the slight increase of 12 cwt. 55 lbs.; while nitrate of soda, &c., alone gave a decrease. Apparently farm-yard manure had brought this land up to a condition in which it required nothing more; hence in no case was Mr. Price justified on commercial principles in applying either superphosphates or meagre increase which we have met with since we discussed the grand achievement of superphosphate and guano upon Harnhill farm; and the good result, it will be noticed, is obtained without farm-yard dung.

MR. W. J. EDMONDS' RESULTS.

Mr. Edmonds' experiments were conducted upon a "poor clay stone-brash," which was subjected to the following series of cropping:—1863, turnips; 1864, oats; 1865, clover and Italian rye-grass; 1866, wheat; 1867, mangold wurzel, manured with good farm-yard manure and superphosphate, with half the crop drawn off; 1868, barley, a poor crop; 1869, winter beans, dunged; 1870, wheat; 1871, seeds, which failed; 1872, wheat; 1873, swedes. The swedes received no farm-yard manure, the land was cultivated by steam in the autumn, and in the spring, and the swedes were sown upon the 12th of June, 1873, and weighed the latter part of November or beginning of December. Here, then, we have a case once more of confessedly poor land, and I think I may add, from the previous cropping, land which could not be in very high condition. This is borne out by the unmanured plots, which gave the very moderate yield of four tons per acre. From previous study, here we conclude should be the proper field for the use of artificial manures, and this assumption is fairly borne out by the results obtained. We must be prepared, however, to have preconceived opinions baffled, and must find refuge in what I have already advanced, namely, that the more we experimentalize the more differences do we find in the effects produced upon farms even in the same district. The results are exceedingly interesting, and the more so because the duplicate plots always support each other in their evidence, so that the average obtained is never far from the separated results of each plot. First we notice a remarkable advantage from the use of guano, and this is accompanied with an exceedingly full plant. Thus, while superphosphate gave a yield of 714 plants, guano was not far behind with its 659 plants; and dissolved guano gave 719 plants; while the combination of guano with superphosphate gave rather more plants than superphosphate alone. This result is not only extraordinary, but repeated as it is over many plots is very difficult to shake. It is more reasonable to consider that the seed is not prejudiced in this case by guano than that the difference is in the result of accident; 11 tons 12 cwt. is the increase from dissolved guano, which keeps its usual supremacy over ordinary guano by a trifling advantage of some 5 cwts. per acre. Superphosphate alone, 3 cwt. per acre, is sadly deficient when compared with the guano results. Guano mixed with superphosphate, plots 4, gives the heaviest yield of all, a not very unusual result when compared with the other series; but the increase is not in proportion with the much greater weight and attendant expense of the dressing. It, however, thoroughly bears out the results of the four previous guano plots, and shows clearly the excellent effect of this manure upon Mr. Edmonds' land during the past season. Again the mixture with organic matter is attended with very fair results, viz. an increase of 16 cwt. per acre over superphosphate used alone. The addition of nitrate of soda, potash salts, and organic matter to superphosphate again yields an increase over superphosphate alone, to the extent of close upon 18 cwt., while the nitrate of soda, &c., No. 7 plots, give an increase over the unmanured portion of nearly two tons. This I take as additional evidence of the benefit of nitrogenous dressings (guano), upon Mr. Edmonds' farm, for we find that, generally speaking, where guano has a marked effect for good, this dressing of nitrate of soda and organic matter exerts a similar beneficial action. I do not shut my eyes to the fact, that Mr. Edmonds in the year 1872 rather declared against the use of guano, and in 1871 his results were not favourable to the use of this fertiliser. Mr. Edmonds is, however, a very extensive occupier, and it may easily happen that there is as much difference between various parts of his holding as between neighbouring farms.

POULTON: MR. H. J. MARSHALL'S RESULTS.

I am informed that the land upon which the experiments were conducted is of good quality and in very good condition.

The swedes were, owing to the land not being ready, not sown till the 25th of June, or about a fortnight later than the best season. There was, nevertheless, a fair crop of from 12 to 15 tons per acre on most of the plots. The soil is described as corn-brash, from six inches to one foot in depth, and has been cropped as follows:—1866, swedes, fed off; 1867, mangolds, drawn off; 1868, wheat; 1869, barley; 1870, clover; 1871, beans; 1872, wheat; or five crops removed during the last six years. The land still being in good condition, we must conclude that it is of very good natural fertility. About twelve loads of dung, fresh from the yard, was drawn on in the winter and ploughed in with digging breasts, after which the land was scuffled either three or four times, and worked down. The unmanured plots yielded 8 tons 9 cwts. 102 lbs. of swedes, and both the guanos and superphosphates were applied with very good effect. Neither does the guano seem to have exerted any great destructive action upon the plants with which it was drilled, although it has done so to a limited extent. The figures which indicate this conclusion are as follows:—there were 1015 plants on the superphosphate plots; 825 after guano; 779 after dissolved guano; and 963 on the unmanured plots. The vitality of the seed being, then, but little injured, we are not surprised to find a very considerable increase from the use of guano, and, in fact, when this destruction of seeds does not take place guano very generally appears as a favourable dressing. Glancing at the table, you will see that the guano gives an increase over the unmanured plots of 4 tons 5 cwt. 70 lbs. of swedes. Dissolved guano maintains the lead it almost always takes with reference to guano, with 5 tons 4 cwt. 102 lbs. as its increase. Superphosphate alone gives an increase of 4 tons 16 cwt. 28 lbs., below that of dissolved guano. Again, we find that guano mixed with superphosphate has once more a very excellent average increased crop, so that plots 4 show an increase of 6 tons 4 cwt. 82 lbs. over the unmanured plots. Organic matter mixed with superphosphate is likewise apparently the cause of an increase of half a ton per acre. A glance at the results of the plots so treated will show that nitrate of soda, potash salts, and organic matter gave on the whole a minus result, which sufficiently accounts for the fact that these substances united with superphosphate did not increase the yield at all beyond that of superphosphate alone.

HILL FARM, SAPPERTON: MR. O'DWYER'S RESULTS.

Mr. O'Dwyer occupies land at a considerable distance from the series which we have been lately studying. In answer to my inquiries with reference to the quality of his land, he says, "The character is gravelly, the quality good, but the condition *very, very bad.*" It had been lying fallow for the two previous years, so that one would naturally expect some freshness to have crept into it. The character given to it by its present occupier is fully borne out by the very bad crop which was grown upon the unmanured portion, an average of 17½ cwt. per acre being only obtained. The assistance of nitrate of soda, potash salts, and organic matter increased the crop to 2 tons 4 cwt. per acre, thereby showing the emptiness of the land—emptiness which made it to more than double its crop upon so innutritious a diet. This land, so out of condition, brings of course to mind the case recorded on Harnhill, and indeed we find a very strong parallel between these two series. Any dressing seems to have been sufficient to cause this land to throw up a crop. Thus, guano alone gives 5 tons 1 cwt. per acre over the meagre crop of 17 cwt. without manure. Dissolved guano again has the advantage over ordinary guano by producing 6 tons 16 cwt. of increase. Superphosphate does not give such good results, but yields the very fair increase of 5 tons 4 cwt. By way of illustrating that land of such poor condition will greedily utilize dressings applied, take the results of plots 4, mineral superphosphate and Peruvian guano mixed, which brought up the increase of 9 tons 4 cwt. per acre, and the yield of 10 tons 2 cwt., or about twelve times the amount of the crop without manure. Again, the addition of organic matter is at once apparent by a definite increase over superphosphate alone, which is likewise borne out by the organic matter, nitrate of soda, and potash salts sown alone. Mr. O'Dwyer's land may be properly termed very susceptible, and bears out many of the conclusions which have been arrived at in studying other series.

CHAPTER V

MANURING OF THE ROOT CROP (*continued*).

Cirencester Chamber Experiments—Practical Directions for Manuring—Injurious Action of Guano—Injurious Action of Nitrates—Summary of Results—Effects of Climate on Manures—Importance of Farmyard Manure illustrated by Effect on Mangel—Methods of applying Fertilizers.

THE inevitable conclusion is, that land in good condition is less influenced by manures than land which is in poor condition. In further support of this conclusion, which is of highly practical significance, the results obtained during 1874 may be quoted. The experimenters were eight in number, and the effect of the fertilizers employed varied greatly on different farms. As superphosphate applied at the rate of 3 cwts. per acre is a standard dressing, we shall contrast its effect upon various classes of land.

Mr. Hawkins, a yeoman farmer, at Oaksey, Wilts, placed at my disposal a flat-lying field of good quality and somewhat stiff character on the south side of the Great Western Railway. Upon this land the unmanured plots produced 12 tons 18 cwts. 64 lbs. of swedes per acre, and, strange to say, all of the dressed plots produced a less weight.

GENERAL RESULT OF EXPERIMENTS TRIED ON MR. HAWKINS' LAND.

	Tons	cwts.	lbs.
2 plots, unmanured	12	18	64
2 „ dressed with 3 cwt. superphosphate, per acre	12	7	96
2 „ „ „ {3 „ superphosphate, 1 „ nitrate of soda,} per acre	10	15	70
2 „ „ „ {3 „ superphosphate, 2 „ dissolved guano,} {drilled together} per acre	10	17	76
2 „ „ „ {3 „ superphosphate, 2 „ dissolved guano,} {sown separately} per acre	12	17	16
1 plot „ „ {3 „ superphosphate, 1 „ nitrate of soda, ½ „ organic matter, ½ „ potash salts,} per acre	9	10	0
2 plots „ „ 3 „ patent bone phosphate, per acre ...	10	18	24

An isolated trial of the above character might produce an impression that money spent on superphosphates and guanos is thrown away.

The results obtained by Mr. Arkell of Dean Farm, Fairford, would, however, cause a different impression. The land may be described as light, poor stone brash, and the reader will, therefore, be prepared for a considerable effect from the applications, The yields per acre were as follows:—

GENERAL RESULTS OF EXPERIMENTS TRIED ON MR. ARKELL'S LAND.

	Tons	cwts.	lbs.
2 plots, unmanured	2	5	50
2 „ manured with 3 cwt. superphosphate, per acre	12	16	48
2 „ „ „ {3 „ superphosphate, 1 „ nitrate of soda,} per acre ...	13	2	86
2 „ „ „ {3 „ superphosphate, 2 „ dissolved guano,} {drilled together} per acre	15	8	34
2 „ „ „ {3 „ superphosphate, 2 „ dissolved guano,} {sown separately} per acre	14	19	76
2 „ „ „ {3 „ superphosphate, 1 „ nitrate of soda, ½ „ organic matter, ½ „ potash salts,} per acre ...	14	16	38
2 „ „ „ 3 „ patent bone phosphate, per acre ...	9	1	3

Mr. W. J. Edmunds, of Southrop, during the same season, allowed a series of experiments to be carried out. The experiments were made upon Maccaroni Farm, described by Mr. Edmunds as "stone brash, very much worn-out;" land, in fact, unable to grow swedes without artificial assistance. A more favourable position for "proving" the effect of fertilizers could scarcely be imagined—just such a soil as M. Ville would choose to show the potency of his complete manure. The results were as follows :—

		Tons	cwts.	lbs.
2 plots, unmanured ...	...	1	7	78
2 „ manured with 2 cwt. superphosphate, per acre ...	...	11	0	100
2 „ „ „ { 3 cwt. superphosphate, 1 „ nitrate of soda, } per acre	...	12	13	24
2 „ „ „ { 3 „ superphosphate, 2 „ dissolved guano, } drilled together	per acre	12	0	80
2 „ „ „ { 3 „ superphosphate, 2 „ dissolved guano, } sown separately	per acre	12	19	12
2 „ „ „ { 3 „ superphosphate, 1 „ nitrate of soda, ½ „ organic matter, ½ „ potash salts, } per acre	...	11	7	50
2 „ „ „ 2 „ patent bone phosphate, per acre	...	7	10	40

It may, of course, be objected that such results as the above were only to be expected. I would, however, point out that all these farmers were practising the usual system of farming of their district, and were probably all applying the standard 3 cwt. per acre of superphosphate with and without dung. With what varying results the statements of crops above recorded clearly show. In some cases the crop was not benefited—we can hardly say injured, because the slight decreases on Mr. Hawkins' field might be attributed either to some natural superiority of the unmanured plot, or to the inevitable irregularities of all agricultural experiments conducted upon a variable material such as the soil. In other cases the entire crop appeared to be due to the dressings used. The conclusion is therefore fairly drawn, that *the peculiarities of the land have more to do with the effect of manures than the composition of the manures used.*

PRACTICAL REMARKS UPON THE MANURING OF SWEDES AND TURNIPS.

The superior effects of phosphatic manures, whether mineral superphosphate, basic cinder, or dissolved bones, is borne out by universal experience. The manuring of the root crops generally is, in practice, summed up by the recommendation to apply a dressing of dung, and drill with 3 cwt. of superphosphate.

The use of the last-named substance is two-fold. (1) To supply phosphates to the growing crop, and thus enable it to appropriate other constituents of plant food from the soil; (2) to stimulate the early growth of the young plants immediately after germination, and thus to carry them over the critical period between the first appearance of the cotyledon leaves above ground and the passage into the second or rough leaf.

When land is in high condition, a small dressing of 2 cwt. of superphosphate, chiefly applied with the latter object, is advisable. When land is decidedly poor, 3 or 4 cwts. may be applied.

Guano is not extensively used in the southern counties, but is more popular among farmers in Scotland, and in the humid climate of Ireland. Mr. Wilson, of Edington Mains, Berwickshire, in his *British Farming*, thus summed up the relative values of Peruvian guano and superphosphate of lime:—"The powerful effect in quickening the growth of the young turnip plants is possessed in nearly as great a degree by Peruvian guano when it is supplied with sufficient moisture. In climates and seasons which may be characterized as moist and cool, guano will show the best results, whereas, in those which are rather hot and dry, superphosphate has the advantage. Accordingly we find guano the comparative favourite in Scotland, and its rival in the drier counties of England. Guano is believed to encourage a great expanse of foliage, superphosphate to influence development of bulb, and to deserve preference for a later seed time. The obvious inference is that, for the turnip crop, at least, these valuable fertilizers should be used in combination."

In weighing this opinion we should remember that the usual plan in Scotland is to sow turnips and swedes upon ridges split over dung, and that guano, superphosphate, &c. are applied by broad-casting them by hand over the raised ridges. This system secures a thorough distribution of the portable manures throughout the soil; whereas, where the drill is used—as in most counties of England—the manures are deposited in a narrow groove in close proximity to the seed. After repeated trial I find as a uniform result that in the southern parts of England guano, nitrate of soda, and sulphate of ammonia exert an injurious effect upon turnip-seed when thus brought into close contact with it. The final effect is good, but the initial action is to diminish the number of plants per acre. Thus in experiments already quoted, undertaken in **1873**, in the district around Cirencester, the injurious effects of guano upon the number of plants per plot was clearly shown, as the following figures prove—

NUMBER OF ROOTS GROWN PER PLOT OF $\frac{1}{20}$ ACRE, 1873.

Name of Experimenter.	Peruvian Guano, 3 cwt. per acre.	Dissolved Peruvian guano, 3 cwt. 60 lbs. per acre.	Mineral superphosphate, 3 cwt. per acre.	Unmanured plots.
Earl Bathurst.	677	668	674	698
R. A. College.	568	587	781	766
Mr. J. Smith.	430	465	799	828
Mr. E. Bowly.	505	614	810	808
Rev. T. Maurice.	274	280	905	571
Mr. L. D. Little.	162	190	746	641
Mr. Price.	411	619	836	683
,, ,,	405	519	865	893
Mr. Iles.	605	538	927	800
Mr. W. J. Edmonds.	659	719	714	723
Mr. Marshall.	825	779	1015	963
Mr. O'Dwyer.	444	534	750	408

The guano plots could always be recognized by the more irregular plant, the greater development of leaf, and the larger average size of the surviving roots. Reference to the above given figures will show that, although the effect was not invariably observed, yet the reduction in the number of plants per acre is amply shown. Even dissolved guano, or guano treated with sulphuric acid, exhibited the same peculiarity, but in a less degree. Superphosphate exerts an opposite effect, and produces a uniform plant, as may be seen by comparing the numbers of plants produced by it, in comparison with the numbers grown on the guano plots, and on the unmanured portions.

As a similar effect is produced by nitrate of soda when drilled with the seed, I introduce observations on this point, brought before the attention of the Cirencester Chamber of Agriculture in February 1875. In these experiments Peruvian guano was not included in the series, as it was not found suitable to the soil or climate of the district. A mixture of superphosphate and nitrate of soda was used in the proportion of 3 cwt. of the former and 1 cwt. of the latter per acre.

NUMBER OF ROOTS GROWN PER PLOT OF $\frac{1}{20}$ ACRE, 1874.

Name of Experimenter.	Superphosphate, 3 cwt. per acre.	Superphosphate, 3 cwt. per acre, nitrate of soda, 1 cwt. per acre.	Superphosphate, 3 cwt. per acre, dissolved guano, 2 cwt. per acre, drilled together.	Superphos. 3 cwt. per acre, dissolved guano, 2 cwt. per acr. sown separately.	Unmanured.
Earl Bathurst.	686	672	644	757	628
Rev. T. Maurice.	870	651	655	903	390
Mr. E. Parsons.	840	611	715	805	624
Mr. Arkell.	828	762	781	851	582
Mr. W. J. Edmonds.	926	803	871	846	580
Mr. Stevens.	926	446	593	688	570
Mr. Brain.	771	616	565	670	640
Mr. Hawkins.	661	554	552	618	640

Attention is drawn to the fact that this prejudicial effect of nitrogenous manures brought into close contact with the seed is greatly qualified in the case of the plots where the dissolved guano and the superphosphate were broadcasted separately over the surface, instead of being drilled together with the seed. By this method the nitrogenous manures were more completely mixed with the surrounding soil, and would not be brought into contact with the plant until after the germination of the seed. These facts are conclusive as to the injurious effects of guanos and nitrate of soda (perhaps of nitrates in general) upon turnip-seed, when brought into close contact with it by means of the water drill.

The facts arrived at by the Cirencester Chamber of Agriculture with regard to manuring swedes were summarized in the following statement of results:—

The following results, obtained upon the swede crop, commended themselves to the attention of members of the Cirencester Chamber as having been obtained in their own neighbourhood; and as being, in each case, backed by the unanimous verdict of a large number of experiments carried out upon a uniform plan by agriculturists of position. Bearing in mind that in each case it is the swede crop which is especially referred to, we find—

1. That poor land, and in poor condition, derives the greatest benefit from artificial dressings.
2. That land in high condition has been proved in many cases to derive little or no benefit from the use of artificial dressings.
3. That land in this (Cirencester) neighbourhood appears to be satisfied with moderate dressings, and the use of heavier dressings is not attended with commensurate results.
4. That 3 cwt. of ordinary mineral superphosphate per acre has given the most economical result during

several years' experience extending over hundreds of plots.

5. That guano, nitrate of soda, organic matter, and even farmyard dung diminish the germinating power of swede seed, and cause a blankness in the crop when they are brought into contact with the seed.
6. That guano and nitrate of soda applied to the growing swedes increase the crop, but scarcely to an extent to warrant their general use.
7. That the average increase in swede crops from the use of 3 cwt. of superphosphate amounts to 5 tons 6 cwt. per acre. That in some cases the increase has been *nil*, while in others it has been as much as 14 tons per acre.

EFFECT OF CLIMATE UPON THE QUANTITY AND KINDS OF MANURES REQUIRED.

The effect of climate upon the action of manures and the growth of plants is acknowledged by all. In dry climates artificial manures produce but small results. Thus in Southern Europe artificial manures are at a discount, as they frequently fail to produce an effect. In such conditions, oil-cake, fed by animals and left in the dungheap, is much more effective than any artificial manure, and dung always produces its effect in whatever quarter of the globe it is employed.

In Great Britain the heaviest dressings of artificial manures are applied to turnips and swedes in Scotland and the north of England. In those districts the turnip and swede crops produce a yield of 20, 30, 40, and 50 tons per acre; while in the southern counties they yield returns of 10, 12, 15, and 20 tons per acre. Heavy dressings may therefore be employed in the northern parts of the country with good effect, while in the south they are unnecessary.

A Northumberland farmer will apply 10 cwt. per acre of a mixture of guano, superphosphate, and bones; and as the late Joseph Lee of Dilston remarked, "they do so because they can in this way produce turnips at the lowest cost per ton."

In Wiltshire or Gloucestershire 2 to 3 cwt. of superphosphate is found to be sufficient, and this because the condition of soil and climate do not force the crop, and 10 to 12 tons per acre are ordinary yields.

FARM-YARD MANURE FOR THE TURNIP CROP.

Farm-yard manure is usually largely employed in turnip cultivation. The quantity of this the most valuable of all manures is unfortunately limited, so that there is scarcely more produced upon a farm than will serve to manure about half the root area.

The distribution of the farm-yard manure is also affected by the wheat breadth, as most farmers like, if possible, to dung their "seeds" for wheat.

The quantity of dung available for the root land is therefore much curtailed, and the question as to its application is generally solved by the proposed destination of the turnips. If they are to be eaten on the ground by sheep they may be grown with the aid of superphosphate alone. If it is intended to cart them off the land they ought to be dunged.

Twenty good loads per acre is an ample dressing, but 12 to 16 loads is often all that can be afforded, and this with 3 cwt. of superphosphate drilled with the seed is in accordance with ordinary practice.

The effect of farm-yard manure upon turnips has been already mentioned. The subject is highly important as the interdependence of the supply of farm-yard manure upon the root crop, and of the root crop upon farm-yard manure, has been spoken of as the keystone of our system of agriculture. This is alike true of turnips, swedes, mangel-wurzel, and sugar-beet, and a few examples of the effects of dung upon these crops is worthy of attention.

Reference to the tables (see p. 74) in which certain results obtained by the members of the Cirencester Chamber of Agriculture will show the importance of liberal farming, *i. e.* of applications of dung upon the turnip crop. Upon Mr. Price's land a coat of dung increased the crop from 9 tons to 14½, or by 5½ tons; and further additions of superphosphate, of guano, and even of superphosphate and nitrate of soda combined, were not able to further raise the yield perceptibly. The results obtained by Mr. Price were as follows—

	Tons.	cwt.	lbs.		Average increase or decrease over farm-yard manure plots. Tons.	cwt.	lbs.
2 Unmanured plots	9 8	8 13	44 4		5	8	90
2 Farm-yard manure	14 14	2 16	16 88	...	"	"	"
2 Farm-yard manure and 3 cwt. of superphosphates	15 11	3 18	84 84	...	— 0	18	25
2 Farm-yard manure and 3 cwt. dissolved guano	13 12	16 3	108 84	...	— 1	9	13
2 Farm-yard manure 3 cwt. Peruvian guano, 3 cwt. superphosphates	15 14	10 14	40 36	...	+ 0	12	97
2 Farm-yard manure 3 cwt. of superphosphates ½ " of nitrate of soda ½ " of potash salts ½ " of organic matter	— 14 16 —	— 0 3 —	— 0 104 —	...	+ 0	12	55
2 Farm-yard manure 3 cwt. Peruvian guano	11 12	10 4	40 52	...	— 2	12	7

The minus results obtained when guano was added are accounted for by the diminution in the number of swede plants which has already been pointed out. The diminution in yield when superphosphates were added must be considered as very curious.

The general conclusion is, however, evidently that the farm-yard manure supplied all that was necessary, and that further additions of fertilizing matters were practically unnecessary.

The results obtained upon Mr. Hawkins' land at Oaksey also show minus quantities difficult to explain, but possibly due to the fact that this land from previous good management (dunging) was fully able to support a root crop without further aid.

It would be rash to conclude from these experiments that dressings of superphosphates may be dispensed with when dung is employed. The success of the crop depends so largely upon a rapid passage beyond the stage at which the turnip-fly attacks the crop, that a moderate dressing of superphosphate ought to be drilled with the seed in order to promote the growth of the young plants.

Experience also would teach that where the climate is favourable to the growth of heavy crops of 30 tons of swedes or turnips per acre, heavy and complicated dressings may be profitably applied.

The effect of dung upon mangel wurzel at Rothamsted bears out what we are endeavouring to impress. In this crop we have a bulky grower suitable for a southern climate. The extraordinary effect of dung is clearly shown in promoting a heavy yield, and the possibility of a heavy return per acre from mangel also renders dressings supplemental to dung much more efficacious than in the case of turnips grown under similar climatic conditions.

The yields of mangel-wurzel, from 14 tons per acre of farm-yard manure, from 1876 to 1887, were as follows :—

	Tons.	Cwts.	
1876.	19	12	
1877.	15	7	
1878.	13	5	
1879.	6	3	(This season was unsuitable for mangel.)
1880.	18	11	

	Tons.	Cwts.	
1881.	13	15	
1882.	14	14	
1883.	22	12	
1884.	15	19	
1885.	3	6	(Failure of the crops on all plots.)
1886.	16	6	
1887.	10	17	(Famous Jubilee drought.)

All these crops with the tops were removed from the land. The effect of 3½ cwt. superphosphate and a very liberal dressing of 500 lbs. of nitrate of soda in addition to the dung, gave the following yields, showing that mangel-wurzel is a crop which pays for liberal treatment better than turnips or swedes grown in similar climatic conditions:—

	Tons.	Cwts.	
1876.	27	13	
1877.	26	8	
1878.	21	4	
1879.	11	11	(This season was unsuitable for mangel.)
1880.	27	16	
1881.	19	12	
1882.	25	2	
1883.	28	15	
1884.	26	13	
1885.	2	1	(Failure of the crop on all plots.)
1886.	22	7	
1887.	2	1	(Famous Jubilee drought.)

All these crops, with the tops, were removed from the land. Thus it is plain that mangel-wurzel is able to avail itself of extra dressings of manures to a greater extent than turnips and swedes *in the south of England;* but we should expect to see heavy dressings applied to turnips produce greater effects in the northern counties and in Scotland.

Once more we must refer to table (p. 71), in order to show how completely these deductions are brought out in the case of the swede crop. This table shows the advantage of dung as a dressing for swedes, although the effect is expressed in terms of small tonnage per acre. It will, however, be noticed that extra heavy dressings upon the dunged portions were unable to raise the yield. Even an extra dose of 400 lbs. of ammonia salts and 2000 lbs. of rape-cake was only followed by an average increase during fifteen years of 2½ tons per acre.

The effect of farmyard manure upon the root crop is therefore evident, and this fact being once established, its importance as regards the succeeding crop follows as a matter of course. A good crop of roots, wholly or even partially fed upon the land, secures a good barley crop; and when land is in high condition the success of the succeeding clover crop is almost assured. The clover again collects materials for the wheat crop, and a successful rotation is the result.

It might be argued that root crops may be raised by superphosphate alone, and that by feeding these roots on the ground all the advantages of an application of farm-yard manure will be realized. This is perfectly true in principle. Root crops may be raised by artificial manures, and the fertility of the ground may be kept up by sheep. Our contention is one of degree rather than of kind, and we say that good crops of swedes cannot be grown without dung. It may also be held that the similarity of sheep-droppings and farm-yard dung is so great, that in both cases the land may be said to be dunged.

VARIOUS METHODS OF APPLYING MANURES TO THE TURNIP CROP.

The differences between the ridge and the flat systems of sowing turnips has already occupied us (p. 52). We have also noticed the difference in effect between guanos and nitrates, sown broadcast and drilled with the seed. The remaining variations in the methods of applying artificial fertilizers may be considered under three heads.

1st. Drilling with ashes or water.
2nd. Broadcasting.
3rd. Top-dressing.

Drilling with ashes or water is the plan ordinarily followed in the southern counties. The objection to it is the deposition of the fertilizer in a narrow groove instead of throughout the soil. On the other hand, broadcasting the manures fails as a system, because a sufficient amount of fertilizing matter is not brought into close contact with the young plants. There are therefore objections to both methods and a *via media* is best secured by drilling a portion of the fertilizers (viz. 2 cwt. superphosphate) with the seed, and applying the remainder by broadcasting it at the time of sowing, and by harrowing it in. The Northumberland system is admirable for the manner in which it secures rich soil around the young plant, and at the same time provides for its growth during its career. In some districts of the Midlands the usual system is to broadcast the whole of the artificial fertilizers, and to incorporate it with the soil by means of harrowing, and this system is said to answer. My own experience is that broadcasting manures combined with drilling clean seed on the flat is not satisfactory. Poor crops have been the invariable result after many trials.

Top-dressing may be used as a means of increasing crops of mangel, but it is scarcely to be recommended for swedes and turnips. As already stated, nitrate of soda is not an efficient manure for swedes and turnips, and the superphosphate may just as well be applied altogether at the time of sowing. In the case of mangel, a top-dressing of 2 cwt. of nitrate of soda and 5 cwt. of common salt will be found to greatly increase the weight of the crop (see Mangel).

CHAPTER VI.

AFTER CULTIVATION OF THE TURNIP CROP.

After Cultivation of the Root Crop—The Turnip Fly—Strawson's Air-power Distributor—Black Caterpillars and Surface Grubs—Wire-worms, Millipedes, and Aphides—Diseases Affecting Turnips—Club-root, Finger and Toe, Mildew—Difficulties in Estimating Costs—Should Farm-yard Manure be Charged?—A Cheaply Grown Turnip Crop—An Expensive Turnip Crop—Basis for Valuing Root Crops—Composition of Turnips—Value of Turnips as a Stock Food—Objections to Turnips fed Alone—Consumption of Turnips.

THE hoeing of the turnip crop, both by horse and hand labour, is a most important factor in successful turnip cultivation. This truth is better appreciated in North Britain than in the south, and we may in fact almost conclude that turnip husbandry is more successfully carried out and better understood in the north and in Scotland than it is in the south of England. There, the climate assists the cultivator, and crops of 30 tons are as easy to obtain as crops of 18 and 20 tons further south.

Hoeing is perhaps best let to men at a price per acre, but it must be confessed that there is a strong tendency to scamp the work when so done, and certainly we cannot expect the same minute care of the individual plant from men who are straining every nerve to "make wages."

The routine of the after cultivation of turnips, and of the root crops generally, is simple, and may be stated as follows:—

1. Harrowing across the rows.
2. Horse-hoeing.
3. Singling or setting.
4. Second horse-hoeing.
5. Second hoeing.
6. Third horse-hoeing.
7. Third hoeing.

These repeated horse- and hand-hoeings, which are accomplished during the three summer months, greatly promote the growth of the crop, and are persevered in until the luxuriance of the growth completely shuts out the men and horses.

The later season for sowing, and the earlier harvest in the south of England, so shortens the period of growth that the third horse- and hand-hoeings are often not given, except in the case of mangel.

Harrowing before the first horse-hoeing is only attempted when the turnips are sown on the flat. It is useful as a surface tillage operation, which moves the soil, and destroys surface weeds. It also pulls out surplus plants in the turnip rows, and conduces to a greater amount of freedom of growth. In some cases a drag-harrow is used, and very usually an implement known as the "A" harrow, so called on account of the resemblance of its frame to the first letter of the alphabet.

The first horse-hoeing is done either with a single row scuffler, drawn by one horse, or by a horse-hoe taking three or four rows at a time. When the turnip rows are 25 or 27 inches apart, the former method is the best, and a lad and horse can get over four acres in a day. Where turnips are grown in rows 16 to 20 inches apart, the latter system is to be preferred. The proper period for the first horse-hoeing is immediately before singling, and the plants ought to be well into the rough or second leaf before it is attempted.

Singling, or setting, is an important work in connection with turnip cultivation. It is usually performed by women in the northern counties and in Scotland, and by men in the south. A woman will single her half acre per day when the turnip rows are 27 to 30 inches apart, and where the seed is sown on the ridge, and the ground is loamy and free from stones. A man will do about the same amount of land in the south, where the rows are 18 to 20 inches apart, and the turnips are sown upon the flat. With women-labour, and on day-wages, the cost will be about 2*s.* 6*d.* to 3*s.* per acre, and where men are employed, and the turnips are thicker on the ground, the work will cost about 5*s.* 6*d.* per acre.

The supervision of this work is not as a rule sufficiently attended to in England. The work is let, and the men do it indifferently well. In Scotland certain points are insisted upon by good farmers, or if not they certainly ought to be impressed upon the workers. These points are the rigorous "singling" of the plants, no "doubles" being allowed to be left. Secondly, the leaving of strong growing plants, and the cutting out of feeble and small plants. Thirdly, the cutting out of all weeds. Fourthly, the moving of all the soil *in* the rows not moved by the scuffler or horse-hoe *between* the rows. In swedes 13 to 15 inches, and in white turnips 10 inches to 12 inches, may be left between the plants. In droughty seasons, or when the "fly" is prevalent, the operation of singling may be advantageously postponed for a time, but in showery weather the work ought to be pushed on briskly. The second horse-hoeing and second hand-hoeing are done at a later stage, when the leaves are about half met. In the second hand-hoeing all "doubles" accidentally left during the first hoeing are removed, all weeds are cut, and the hoe is circled around each plant, so as to loosen the soil and maintain a fine tilth.

The third horse- and hand-hoeing may or may not be given, according to circumstances. At this stage the leaves are usually well met in the rows. This terminates the cultivation of the turnip crop.

THE TURNIP-FLY, OR FLEA-BEETLE.

One of the most serious difficulties in turnip cultivation is found in the attacks of the turnip-fly. These small creatures are known scientifically as *Altica* or *Phyllotreta nemorum* and *A.* or *P. concenna.* Both are true beetles, the first being of elongated oval form, of minute size, and distinguished by one longitudinal straw-coloured stripe on either wing-case. The other is still smaller, of oval shape, and entirely black. They are to be found before the appearance of the turnips upon charlock and other cruciferous plants, from whence they migrate to the turnip-fields in vast numbers as soon as the fleshy cotyledon leaves of the turnip-seed appear above ground. Their attack is frequently destruction of the entire crop, and entails re-sowing, and occasionally even a third sowing. During the attack the field ought to be frequently visited, and judgment is required as to whether the young plants will weather the storm, or a second sowing will be necessary.

Certain measures have been suggested, and others are customarily acted upon as preventatives, and several of these measures fall within the scope of the general good cultivation of the crop which ought to be observed irrespective of any insect attack.

Thus, autumn cultivation of stubbles, the extirpation of weeds, a fine state of tilth, a rapid germination of the seed, and a quick passage through the critical stages of growth, may be viewed in connection with and as preventatives of the attack of the turnip-fly, or as ordinary precautions towards securing a good crop of turnips. The special measures for combating the attack are numerous, and while some are commendable, others of them are either troublesome or fanciful, and are not likely to be adopted by farmers growing an extensive area of turnips.

I shall take the most practical and simplest suggestions first. Plenty of seed is a safeguard against the turnip-fly. In favourable seasons 1½ to 2 lbs. of seed are sufficient, but in dry seasons, when the fly is strong, double these quantities may be sown with advantage. A mixture of old and new seed is also to be recommended, as old seed is slower in showing itself, and a relay of plants in the row is thus secured to fill up blanks caused by the first onslaught of the enemy. The fly is more partial to white turnips than to swedes, and there is no difficulty in discriminating between these two descriptions of turnips. It has, therefore, been suggested to protect the swede crop by sowing white turnip-seed with the swede seed, and removing the white turnips at the time of hoeing. Upon the same principle three or four lbs. of white turnip-seed may be sown broadcast at the time that the swedes or turnips are drilled, so as to distract the attention of the fly from the rows. These surplus turnips are easily got rid of in the several horse- and hand-hoeings to which the crop is subjected during its growth.

Rolling and brush-harrowing during the attack of the fly are also beneficial in disturbing the fly, and allowing the turnips to grow.

The plan of applying a fine powder as a dressing to the young plants has also been adopted with success. This system was used by the late Mr. Fisher Hobbs, of Boxted Lodge, Chelmsford, a very noted agriculturist, and was suggested to him by his bailiff. The receipt is as follows :—

1 bushel of white gas-ashes, fresh from the gas-house;
1 bushel of fresh lime from the kiln;
6 lbs. of sulphur;
10 lbs. of soot;

well mixed together, and reduced to as fine a powder as possible. This is enough for two acres when drilled on to the young turnips placed 27 inches apart between the rows. It must be applied very early in the morning, when the dew is on the leaf. If the fly continues troublesome, the dose must be repeated. Another mixture recommended by the same authority consists of—

14 lbs. of sulphur;
1 bushel of fresh lime;
2 bushels of dry road dust

per acre, mixed a few days before application, and applied at night. Mr. Hobbs was very positive as to the utility of these mixtures, and stated that "By these means 200 to 220 acres of turnips, swedes, and rape have been grown on my farms annually for eight or nine years, without a rod of ground losing plants."

It has been suggested to steep turnip-seed for a short period in turpentine before sowing. The effect is not injurious upon the germinating power of the seed, and it is alleged that the powerful odour of the turpentine constitutes a safeguard against the fly.

The latest proposal is that of Mr. Strawson, who has invented a machine under the descriptive name of an "Air-power distributor." This instrument is adapted either for sowing seed or distributing finely divided top-dressings, and may be used for the distribution of liquids as well as solids. It was first exhibited at the meeting of the Royal Counties Society at Bournemouth in 1888, and was publicly tried after the show on the farm of the College of Agriculture, Downton, near Salisbury. An eye-witness of these trials, writing to the *Agricultural Gazette*, wrote:—"We are able to report that Mr. Strawson has brought out an efficient instrument, capable of performing what its inventor has striven to realize—a perfect distribution of various substances used in agricultural operations. It was first tested with oats, the trial being conducted upon the turnpike-road, in order that the spectators might note the degree of distribution effected. The material (oats in this case) is placed in a hopper, capable of holding six to eight bushels. The material is allowed to feed gradually downwards, and is delivered over a wide nozzle in a continuous stream. From the nozzle issues a blast of air, produced by a fan actuated from the travelling wheels of the machine, and worked up to a velocity of 3600 revolutions per minute. The direction of blast and of material is further determined by a fan-shaped, flanged plate, over which the material is blown in a fan-like form, extending over a width, when it reaches the ground, of about 23 feet. The oats were completely separated, and covered the ground with extraordinary regularity. The machine was next charged with water, and a suitable nozzle was fitted on, in place of that used for dry matter. Here the distribution of the liquid was very perfect. The water was thrown out as an impalpable spray, from which nothing could escape. The machine was next tried with paraffin-oil, when the effect was still more marked, as the paraffin was rolled out in a cloud of vaporous-looking fine spray, calculated to envelop every blade of grass or leaf of turnip over which the machine passed. The effect when finely-slaked lime was used was perhaps the most striking, as the lime formed a dense white cloud, and was distributed with absolute uniformity, every blade and culm of grass being covered as if by hoar-frost.

Such an instrument as this is likely to be of the utmost value in all cases of insect attack, and it is difficult to see how the turnip-fly can possibly resist it, if it is charged with a mixture of carbolic acid, or paraffin and water, or with such a mixture as that recommended by the late Mr. Fisher Hobbs.

The turnip-fly is by far the most pertinacious of the insect pests affecting these crops. There are, however, others which demand at least a passing notice.

The Black Jack or Nigger is the larval form of the turnip saw-fly (*Athalia Spinarum*), a pale, yellow, four-winged fly, of the order *Tenthradinæ*, which deposits its eggs under the cuticle of the lower side of the leaf near the margin. The female punctures the cuticle by means of her saws, and lays from 250 to 300 eggs, flitting from plant to plant. These hatch after a period of from five to eleven days, according to the state of the weather. The caterpillars when grown are of slaty-black colour, with a darker lamp-black line down the back. The head is of horny black, and they feed with the tail raised. When full grown they fall to the ground, and bury themselves under the surface, and surround themselves with an earthy cocoon of close texture, brown outside and silvery inside, and in this the caterpillar spins a transparent oval cocoon, and changes to a pupa. The *Athalia Spinarum* is not a constant visitor, but commits serious ravages from time to time. In 1783 a large area of turnips was destroyed by it, and in 1857 there was a destructive outbreak in the north of England. Last summer attention was drawn to the presence of great numbers of the perfect insects in Hampshire; but owing to the continued wet weather the eggs failed to hatch, and the dreaded attack did not take place.

The black caterpillar is usually found to be congregated in patches of the field rather than uniformly over the whole area under turnips. It may be hand-picked, subjected to heavy rolling, or to the action of Mr. Strawson's distributor, which would probably make short work of them.

The surface grub, or leather jacket, is a formidable enemy of all the root crops. These grubs attain a length of from 1 to 1¼ inch, and are of greenish-brown colour. They are very tough, and are not injured readily by pressure; the presence of an increasing number of blank spaces, and the occasional appearance of flagging leaves, is evidence of the attack, and, on closer examination, the soil around the root is found to be moistened with wasting sap. On scraping away the soil the grubs will be discovered, sometimes as many as a dozen being engaged on one root. The attack is continual during the growth of the crops, and the result is an uneven plant and malformed roots, owing to the excavations of the grubs made while the root is growing.

The surface grub is the larva of the crane-fly (*Tipula oleracea*), and probably certain moths, among which *Agrotis exclamationis*, *A. segitum*, *Triphœna pronuba* and *Mamestra Brassicæ* have been named. On fields affected by them, flocks of rooks, lapwings, and starlings are attracted, and ought not to be disturbed. The size of the caterpillars also renders them easy to collect, and thus handpicking may be resorted to at 1*d.* or 2*d.* a quart-measure full.

The wire-worm (*Elater obscurus* and *lineata*) and a snake millipede (*Julus Londonensis guttatus*) also attack turnips, but we are not able to suggest any practical measures of prevention beyond the general rules of good farming. If land is affected with these pests, it should be treated during previous cropping, when the "worm" may be more successfully combated. It cannot be attacked when the land is under roots.

The Aphis, green fly, or plant-louse (*Aphis rapæ*) is often troublesome to turnips in August and September. This is one of the forms of what farmers and gardeners call "blight." These Aphides congregate upon the lower side of the leaf, and by the exercise of their suctorial powers cause a cockled or puckered appearance of the leaf, in which cavities, the broods find shelter. This habit of the insects renders it difficult to syringe them, and might even prove a sufficient protection from the action of the distributor already mentioned. The peculiar system of propagation characteristic of the Aphides causes the plague to extend from centres. If a turnip is observed to be affected it should at once be pulled and buried. If on walking over the field odd plants are to be seen thus struck with blight, it would be advisable to let men or women go carefully over the whole area, taking five or six rows at once, with instructions to look carefully for and collect every affected plant, and bring them to the headland where they may be buried. In seasons when this blight is prevalent vast swarms of the winged broods fill the air towards the close of the season.

Turnips are usually affected by the turnip gall weevil (*Ceutorhynchus sulcicollis*), a small beetle which punctures the skin of the turnips and causes a small gall. On carefully slicing the top of the gall, a pale-coloured maggot is disclosed. We are not aware that the injury from the attack of this insect is serious.

The turnip is subject to several diseases. It is not our purpose to go minutely into this part of the subject. The points of contact between various sciences and agriculture are so numerous that we might be led away from our chief objects were we to follow entomological or botanical researches on vegetable attacks and diseases to their scientific limits. We rather prefer to indicate, and, when possible, to make practical suggestions, than to extend this treatise into a work upon vegetable nosology or agricultural chemistry. Special works upon these subjects abound, and should be consulted.

Club-root, or clubbing, is a disease to which all the cabbages and mustards are liable. It consists in the formation of terminal tubercles upon the root-fibres, which interfere with the functions of the roots. The result is, a number of fleshy enlargements on the under side of the growing turnip in place of a healthy ramification of root fibres. The leaves of such roots retain their green appearance for a time, but the growth of the bulb is arrested, and in time it rots. The cause of clubbing is probably a fungus, but the predisposing cause is want of lime in the soil; and a dressing of this easily available substance will usually cause the disappearance of this disease from a field which has been known to be affected with it. This disease is also known as anbury, on account of its resemblance to the warty excrescences seen clinging to the bellies of young cattle. Finger-and-toe is sometimes confused with the last disease. This is, however, looked upon as a return to the original and unimproved type of the turnip rather than as an actual disease. The selection of good seed and liberal management are the best preventatives. Dr. Gilbert has pointed out that the turnip grown on unmanured plots " will revert to its more natural characteristics if the mode of culture be not such as to favour the artificial development." The same authority also says—" The character of the unmanured root was, moreover, totally different. It had more the shape of a carrot than of a turnip; whilst its composition was also totally different from that of the cultivated root." Finger-and-toe appears to be a return to a divided or fanged character of root growth instead of the globular form terminated by a single central tap-root.

Mildew often attacks turnips, and more especially swedes. It is often attributed to too early sowing, and appears to be occasioned by a check to the growth of the plant, owing to hot and dry weather. A rapid growth thus checked, is the most ordinary condition in which turnips become mildewed. The disease wears itself out, and growth is resumed by the formation of fresh leaves from the central upward axis, and the mildewed leaves gradually crumple up and are forgotten. A diminution of the crop is the consequence of mildew, and the best preventatives are the avoidance of too early sowing, and the use of the horse- and hand-hoe.

Turnips are liable to rot. The outer shell or skin remains intact, but the flesh is altered to an offensively smelling pulp. This is most frequently observed in early sown turnips which have arrived at full maturity, and which have passed their prime. It is not often to be noticed among later sown turnips, in which vitality is strong to the close of the growing season. Neither is it to be seen among turnips of moderate size, but in the case of overgrown specimens. A practical preventative is therefore found in not allowing white turnips room enough to overgrow their strength.

THE COST OF GROWING A TURNIP CROP.

Cost per acre and cost per ton are the two aspects from which the outlay in producing a turnip crop must be viewed. Unfortunately the cost per ton is the most practical aspect of the question, especially as the yield per acre of turnips and swedes varies within wider limits than is the case with other ordinary farm crops. Attention has already been directed to the extraordinary variations in weight per acre between north and south, but it may be well to re-state that while 10, 12, and 15 tons are usual crops south of the Thames and Severn, the weight looked for per acre gradually increases as we travel northwards, until 20 and 30 tons are not unusual, and 50 tons are scarcely looked upon as phenomenal.

The question of the cost of growing a crop of turnips is beset with the following preliminary difficulties which ought to be clearly understood before entering on its discussion. First, the turnip crop stands as a substitute for fallowing. The cleaning and manuring of the land is necessary both on account of the exhaustion and foulness due to the previous corn crop, and as a preparation for future crop. It is impossible to say how far the expenses actually incurred in the cultivation of roots should be debited against them, and how far it should be carried on as a debt upon the succeeding crops. If, indeed, it could be shown that the turnip crop is capable of paying its own expenses, we should have gone far to establish the opinion that arable farming may still be carried on at a profit. Such a conclusion is scarcely warranted by experience, chiefly because this crop is particularly liable to complete failure, as, for example, was the case so recently as 1887. A heavy crop of roots may be highly profitable, a medium crop may leave the land somewhat in debt, and a failing crop may entail a heavy expenditure. It is therefore impossible to say in the abstract whether roots should be regarded as profitable or the reverse.

Another difficulty arises with reference to the estimate put upon the cost of the farm-yard manure. But farm-yard manure is seldom bought, and is made from the straw, hay, and roots, bred on the holding, enriched by cake and purchased corn. If farm-yard manure is valued and charged against the turnip crop, it is only fair to credit back the straw as part of the proceeds of corn-growing, and thus a second fictitious valuation is introduced, as straw is seldom actually sold. It may, indeed, be held that if farm-yard manure is charged against the root crop, the root crop ought to be valued at market price instead of at consuming price. In other words, if the farmer purchases farm-yard manure for his root crop, he might be considered as entitled to sell the crop. We therefore conclude that farm-yard manure should not be valued as a cost against the root crop, but that the labour thereon should be so charged, and in this conclusion we are supported by the usual course of valuations between outgoing and incoming tenants. On this understanding we should be content to value both straw and roots at a consuming price only.

The cost of root cultivation varies, first, as between clean and foul land, and secondly, as between light and heavy land. The cheapest cultivation is performed on light and clean ground, and the most expensive upon foul stiff land.

As an example of inexpensive cultivation for roots, we may take the case of light, clean land, put in rye after harvest, and then fed off with sheep in the spring. The cultivation would be as follows:—

	£	s.	d.
Cost of dunging with 16 loads ...		10	0 *
1 plough		8	0
2 double harrowings		2	0
3 bushels of rye-seed		12	0
Drilling the same		2	0
1 harrowing after drill			6
	£1	14	6

These costs we shall assume to be borne by the rye crop. The succeeding turnip cultivation would, or might be, as follows:—

	£	s.	d.
1 plough		8	0
2 double draggings		4	0
2 double harrowings		2	0
1 rolling			9
1 drilling with ashes, say ...		3	0
1 harrowing after drill			6
1 rolling			9
1 harrowing before horse-hoeing ...			6
2 horse-hoeings		2	0
2 hand-hoeings		9	0
Total tillages ...	£1	10	6
2 cwt. of superphosphate		8	0
2½ lbs. of seed at 8*d*.		1	8
Rent, rates, and taxes	1	10	0
	£3	10	2

If this calculation is considered low, all we can say it is according to practice in Wiltshire and Hampshire, and that thousands of acres are put in at no more expense every season.

When light lands are more or less foul, the cleaning of the land may be assumed to cost about £2—a figure which we arrive at as follows:—

* For calculations as to cost of tillage, see Bare Fallows, p. 27.

	£	s.	d.
1 thin ploughing or paring ...		6	8
2 double draggings		4	0
2 double harrowings		2	0
1 rolling		1	0
2 chain-harrowings		1	0
Collecting and burning couch ...		5	6
In very foul land a repetition of the same system of cultivation ...	1	0	2
	£2	0	4

By adding £2 0*s.* 4*d.* to the above estimate of £3 10*s.*, the cost of cleaning land and cultivating roots after rye would amount to £5 10*s.* 6*d.*

The cost of cultivating for roots on foul, stiff land may be stated as follows:—

	£	s.	d.
Twice steam cultivated	1	0	0
2 double drag harrowings ...		4	0
1 rolling		1	0
2 double harrowings		2	0
2 chain-harrowings		1	0
Couching and burning		6	0
1 ploughing		8	0
Various dressings, as above ...		8	0
Couching and burning		3	0
Filling, carting, and spreading dung		10	0
1 deep ploughing		10	0
1 spring ploughing		8	0
1 „ cultivation		3	6
2 double draggings		4	0
2 „ harrowings		2	0
Raking off couch		3	0
Rolling before drill			9
Drilling with water		5	0
Harrowing and rolling after drill ...		1	3
3 horse-hoeings and harrowing turnips		4	0
3 hand-hoeings		10	0
Total tillages ...	£5	14	6
Seed		2	0
Superphosphate, 4 cwt. at 3*s.* ...		12	0
Rent, rates, and taxes	1	15	0
Total cost ...	£8	3	6

Thus according to circumstances we find that the cost of turnip cultivation may vary from £3 10*s.* to rather over £8 per acre. We are aware that the amount of cultivation supposed to be expended in the last case is very heavy, and might be objected to as excessive. The object in introducing it is to show that the cost of turnip sowing ought in no circumstance to rise higher than about £8 per acre, while in most cases it is much less.

THE VALUE OF THE TURNIP CROP.

No question has been more discussed than that of the value of the turnip crop. As the value of the crop depends in a great measure upon the number of tons per acre, it is necessary in the first place to inquire as to what may reasonably be expected. After long experience we are inclined to put an average crop of swedes or turnips in the southern counties at twelve tons per acre. This estimate takes into account the risk of partial or of complete failure, and is given as a mean result between failure and such full crops as twenty-five tons.

In the north of England we may assume 20 tons as equally well representing an average result, while in Scotland we should be disposed to place it as high as 25 tons per acre.

The value of a ton of swedes has often been discussed, but we find it exceedingly difficult to arrive at a figure which will commend itself to all good farmers. Roots are so rarely consumed alone that it is difficult to say how much of an animal's increase is due to the roots, and how much to the hay, straw, and concentrated foods which assist to form the dietary.

Some years ago an exceptionally valuable opinion was expressed by three noted agriculturists upon this point, namely, by the late Mr. Hope of Fenton Barns, Mr. John Wilson of Edington Mains, and Mr. W. McCombie of Tillyfour, to the effect that a ton of roots was equivalent to the production of one stone of 14 lbs. of beef. I hold a letter from Sir John Lawes, in which he agrees that this estimate is fairly correct. If we take this *dictum* as at least approximately correct, and the price of the best quality of beef as 8*s.* 2*d.* per 14 lbs., or 7*d.* per lb., then a ton of roots would be worth 8*s.* 2*d.* Applying this estimate of the value of one ton of roots ranging from 12 to 30 tons per acre, the following figures will represent the value per acre of what is generally called the turnip crop. We should, however, rather view the figures as representing the value of swede crops than white turnips.

				Per acre. £	s.	d.
A crop of	12	tons per acre dressed swedes	@ 8/2 per ton	4	18	0
,,	13	ditto	ditto	5	6	2
,,	14	ditto	ditto	5	14	4
,,	15	ditto	ditto	6	2	6
,,	16	ditto	ditto	6	10	8
,,	17	ditto	ditto	6	18	10
,,	18	ditto	ditto	7	7	0
,,	19	ditto	ditto	7	15	2
,,	20	ditto	ditto	8	3	4
,,	21	ditto	ditto	8	11	6
,,	22	ditto	ditto	8	19	8
,,	23	ditto	ditto	9	7	10
,,	24	ditto	ditto	9	16	0
,,	25	ditto	ditto	10	4	2
,,	26	ditto	ditto	10	12	4
,,	27	ditto	ditto	11	0	6
,,	28	ditto	ditto	11	8	8
,,	29	ditto	ditto	11	16	10
,,	30	ditto	ditto	12	5	0

In confirmation of the last-named sum of £12 5*s.* per acre, we find a correspondent of the *Agricultural Gazette* for Nov. 26, 1888, writing from the north—"We consider 18 tons a very small crop, and will therefore place it at 30 tons, which at 7*s.* per ton would be £10 10*s.*, and leave a profit of £5 8*s.*

per acre. When sold to eat off by sheep I believe about £12 per acre is the usual price in ordinary years."

We are aware that many good farmers would demur to the value of 8*s.* 2*d.* and even of 7*s.* per ton as the feeding value of swedes, on the ground that they are often of little value on account of their general abundance. This is sometimes the case in early spring, when a large supply of turnips remains in the country, but this is compensated for by other seasons when turnips, and roots in general, are almost at famine prices.

When swedes are let to be eaten upon the land by sheep, we have a means for arriving at their consuming or feeding value. According to this system the farmer lets the "eatage" of his turnips at a price per head per week, and the consuming value of the roots would be arrived at by adding the profit, or expected profit, to the owner of the sheep, to the contract price paid to the owner for the keep.

The price paid varies from 3*d.* to 6*d.*, and in extreme cases to 8*d.* and even 9*d.* per head per week, and to this we propose to add 2*d.* per week in each case as a fair profit from the consumption of the roots.

Now a sheep will consume and waste 20 lbs. of roots a day, or 140 lbs ($\frac{1}{16}$ ton)* per week.

In experiments on sheep-feeding conducted at Rothamsted, 46 Cotswolds consumed in four weeks

20,838·4 lbs. of swedes,
1485·8 lbs. of cake,
1269·0 lbs. of clover hay,

that is, with a fair allowance of cake and hay these 46 sheep consumed on an average 16 lbs. of swedes per day, but as this was a strict experiment carried out in sheds, and the sheep

* As, for stock-feeding estimates, the winter lasts about 32 weeks, it is readily seen that a sheep in the course of a winter will consume 2 tons of roots, and that a crop of 16 tons per acre will maintain 8 sheep per acre for the entire winter.

vere receiving about 1 lb. of cake and 1 lb. of hay per day, we nay consider 20 lbs. as fairly representing what an ordinary-ized sheep would consume in the field.

Taking a sheep as consuming $\frac{1}{16}$ of a ton per week, the 'alue per ton is readily arrived at, and the following statenent gives a tabular view as to what is realized per ton)y sheep-feeding, on the assumption that the feeding value s represented by the contract price, and 2*d.* per week is illowed as a fair profit to the contractor.

At 4*d.*	per	week	+ 2*d.*	the roots	realize	for eating	8*s.* 0*d.*	per	ton
At 5*d.*	,,	,,	+ 2*d.*	,,	,,	,,	9*s.* 4*d.*	,,	,,
At 6*d.*	,,	,,	+ 2*d.*	,,	,,	,,	10*s.* 8*d.*	,,	,,
At 7*d.*	,,	,,	+ 2*d.*	,,	,,	,,	12*s.* 0*d.*	,,	,,
At 8*d.*	,,	,,	+ 2*d.*	,,	,,	,,	13*s.* 4*d.*	,,	,,

The value of the turnip crop may also be approached by nquiring what is the absolute amount left in money value)y sheep feeding upon them, and this may be taken out as follows. Sheep which have been winter grazed may be fairly expected to leave 1*s.* per week. In this case they would receive cake and hay, which may be computed at 6*d.** per week, leaving 6*d.* for the swedes, which, upon the above given basis of 140 lbs. per week, would give the feeding value of the swedes at 8*s.* per ton.

When high-bred young stock consume turnips, the amount realized per ton as feeding value must in many cases greatly exceed the estimate of 8*s.* per ton.

THE CONSUMPTION OF THE TURNIP CROP.

The turnip crop, including swedes, is the mainstay of the stock farmer during eight months out of the twelve. It has been objected that the turnip as a stock food is largely

* Mixed cake and corn at £6 per ton and hay at £3 per ton (consuming value) represent respectively ·643*d.* and ·321*d.* per lb.; and if $\frac{1}{2}$ lb. of cake and 1 lb. of hay be allowed per diem, the cost would be $2\frac{1}{4}$*d.* for each, or $5\frac{1}{2}$*d.* per week for cake and hay.

composed of water. The amount of water varies with the description of turnips, white turnips containing 92 per cent., yellow turnips 91 per cent., and swedes 89 per cent., and consequently the percentage of dry matter in the three descriptions of turnips is respectively 8, 9, and 11 per cent.

About half of the dry matter of turnips is sugar, as is shown by the following table compiled by Dr. Gilbert:—

ESTIMATES OF THE APPROXIMATE PERCENTAGES OF DRY MATTER AND OF SUGAR IN DIFFERENT DESCRIPTIONS OF ROOTS.

	Dry matter.	Sugar per cent.	
		In fresh roots.	In dry matter.
	Per cent.	Per cent.	Per cent.
White turnips ...	8·0	3·5 to 4·5	44 to 56
Yellow turnips ...	9·0	4·0 to 5·0	44 to 56
Swedish turnips ...	11·0	6·0 to 7·0	55 to 64
Mangel-wurzel ...	12·5	7·5 to 8·5	60 to 68

The average composition of Aberdeen yellow turnips as made out by Mr. David Wilson, jun., and reported in Vol. xviii. *Journal of the Highland and Agricultural Society*, 1888, was as below:—

MEAN OF MR. DAVID WILSON'S RESULTS.

	In fresh roots.	In dry matter.
	Per cent.	Per cent.
Water	91·09	...
Sugar	4·72	52·94
Woody fibre	1·03	11·54
Albuminoids	0·54	6·06
Non-albuminoid nitrogen × 6·25 ...	0·60	6·67
Extractive matter free of nitrogen	1·36	15·23
Ash	0·66	7·47
Total	100·00	100·00

AMOUNT AND CONDITION OF NITROGEN.

Per cent. in dry matter:—	
Of albuminoids	0·970
Of non-albuminoids	1·086
Total	2·056
Per cent. of total as albuminoids	47·3
Albuminoid ratio	1 to 12·4

As these results are admitted to correspond with those obtained at Rothamsted upon swedes, they may be taken as representative of the composition of the turnip crop.

It will be noticed that the percentage of water is 91. The dry matter is more than half sugar, and about half the nitrogen exists in the form of albuminoids. The percentage of woody fibre is low, and probably very little, if any, is indigestible.

The large amount of water in turnips constitutes an objection to their too free use. It is somewhat startling to be told that in carrying 100 tons of turnips we are hauling home 91 tons of water. The same might however be said with reference to fresh beef, vegetables, eggs, milk, fruit, and a large number of articles of diet which are highly esteemed. The presence of a large proportion of water seems indeed to be inseparable from succulent vegetable growth, and applies as truly to grass as it does to turnips, and yet grass is an unrivalled food for the production of both beef and milk. The water is so combined in and with the tissues of the vegetable as to make it luscious, and no doubt a bullock or sheep enjoys his turnips as much as we enjoy our strawberries or peaches. It seems then unreasonable to state that the water in a turnip is of as little account as the water in a trough or a pond. Rob a turnip of its water, and its attractiveness would be gone. It would bear a similar relation to a fresh turnip that "jerked" beef does to a fresh beefsteak, or dry bread does to moist fresh bread.

Turnips are too watery to be fed alone, and practice has benefited by the introduction of concentrated foods to be used in conjunction with them.

The albuminoid ratio, or the ratio of albuminoid to the carbohydrates is various. Dr. Aitkin found the albuminoid ratio of Fosterton hybrid turnips grown at Pumpherston to be from 1 : 7·6 to 1 : 12·2, and to average about 1 : 10. Mr. David Wilson found the albuminoid ratio of yellow Aberdeen turnip to be 1 : 12·4. The albuminoid ratio of turnips is therefore low, and suggests the advisability of feeding them with more concentrated foods, such as cakes mixed with cereal meals, in which the albuminoid ratio approaches to or exceeds 1 : 5.

The quantity of turnips that animals will eat when the supply is unrestricted and when turnips form the whole of the diet is very great. A working bullock will eat 250 lbs. of turnips in a day, and cattle in Scotland often consume 16 to 18 stones of 14 lbs. each.

Sheep will eat 30 lbs. to 35 lbs. per day, and probably a quarter of the animal's live weight may be considered as a measure of the amount he is capable of consuming of grass or of turnips. Cattle fed too liberally on turnips are liable to attacks of diarrhœa, and to fits of trembling, as well as to attacks of "hove," or tympanitis.

Sheep suffer much from chills and increased mortality when too exclusively fed on turnips, and almost all good farmers recognize the importance of supplementing roots with abundance of dry chaff, long hay, and a moderate supply of cake and corn.

When turnips give heavy crops of 30 tons to the acre, they are justly looked upon as the cheapest food which can be supplied to an animal; and in districts where the turnip grows to the heaviest weights per acre, the root is of higher feeding value than it is in the south. Cattle may be fed fat on turnips and oat straw alone in our northern counties, and still more rapidly so in Aberdeenshire, whereas a south country swede would not possess the necessary quality for using alone.

Roots are by common consent more liberally fed to sheep than to cattle. Thus sheep usually are found to consume about 20 lbs. of roots per diem, and if heavily "caked" the allowance may be brought back to 15 or even 12 lbs.

Bullocks are often fed with 20 lbs. of pulped roots mixed with chaff, meal, and cake, and supplemented with a little long hay and water. Fifty-six lbs. of roots is now-a-days considered a rather liberal allowance for fattening cattle in the Midlands and southern counties, and yet 20 lbs. for a sheep is a much heavier amount in proportion to the animal's weight than 56 lbs. to an ox.

Turnips may be fed upon the land or hauled off for use in yards. The first system is the more economical, the combined operations of carting off the turnips and storing them, and bringing back the manure produced by their consumption, amounting to at least £1 per acre. Wherever the nature of the ground allows of folding, the system is to be recommended.

On all dry, light-textured soils, especially when far removed from the homestead, the system of folding with sheep is excellent. On the other hand, on the stiffer lands, and especially when they are situated near the homestead, either all or a portion of the roots may be stripped off for the cattle.

CHAPTER VII.

MANGEL-WURZEL, CARROTS, AND PARSNIPS.

Introduction of Mangel—Its Advantages—Why not more generally Cultivated—Importance of Autumn Cultivation—Cultivation and Manuring—Manuring of the Mangel Crop—Small Effect of "Superphosphate" on Mangel—Paramount Importance of Nitrogen—Effect of Superphosphates and Nitrates—Effect of Potash Salts on Mangel—Potash Salts with Nitrate of Soda and Sulphate of Ammonia—Best Manures for Mangel—Common Salt for Mangel—Mangel Cultivation—Top-Dressing Mangel—Storing Mangel—Uses for Mangel—Mangel Cultivation—Weights of Mangel per Acre—Carrots—Parsnips.

It is difficult to avoid considering mangel-wurzel in connection with the turnip crop. What are known as the root crops include mangel, swedes, yellow turnips, and white turnips, or as they are sometimes spoken of, as mangel and turnips.

Mangel-wurzel is, however, a plant of a different nature to the turnip, and belongs to a distinct natural order. All the turnips, cabbages, and mustards belong to the natural order *Cruciferæ*, while mangel belongs to the *Chenopodiaceæ*, or Goose-foots. The mangel flower is described by botanists as a green perianth or inflorescence destitute of coloured petals. The root exhibits concentric rings throughout its section similar to beetroot, and the flavour is unlike that of turnips.

Mangel-wurzel was introduced into this country by Thomas Booth Parkins in 1786, the seed having been procured at Metz (Wilson). It is largely grown in France as *Racine* *de disette* and *Racine d'abondance,* and in Germany as mangel-wurzel and *futter rüben,* in contradistinction to *zucker rüben,* or sugar-beet. The mangel was considered by Von Thäer and others to have originated from a cross between the red and white varieties of 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 character during so many years have acquired for it the general admission as a distinct species (Wilson). Mangel-wurzel is essentially suited for the southern portions of these islands, although it may be cultivated anywhere south of the Tweed. The conditions of climate which suit mangel are not those most favourable for the growth of turnips. Thus, hot dry summers, which are injurious to turnips, are favourable to mangel, and the greater heat of the south of England is more favourable to it than the cooler climate of the north.

Mangel-wurzel possesses certain properties which place it at an advantage with reference to turnips.

1. Thus it is, under conditions favourable for its growth, a heavier cropper than turnips. Mangel can produce 100 tons per acre, and crops of 70 tons are not uncommon.
2. The nutrient properties are higher, as it contains a larger percentage of dry matter, and of this a more considerable proportion is composed of sugar.
3. Its keeping properties are excellent. Mangel will preserve its qualities into July and August, and it has been known to keep until the following winter, and then come out in good condition.
4. Mangel may be fed in moderate quantities to milk cows without imparting a flavour to the milk.
5. The leaves are more valuable for fodder than are the leaves of turnips.

6. It stands drought with great patience, and is less dependent than turnips upon the weather.
7. It is subject to no serious disease, and although this statement may not be absolutely correct, we can say, after having grown mangel for thirty years, we never knew it to be attacked with any disease.
8. It is not liable to insect attacks—the only serious difficulty we have experienced from insects having been from an attack of surface grub, or leather jacket.
9. It will grow on the stiffer classes of land.

The advantages of mangels over turnips are therefore both numerous and important, and yet the land devoted to mangel is much less than that occupied by turnips. In the five years from 1882-6 the average extent of turnips grown in England and Wales was 1,531,921 acres, while of mangel there were 337,521 acres. In Scotland there were 487,810 acres of turnips, and only 1432 acres of mangel. The comparatively small area of mangel as compared with turnips is owing to the smaller area of land suitable for it. Mangel can only grow on good land, and its cultivation is consequently restricted to flat haughs of alluvial soil, and to rich loams. It is never seen upon the exposed and thin soils of the downs, or the thin, cold soils of the inferior oolite, nor yet upon many tracts on which the turnip is found to thrive.

Mangel-wurzel requires good treatment as well as good land. It must be well dunged and liberally top-dressed, and it is almost always carted off the land and stored. Taking these points together, it will be seen that mangel is likely to continue as an addition rather than as a substitute for the turnip.

CULTIVATION OF MANGEL-WURZEL.

The preparation of the ground for mangel-wurzel is in many respects similar to what has been already described under the head of the cultivation of turnip ground (p. 45). So similar is the cultivation for turnips and mangel that in certain circumstances they might be spoken of as identical. The main differences are due to the early period of the year at which mangel is sown; to the stronger nature of the ground upon which it thrives; to the heavy yield per acre it produces, and to the fact that it is, as a rule, carted off the land. Each of these points affect the cultivation of the mangel; taken together they point to the necessity for deep autumn cultivation and liberal treatment.

Autumn cultivation, although much to be recommended for turnips, is still more necessary for mangel. The field ought to be ready in March or early April, and in the stiffer classes of mangel land it would hardly be wise to reckon upon such land being fit to plough between November and March. Autumnal cleaning and autumnal deep ploughing, therefore, seem peculiarly fitting in the case of these crops; and as it is impossible to clear all the stubbles in September and October, we naturally select those which are intended for the earliest sown fallow crops, such as mangel-wurzel and potatoes.

Depth of furrow, when the final autumn ploughing is given, is also much to be insisted upon. On deep land, suitable for these crops, we may give a *carte blanche* to plough as deep as possible, and 7, 8, or 9 inches may be named as suitable depths. Some agriculturists would even wish to go deeper, and to use the subsoiler in order to obtain a shattered condition of soil to the greatest possible depth. On stiff soils the system of splitting ridges over the dung in the autumn may be recommended.

The work would proceed as follows:—The stubble would be cleaned and deeply ploughed; ridges would then be raised, and before carting on the dung a three-tooth cultivator with the tines set close would be passed along the bottom of the ridges. The dung would then be carted on to, and spread between, the ridges, which would then be split over the dung. The work would then be suspended until spring, and the land would thus be exposed to the full action of the winter's frost.

Before sowing, the ridges should be gently harrowed, and once more formed up into shape with the double mould-board plough, and the seed would be sown upon the ridges. A dressing of artificial manures might be broadcasted either before or after the harrowing. A more usual plan is to split ridges over the dung in the spring upon the same principle described, under the name of the Northumberland system of turnip husbandry. The system of simply ploughing in the dung in the autumn is also adopted, in which case the mangel is sown upon the flat, or dunging is postponed until the spring, and the manure ploughed in immediately before sowing. Whenever the land is ploughed in the autumn, it is necessary to plough once or twice more as opportunity offers, so as to obtain that thorough and deep tilth so important for this crop.

TIME OF SOWING.

To obtain heavy crops it is necessary to sow early. We have known mangel sown in February, and a good deal is sown in March. The main crop is sown in April, and when taken after a fodder crop such as rye, seeding is sometimes postponed until the middle of May.

QUANTITY OF SEED, AND METHOD OF SOWING.

The quantity of seed will be 7 lbs. per acre. Mangel is best drilled either with water or ashes in rows varying in width according to the soil and climate, from 18 inches to 25 inches. There is no advantage in extending the width between the drill rows, as mangel, like turnips, may easily be grown to too large a size (*see* page 62).

Mangel-seed is surrounded with a rough integument which retards the quick germination of the embryo and the appearance of the cotyledon leaves; it is therefore advisable to steep the seed for twelve hours before sowing either in warm water or liquid manure. The seed is then spread upon a sieve or a canvas cloth, and allowed to dry sufficiently to avoid its clinging together. By this means a more rapid germination is secured.

Mangel will bear transplanting in damp weather, but as a rule the best system is to sow at once in the field. It has, however, been suggested by M. de Gasparin that if mangel is sown in a seed-bed in January, and protected from the weather, it may be transplanted in February with good results. The young plants are then thicker than a man's finger, and are said to grow to enormous size when planted out into a well-prepared and rich soil. This suggestion is well worth the attention of practical men.

MANURING THE MANGEL CROP.

Mangel requires liberal treatment. Its capacity for growth is extraordinary, and far surpasses that of either swedes or turnips; and on the same principle as the Scotch farmer is lavish in his expenditure of manure for his turnip crops, so may the south country farmer indulge his mangels..

Insufficient attention is given by farmers to the botanical differences between mangels and swedes or turnips. Both are looked upon as "root crops," and the treatment they receive is often almost identical. So far as manuring is concerned the requirements of the two classes of plants are very different.

Superphosphates, which tell in a marked degree upon the turnip crop, including swedes, exert a much less marked effect upon mangel; and nitrates, which produce only a small effect upon turnips and swedes, tell powerfully upon mangel. Farm-yard manure is a universal fertilizer; but its effect in producing a heavy yield per acre is seen more clearly in the case of mangel even than when applied to turnips. The action of farm-yard manure on mangel has been recorded by many practical and scientific agriculturists. Boussingault insisted upon its importance. Count de Gasparin stated many years ago that one ton of dung will give an increase of 1·65 tons of mangel, and that for every ton applied; while M. Crud, whose experience is recorded in *Cours d'Agriculture*, tome i, p. 655, considers that two tons increase in the crop is obtained for each ton of dung applied. The effect of common salt upon mangel is also very considerable, and should not be overlooked.

As the subject of manuring is a very important one, I shall enter upon it at some length, referring particularly to results obtained by Sir John Lawes at Rothamsted. These experiments were commenced in 1876, and have been continued ever since. During the entire period the system of continuous and consecutive sowing of the same crop year after year, and the removal of the entire produce, has been adopted, and attention has been given not only to the yield of roots, but also to the weight per acre of leaves. This last item we propose to neglect, as the chief interest lies in the weight of dressed mangel per acre. In these experiments the effect of season is shown by the great fluctuations in weight per acre, varying from minimum returns of 14 and 15 tons in unfavourable seasons, to 33 tons in good mangel years.

As might be expected, the yields of the continually unmanured plots were very small, and to practical farmers are not of great moment. For the sake of comparison it is certainly necessary that a series of experiments should contain two or more unmanured plots, although to the practical farmer the relative effects of accredited fertilizers is of greater importance. The following tables of average results are introduced by permission, and show the descriptions of dressings and the effects produced during periods of four and five years respectively.

TABLE VIII. EFFECT OF VARIOUS DRESSINGS AND CROSS DRESSINGS UPON THE MANGEL CROP AT ROTHAMSTED, AS TESTED BY SIR JOHN LAWES.

AVERAGE OF FIVE SEASONS, 1876, '77, '78, '79, and 1880.

		Manures per Acre per Annum.									
		Series 1.		Series 2. As Series 1, and Cross-dressed with 550 lbs. Nitrate Soda.		Series 3. As Series 1, and Cross-dressed with 400 lbs. Ammonia salts.		Series 4. As Series 1, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. Ammonia salts.		Series 5. As Series 1, and Cross-dressed with 2000 lbs. Rape-cake.	
		Tons	cwt.	Tons	cwt.	Tons	cwt.	Tons	cwt.	Tons	cwt.
1	Farm-yard Manure (14 tons)	14	12	20	17	23	0	24	19	21	1
2	Farm-yard Manure (14 tons), and 3½ cwt. Superphosphate[1]	15	1	22	18	22	14	24	2	22	3
3	Without Manure (1846, and since)	4	6	13	6	8	3	11	16	11	4
4	3½ cwt. Superphosphate, 500 lbs. Sulphate Potass, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5	14	19	8	15	11	24	8	18	18
5	3½ cwt. Superphosphate	5	1	16	9	9	14	12	10	12	5
6	3½ cwt. Superphosphate, 500 lbs. Sulphate Potass	4	10	17	6	14	0	21	1	16	8
7	3½ cwt. Superphos. 500 lbs. Sulphate Potass, 36½ lbs. Am.-salts (2) ...	6	0	17	13	14	13	20	16	16	18
8	Unmanured, 1853, and since; previously part unman., part Superphos.	3	9	11	0	7	1	12	0	10	2
9	Farm-yard Manure (14 tons), 3½ cwt. Superphosphate[3]	...		...		17	3	...		...	

[1] "Superphosphate of Lime"—in all cases made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr.; 1·7 (and water). [2] "Ammonia salts"—in each case equal parts Sulphate and Muriate of Ammonia of commerce. [3] Plot 9 sown on the flat instead of on ridges; plants ridged up afterwards: rows 22 inches apart, plants 10 inches apart in the rows.

TABLE IX. EFFECT OF VARIOUS DRESSINGS AND CROSS DRESSINGS UPON THE MANGEL CROP AT ROTHAMSTED, AS TESTED BY SIR JOHN LAWES (*continued*).

AVERAGE OF FOUR SEASONS, 1881, '82, '83, 1884.[4]

		Manures per Acre per Annum.									
		Series 1.		Series 2. As Series 1, and Cross-dressed with 550 lbs. Nitrate Soda.		Series 3. As Series 1, and Cross-dressed with 400 lbs. Ammonia salts.		Series 4. As Series 1, and Cross-dressed with 2000 lbs. Rape-cake and 400 lbs. Ammonia salts.		Series 5. As Series 1, and Cross-dressed with 2000 lbs. Rape-cake.	
		Tons	cwt.	Tons	cwt.	Tons	cwt.	Tons	cwt.	Tons	cwt.
1	Farm-yard Manure (14 tons)	16	15	23	9	21	7	25	3	25	3
2	Farm-yard Manure (14 tons), and 3½ cwt. Superphosphate[5]	16	12	25	1	21	9	24	18	24	8
3	Without Manure (1846, and since)	4	17	12	18	6	0	9	19	11	3
4	3½ cwt. Superphosphate, 500 lbs. Sulphate Potass, 200 lbs. Chloride Sodium (common salt), 200 lbs. Sulphate Magnesia	5	16	17	14	16	2	26	18	20	9
5	3½ cwts. Superphosphate	5	7	14	13	8	0	11	5	12	10
6	3½ cwts. Superphosphate, 500 lbs. Sulphate Potass	4	15	14	11	14	8	24	2	19	7
7	3½ cwts. Superphos., 500 lbs. Sulphate Potass, 36½ lbs. Am.-salts[6] ...	6	12	14	16	14	13	23	12	20	15
8	Unmanured, 1853, and since; previously part unman., part Superphos.	4	5	10	3	5	9	9	15	10	7
9	Farm-yard Manure (14 tons), 3½ cwts. Superphosphate[7]	...		...		18	10	...		...	

[4] Owing to the failure of the plant on many plots, and the irregularity of the crops in 1885, the produce of that year is not brought into the average.
[5] "Superphosphate of Lime"—in all cases made from 200 lbs. Bone-ash, 150 lbs. Sulphuric acid, sp. gr.; 1·7 (and water).
[6] "Ammonia salts"—in each case equal parts Sulphate and Muriate of Ammonia of commerce.
[7] Plot 9 sown on the flat instead of on ridges; plants ridged up afterwards; rows 22 inches apart, plants 10 inches apart in the rows.

The lessons to be learnt from the above tables are, first, the comparatively small effect of superphosphate of lime. Scarcely a ton an acre additional crop is obtained over the continuously unmanured plot by this dressing when used alone, a result which may be partly ascribed to the depleted condition of the soil, owing to the continuous removal of the crops. But even during the first season (1876), when the land might be considered as containing the usual elements of a cultivated soil, the result from the use of superphosphate was small, and only amounted to one ton per acre. The effect of superphosphate upon swedes has already been dealt with, and the contrast between the two crops in respect of this popular fertilizer is made apparent by comparison.

Superphosphate, whether applied alone or in combination with sulphate of potash, sulphate of magnesia, or chloride of sodium (common salt), or even farm-yard manure, does not appear to affect mangel-wurzel in the same degree in which it affects and benefits turnips and swedes. Even when applied with farm-yard manure and a heavy dressing of nitrate of soda or rape-cake, the effect is not greatly heightened by the superphosphate, being as frequently below as above the plots from which it was excluded.

Next we learn the paramount importance of nitrogen as a fertilizer for mangel. The wonderful effect of farm-yard manure must be primarily ascribed to its nitrogen, and the inexhaustible requirements of mangel for nitrogen are still further seen by the continued increase when yet more nitrogen is added. Take, for example, the effects of fertilizers in the year 1876, the first of the series. We prefer this year, simply because the condition of the ground may be considered to more closely resemble that of an ordinary field, than after an abnormal or unusual exhaustion owing to the removal of many crops of mangel.

dressing appears capable of keeping up the fertility of the land for mangel, even when a heavy crop is removed every year for a space of eight years.

The addition of superphosphate to this dressing, as seen in the fifth line of the table, does not appear to have been followed by any good result, the crop indeed being perceptibly *less* when this extra expense was incurred. The want of effect of superphosphate is apparently shown in line two, where dressings of farm-yard manure and superphosphate give poorer crops than farm-yard manure alone. The effect of superphosphate when used in combination with nitrate of soda and dung is however perceptible, as is shown by the figures below:—

	1876		1877		1878		1880		1881		1882		1883	
	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.
1 14 tons farm-yard manure 550 lbs. of nitrate of soda	25	2	24	13	18	15	26	8	17	19	21	19	27	5
2 14 tons farm-yard manure 3½ cwt. of superphosphate 550 lbs. of nitrate of soda	27	13	26	8	21	8	27	16	19	12	25	2	28	15

It is therefore incorrect to say that superphosphate exerts no effect, or an injurious effect, as, when combined with nitrate of soda, it yielded in these experiments from 2 to 4 tons extra yield. The dressing of 14 tons of farm-yard manure and 3½ cwt. of superphosphate, top-dressed with 550 lbs. of nitrate of soda, is in fact the cheapest and best dressing of the whole series; and the addition of 2000 lbs. of rape-cake, although increasing the yield considerably, must have been unremunerative.

The effect of potash as a manure for mangel was not made evident when used in combination with superphosphate. According to the actual figures, smaller crops appear to have been grown with 3½ cwt. of superphosphate and 500 lbs. of potash salts than with 3½ cwt. of superphosphate. The beneficial effect of the potash was, however, brought out when nitrogen was added in the form of top-dressings of nitrate of soda, sulphate of ammonia, or rape-cake.

COMPARATIVE EFFECT OF NITRATE OF SODA AND SULPHATE OF AMMONIA UPON MANGEL TREATED WITH SUPERPHOSPHATE AND POTASH.

	1876		1877		1878		1880		1881		1882		1883	
	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.	T.	C.
3½ cwt. superphosphate	7	10	6	1	4	14	5	3	5	11	4	14	5	3
3½ cwt. of superphosphate, 500 lbs. potash salts	6	16	5	8	3	18	4	15	4	19	4	5	4	6
3½ cwt. of superphosphate, 500 lbs. of potash salts, 550 lbs. of nitrate of soda (top-dressed)	21	2	20	19	15	1	21	10	16	8	15	16	21	1
3½ cwt. of superphosphate, 500 lbs. potash salts, 400 lbs. ammonia salts (top-dressed)	17	15	15	6	12	0	18	12	11	9	17	2	19	4
550 lbs. of nitrate of soda alone	20	13	16	17	10	2	14	0	11	6	14	5	18	14
400 lbs. of ammonia salts alone	14	3	8	16	4	7	9	17	3	15	6	3	8	6

The above table shows that in every year, from 1876 to 1883, mineral manures, given in the form of superphosphate of lime and potash-salts, exerted but little effect, and it is certainly difficult to explain why in this case the addition of potash salts should have in every year caused a positive decrease in the yield of mangel.

The attention of the reader is next called to the two bottom lines of the table, in which nitrate of soda and ammonia salts are applied separately, and the fact will be clearly brought out, that nitrate of soda produces a much greater effect when used alone than ammonia salts when similarly used. The difference is very marked and very uniform, many more tons per acre being produced by the nitrate of soda than by the ammonia salts.

Now let us examine the two middle lines of the table, and we shall notice that nitrate of soda, as a top-dressing after

TABLE SHOWING EFFECT OF POTASH SALTS WHEN ASSOCIATED WITH SULPHATE OF AMMONIA.

	1876		1877		1878		1880		1881		1882		1883	
	T.	c.	T.	c.	T.	c.	T.	c.	T.	c.	T.	c.	T.	c.
3½ cwt. superphosphate, cross-dressed with 2000 lbs. of rape-cake and 400 lbs. of ammonia salts	17	2	15	3	8	4	12	9	10	9	11	12	14	12
3½ cwt. superphosphate, 500 lbs. of potash salts, cross-dressed with 2000 lbs. of rape-cake and 400 lbs. of ammonia salts	26	8	24	18	15	3	27	4	17	7	24	4	33	5

These results are very extraordinary. We had found but little effect from applications of potash when applied as a constituent of a mineral dressing. Again, we have noticed a small and entirely inadequate result when applied, and subsequently top-dressed with 550 lbs. of nitrate of soda. But, applied with ammonia salts, subsequently top-dressed, and potash appears as a powerful fertilizer. Perhaps in ordinary practice the system of giving a dressing of farm-yard manure, drilling with superphosphate, and top-dressing with nitrate of soda, would commend itself as good and liberal treatment, and the wisdom of such a course is indicated by the Rothamsted experiments. If we call this dressing No. 1, and let a dressing of farm-yard manure and superphosphate, top-dressed with ammonia salts, be indicated as No. 2, we have the following comparative result:—

	No. 1. Farm-yard manure. Superphosphate. Nitrate of soda.		No. 2. Farm-yard manure. Superphosphate. Sulphate of ammonia.	
	TONS	CWT.	TONS	CWT.
1876 ...	27	13	29	8
1877 ...	26	8	26	18
1878 ...	21	4	19	15
1880 ...	27	16	25	15
1881 ...	19	12	16	10
1882 ...	25	2	23	5
1883 ...	28	15	23	5

CONCLUSION.

Difficult as it is to understand the comparative effects of nitrate of soda and sulphate of ammonia when potash is added to superphosphate, the best results, so far as weight per acre is concerned, rest with the nitrate of soda.

We should, however, receive the results above given with caution, because the conditions are abnormal. In ordinary cultivation, for example, where the mangel crop takes its place in a rotation of crops, the effect of potash salts could not be relied upon to produce an increase. Nitrate and farmyard manure may, however, always be applied with good effect. Whether the nitrates are applied as nitrate of soda or as ammonia salts will depend upon circumstances, and will be controlled by the personal observations of each farmer, and by the relative market price of each fertilizer. We are disposed to think that a dressing of dung ploughed in, 2 to 3 cwt. of superphosphate drilled in with the seed, and a top-dressing of 2 to 3 cwts. of nitrate of soda applied in July, will give the best possible results obtainable in the majority of cases.

COMMON SALT AS A DRESSING FOR MANGEL.

This cheap substance has been much recommended for mangel. The very name of the plant, *Beta maritima*, suggests salt, and, no doubt, on the sea-board, where the plant thrives in the wild and unimproved state, a large quantity of salt is precipitated to the ground by sea-fogs and sea-frets, as well as by ordinary rain. An inspection of the analysis of mangel reveals an extraordinary amount of chlorine and sodium, the constituents of common salt, amounting to 51 per cent. of the entire ash, while in the case of swede turnips the percentage of these elements is under 20. Sir James Caird many years ago estimated the effect of a dressing of

5 cwt. of common salt as capable of raising the yield of mangel as much as 10 tons per acre; and I have heard the late Professor Baldwin state that the same dressing of salt increased a mangel crop 5 tons per acre at Glasnevin.

The late Dr. Voelcker, in experiments conducted upon sandy soil of great depth, upon the value of salt as a dressing for mangel, found a constant but variable increase with dressings of 3, 5, and 7 cwt. per acre, amounting to 2 tons 6 cwt., 5 tons 11 cwt., and 4 tons 1 cwt. respectively, when the quantities named were severally applied. Such experiences, coupled with the known composition of mangel, will be considered conclusive; and I have no doubt myself as to the great utility of salt for mangels. It must, however, be allowed that a different opinion has been held and stated by Sir John Lawes and Dr. Gilbert, but under certain limitations as to conditions not likely to occur in ordinary farming. Sir John Lawes quotes approvingly the following opinion of Mr. Barral:—"I am prepared to declare that salt is of no value at all as a manure, if used without other fertilizing matter." Sir John adds, with reference to his own experiments:—"The salt evidently seemed to check the growth of the mangold-wurtzel the produce of roots without salt was 21 tons 2 cwt.; with 5 cwt. it was 20 tons 10 cwt., and when 10 cwt. of salt was applied there were only 18 tons." Sir John's paper speaks somewhat positively against the use of salt, but no experiments can set aside those made by other questioners of nature.

In ordinary practice salt is used in combination with other fertilizing substances, and the applications have been followed with excellent results. As in the case of turnips, so here, much must depend upon the soil, season, and climate; and the conclusion seems to be that in very dry soils, and especially in hot and dry seasons, and when used in combination with a liberal supply of other manures, salt will exert a beneficial effect. To this view the late Dr. Voelcker evidently assented, for he says :—"Indeed, my own experience is, that salt occasionally does more harm than good, not only to mangolds but to other crops as well; and I have no hesitation in saying that in cold summers even a moderate dressing is injurious to mangolds when the crop has to be grown on a cold calcareous clay, or on similar stiff soils." We have here only another instance of the importance of each farmer studying the peculiarities of his own farm, and undertaking a few simple experiments with a view to discovering the most suitable fertilizers for his particular situation.

AFTER CULTIVATION.

Mangel-wurzel is slow in germinating unless the seed-bed is moist and the weather favourable. Two strap-shaped, thick, cotyledon leaves, supported on a stem which from the first shows the red or yellow colour characteristic of the variety, marks its first appearance, and soon are seen to indicate the rows in which the seed was deposited by the drill.

At the same time other seedlings, often of very similar appearance, begin to cover the ground to such an extent as to endanger the crop. It is, therefore, often necessary to flat hoe by hand before the horse-hoe is used. After this the usual routine of horse- and hand-hoeing already prescribed for turnips (p. 121) must be carried out, particular care being taken to avoid cutting or bruising the young plants. Mangel-wurzel has not the quick healing habit which is to be observed in swedes or turnips. If cut with a hoe or wounded by a grub it continues to "bleed," or exude juice, and the wounded part does not become covered with a protecting skin or scar, but remains open as a running sore during the life of the plant. The cut surface appears to deepen with the growth of the root, and on examination will be seen to be incrusted with the dried juices, and not covered with a healthy skin as in the case of a swede or turnip. Such wounds are easily attacked by frost, and become centres from which the substance of the root blackens and rots.

Great benefit follows the top-dressing of mangel with nitrate of soda, or a mixture of nitrate of soda and salt in July, or after the second hand-hoeing. We recommend

2 cwt. nitrate of soda,
4 cwt. of salt,

well mixed together, and applied at twice, as a more complete distribution of the dressing is thus obtained. Care should also be taken to thoroughly pulverize the nitrate, in order to avoid lumps of the size of nuts or larger from finding their way on to the ground. Such lumps may prove injurious, and in any case are very undesirable.

Sulphate of ammonia may be employed instead of nitrate of soda, and we have heard very good farmers express their preference for it. Such application of highly nitrogenous manures are followed by great luxuriance of the tops, and a proportionate increase in the roots themselves.

STORING MANGEL.

Mangel is occasionally fed upon the land by sheep, but the system is not to be recommended. If the reader will refer to the table (p. 140), showing the general composition of our principal root crop, he will see that fresh mangel contains twice as much sugar as white turnips, one-half more sugar than yellow turnips, and one-sixth more than swedish turnips. This is owing partly to a larger proportion of sugar, and partly to a less proportion of water, and the result is a higher feeding value in the case of mangels than of any description of turnip, taking sugar as the standard for comparison. Mangel is not in the best condition for feeding purposes until it has been stored for several months, and when given in October and November it sometimes causes cattle to scour. After it has become mellowed by keeping it forms a most valuable food, and its good qualities are best realized in the summer, when it is used in conjunction with vetches, rape, and cabbage. It is therefore evident that it should be stored carefully, and in such a manner as will allow of its being kept for seven or eight months.

Mangel is injured by severe frosts, but may be allowed in most seasons to remain on the ground during October. Such frosts as we experience during this month and in early November are not likely to injure mangel, but when they occur storing should be suspended, and a day or two of mild weather allowed to intervene, so as to give time for the frost to get out of the roots. Frozen mangel will probably rot in the heap, but if time is given to permit the cell walls to regain their elasticity no harm will follow. The tops form a protection against ordinary frosts, and when the clearness of the sky betokens their approach, instructions should at once be given to the pullers to place the roots in small heaps and cover them with leaves.

On no account should mangel be injured with knives, or pierced with prongs or forks. Labourers will sometimes strike a knife into a mangel in order to assist them in pulling it from the ground. This should not be permitted. The hand alone must be used, and in order to avoid any excuse for employing the knife for the purpose, it is usual to have the leaves twisted off by hand. In other cases the mangel are laid in a double row, with the roots turned inwards towards each other, and the tops turned outwards, and one man passes up and down each double row, cutting off the tops with a knife. The tops should not be cut off close to the root, but so as to leave the crown or neck about half an inch long, to avoid the tendency to "bleed" already mentioned.

Orange Globe mangel is easier to pull than Long Red, and the breaking of this latter variety, as it is pulled, forms a minor objection to its use.

Mangel ought not to be trimmed with a knife before storing, but transferred to the heap with all the root-fibres and much of the soil adhering. The soil will no doubt find its way back to the field, or to some other field, in time, and mangel will be found to keep sounder on account of its presence.

The heap is best made in the form of a prism, or of a long heap of triangular cross section. These heaps are made close to the cattle-sheds, or, if intended for sheep, are placed on the headlands of fields under rye, trifolium, or vetches for consumption in the spring and summer.

Mangel heaps may be formed 6 feet wide at the base and 4 feet high to the apex. They may be made much larger without injury, and we have seen them 14 feet wide at the base, and of proportionate height. In such heaps mangel will keep as long as is necessary.

Mangel requires to be well protected from frost. It is in the first place covered with muckle or refuse straw to the depth of about 10 inches. A trench is then dug around the clamp, and the soil is thrown upon the sides to the depth of 8 inches. The whole is then neatly thatched with straw. It is advisable to leave the apex of the heap clear of earth, so as to secure a certain amount of ventilation, and for the escape of watery vapour which rises from the mangel.

The cost of pulling, topping, and throwing into carts is from 6*s*. to 8*s*., according to the crop. The cost of carting depends upon the distance. The cost of building the clamp and covering it may be put at 5*s*. per acre, and the total cost will in cases where the mangel is carted half a mile amount to £1 per acre.

CONSUMPTION.

Mangel is an excellent food for all sorts of stock. Horses are very fond of them, and two or three roots per head per day may be given with advantage during winter, especially when the horses are eating straw instead of hay. They form a capital basis of feeding for fatting bullocks. They are a favourite food for milking-cows, as they communicate no unpleasant flavour to milk, unless given in excessive quantities. They are also good for pigs, and form a pleasant addition to the food of poultry, especially if confined in wire compartments.

For sheep they are invaluable at certain seasons. The roots are useful in the lambing-pen, as they produce a good flow of milk, and are much relished by ewes. As already stated, they are invaluable when cut into troughs for sheep feeding upon spring and summer fodder crops, such as winter rye, winter barley, trifolium, and vetches. Ram-breeders and exhibitors of prize sheep could not do without a supply of mangel, and visitors to the summer show-yards will notice that cut mangel is always placed before the sheep by their attendants, together with cabbage and green fodder. As a winter's food for ordinary sheep stock, mangel is not on the whole so useful as swedes. As already mentioned, they are not adapted for the high-lying and comparatively poor soils of the upper chalk, the extensive tracts of the oolitic limestones, or other sheep-breeding districts where poor land predominates. Their cultivation is consequently limited. Mangel is not considered to be a suitable food for wether sheep, as they are alleged to produce an irritation at the neck of the bladder, which causes a difficulty in passing water.

COST OF PRODUCTION.

The quality of the land required, and the liberal treatment which the nature of the plant necessitates, as well as the weight per acre which the crop is capable of producing, all tend to increase the cost of growing mangel beyond that of ordinary turnip cultivation. The following detailed estimate, although only approximate, will give a fairly correct idea as to the expenses incurred:—

	£	s.	d.
Double steam cultivation after harvest	1	4	0
Dragging, rolling, harrowing and couching ...	1	0	0
Filling, carting, and spreading 20 loads of dung per acre		10	0
Deep ploughing, with three horses		12	0
Spring ploughing		10	0
Spring cultivation before sowing		10	0
7 lbs. of seed at 9*d.*		5	3
Drilling with water		5	0
2 cwt. superphosphate at 3*s.*		6	0
2 ,, of nitrate of soda at 11*s.*	1	2	0
5 ,, of salt at 1*s.* 3*d.*		6	3
3 horse-hoeings at 1*s.*		3	0
Hand-hoeing		12	0
Pulling, topping, and carting		16	0
Heaping and covering		4	0
Rent, rates, and taxes	2	10	0
Total cost ...	£10	15	6

VALUE OF THE CROP.

After an expenditure such as the above, and taking into account the rental of the land, and the quantity and cost of the fertilizers used, a good crop might reasonably be expected. Among the most recent statements as to the weight of mangel grown per acre, we find 63 tons 8½ cwt. per acre grown by Mr. John Treadgold at Captain Stopford's, R.N., Falconer's Hill, some of the roots weighing

36 lbs.; 50 tons per acre grown by Wm. Moore, Esq., of West Coker; 80 tons (judged, not weighed) by Mr. S. Symons, Camborne, &c. The *Mark Lane Express* for Dec. 13, 1886, records the following case:—"Many of the roots on Messrs. Sutton's stand have been drawn from a field of 120 acres. This is one of the most remarkable crops on record, and has yielded a little short of 6500 tons. Well forward on the stand is a perfect specimen of Mammoth Long Red mangel, which, when lifted, weighed 73 lbs."

Forty, fifty, sixty and seventy tons per acre have been frequently grown, and it is unnecessary to quote such examples at length, as no one who has knowledge of the capabilities of the crop will doubt them. Still, we must not conclude that these are ordinary crops. On lighter and thinner soils, and under more usual management, we should be disposed to limit our expectation to 30 or 35 tons per acre, and we are well aware that frequently 20 and 25 ton crops only are grown. If heavy crops are to be realized, the seed must be sown early. We well remember a fine crop growing on the Barking Creek sewage-farm, which we were told was sown in February; and in the eastern counties the mangel is "up in row" in April. When sowing is delayed until May, smaller crops can only be looked for. There is no advantage in growing mangel of 40 lbs. weight each. Such roots contain but little solid matter, and we do not think we are over-stating the case when we estimate the dry or solid matter in such heavy roots at half the percentage weight found in mangels of more moderate size—say of 10 lbs. each.

In valuing the crop for feeding purposes, we should be disposed to put it at 10*s*. per ton, and on this assumption, which might easily be supported by facts (see remarks on the value of the turnip crop, p. 133), a 30-ton crop of mangel is worth £15 per acre. It is therefore evident that mangel-clean it according to rules already laid down (p. 46). A liberal dressing of dung is then applied, and the land is ploughed as deep as possible. In some cases the subsoiler follows the plough, so as to stir the land 14 or 15 inches in depth. The land is then left to the influences of frost, changes of temperature, and the effects of alternate wetness and dryness, and the result of these natural forces is a complete pulverization of the soil.

Carrots ought to be sown in the last week of March, or early in April, and this often precludes the use of spring ploughing or cleaning. It is in fact the best plan to retain the fine surface obtained during the winter, and to trust to the natural open and deep character of the soil selected.

Before sowing, the land ought to be well harrowed and rolled, in dry weather, and the seed may then be drilled with 3 cwt. of superphosphate per acre, in rows 12 to 18 inches apart, according to the land and the variety chosen.

Certain peculiarities of the seed necessitate special treatment. First, the prickly or hairy character of the fruit (seed) causes it to hang together, and this is best prevented by well and carefully mixing it with moistened sand at the rate of 2 bushels per acre. The surface of the ground should be lightly rolled with a wooden roller, and the weights should be lifted off the levers of the drill coulters, so that the seed shall not be deposited too deeply.

As the tops of the carrot are small and the leaves are finely dissected, it is advisable to mix a few oats or a little barley with the seed, for the purpose of indicating the drill row. If this precaution is not taken surface weeds spring up and completely hide the carrots, and if this takes place it may become necessary to plough up the ground. Carrot-seed ought to be new, *i. e.* the produce of the previous year's growth.

The most troublesome work connected with the cultivation of this crop is in connection with digging and securing it. Each carrot requires to be lifted separately. The best instrument for the purpose is a two-pronged fork, 12 to 14 inches long, and set about 3 inches apart, and a tread or shoulder is provided for the foot of the digger. The work must be carefully done, and costs from 12*s.* to 30*s.* per acre, according to the crop. If the weather is open and dry the roots should be allowed to dry before storing, and they are then packed in clamps about 3 feet wide and 2 feet high. The clamp is built by arranging the carrots crowns outwards, and the tails toward the centre of the heap. By this plan the clamp presents a neat appearance, and is then covered with straw and earth. Ventilation should be provided by the use of draining-pipes used as chimneys, placed every two yards along the top.

Carrots are well suited for alternate growth with mangel-wurzel. A row of carrots and a row of mangel, 25 inches apart, give 50 inches between the mangel rows, and the tops of the carrots being small allow of abundance of room for the development of the mangel leaves. The carrot root searches more deeply than the mangel, and the consequence is that the two crops grow side by side without interfering with each other's growth. As an example of the careful cultivation of crops in Belgium, the following system described by the late Professor Wilson may be given:—"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 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 the seed. This germinates and continues its growth

CHAPTER VIII.

RAPE—KALE—CABBAGES, AND KOHL-RABI.

Soils Suitable for Rape—Cultivation of Rape—Second Growth of Rape not Valuable—Thousand-Headed Kale a comparatively new Crop—Its Duration—Thousand-Headed Kale—Value of Cabbages to Clay Land Farmers—Varieties of Cabbages—Cultivation of Cabbages—Consumption of Cabbages—History of Kohl-rabi—Its Valuable Qualities—Its Cultivation—Composition of the foregoing Crops.

THE crops which we have now to consider belong to the same natural order and to the same genus as turnips. They are all included botanically among the cabbages, or *Brassicæ*, and viewing them in this connection, the great diversity in form which they exhibit is striking. These differences are principally confined to the stem and the leaves. The flowers, fruit, and seed are so similar that it is not easy to distinguish them; but the extraordinary variety in the arrangement of the leaves offers a striking example of plasticity under cultivation. Looking generally at the group of cabbages, whether cultivated in the garden or the field, we note the spreading growth of the Borecole, or Kale; the wonderful development of flower-buds constituting the head of Broccoli and Cauliflowers, with their many varieties adapted to late and early sowing; the neatly-packed leaf-buds of the Brussels Sprouts; the compact head of the cabbage as seen in the Imperial or Nonpareil; the puckered hardy foliage of the Savoy; the immense growth of the Cattle Cabbage or Drumhead; the spreading flower-buds of the Majors. All these varieties spring from the *Brassica*

Oleracea, a weed which grows in ditches and moist situations, and are marked by developments of leaf and flowers induced by careful selection and cultivation. The development of the stalk or stem is seen in the Kohl-rabi, which carries its leaves upon an enlarged central axis composed of cellular matter of the same flavour and texture as a cabbage-stalk.

RAPE appears to be a cultivated variety of the swedish turnip (*B. campestris*), in which the leaf has been developed, while the root remains divided and fibrous. Botanically the two plants are identical. There is also a parallel variety of rape which seems to bear the same relation to the white turnip (*B. rapa*) which the first-named bears to the swede. In this country the rape usually cultivated is the *Brassica campestris*, or smooth-leaved variety, in which the leaf presents the same glaucus tint and waxy texture as that of the swede turnip. The central axis is studded with leaf-buds at the axils of the branches, which are ready to develop into fresh leafy food under favourable circumstances. The principal varieties are the Giant and the Essex Dwarf, which differ from each other in stature. Rape occupies the same position in a rotation as the root crop. It is best suited for peaty soils and heavy clays, but may be grown upon an extensive range of soils. It is a great favourite with the sheep-farmers of the chalk and of the oolitic limestones, and may in fact be recommended for all descriptions of land excepting poor thin soils and burning gravels. It attains the finest proportions, and the heaviest weight per acre, upon the fens of Lincolnshire and the adjoining counties, where flat vegetable soils prevail, and in no districts is the cultivation of rape better understood. The late Mr. John Algernon Clarke, in his *Farming of Lincolnshire*, relates that in these situations the crop becomes impenetrable like a fence, and that sheep may be placed upon it without requiring to be confined by hurdles.

Also, that such a crop will maintain 400 sheep per acre for one week, which is equivalent to the amount of keep supplied by 20 tons of swedish turnips. On these soils neither swedes, turnips nor mangel thrive particularly well, as they are disposed to run to leaf, and become soft and hollow (cored) in the middle. The leafy character of the rape is well suited to these soils. On stiff clay soils rape thrives better than swedes and turnips, as it is hardier in germination, and does not require the extremely fine tilth which is necessary for those crops. The roots of rape are much stronger and deeper searching than those of the turnip or swede, and this peculiarity is sometimes the cause of difficulty when the land is to be ploughed up for wheat. Rape also allows of rather later sowing than swedes, and it is customary to resow with rape if swedes should happen to miss plant or be eaten off with the "fly." On a similar principle rape may be mixed with turnip-seed for late sowings, or, as is constantly done in sheep-farming districts, one or two rows of rape are introduced in each drill-breadth for the benefit of lambs in the early spring.

Rape may be mixed with vetches by broadcasting the vetches over rows of rape, and horse-hoeing them in, and the combined crops yield very excellent sheep keep, as may be seen on the wolds of Yorkshire during summer. Rape may also be raised in seed-bed, or surplus plants may be drawn before singling, and planted out, upon the same principle as cabbages or kale are transplanted. It is particularly adapted for clay lands when early-sown, as it is consumed upon the land in summer and early autumn, at a time when these lands will bear sheep without injury, and the cultivation allows of wheat-sowing in October.

The preparation of the land for rape is identical with the cultivation for swedes, but it requires rather a better quality of soil for its successful growth than do swedes.

Its requirements with regard to manures are also similar. The leafy nature of the rape points to the advantage of nitrate of soda and other nitrogenous dressings as particularly suitable for producing a maximum yield. It has already been pointed out that nitrate of soda causes an undue development of tops in the case of swedes, but what is a disadvantage in the cultivation of this crop becomes an unmixed advantage in growing rape, and hence a top-dressing of nitrate of soda may be recommended without reserve.

The question is sometimes discussed as to whether rape should be singled like turnips, or left thickly together in the row. I am convinced that the former plan is in every way to be preferred, and that if good crops of rape are to be grown, it must be from plants set out at regular intervals of from 12 to 15 inches.

Rape will stand for a second crop by leaving the stumps after the sheep have eaten them down close. In many cases the second crop is as bulky as the first growth, but it would be a mistake to think it is of equal value. There is, indeed, good reason to believe that the second growth of rape is undesirable as a sheep keep. It is liable to injure ewes in lamb, and its consumption, unless in very small quantities, is often followed by one of those strokes of ill-luck to which flock-masters have from time to time to submit. Lambs will not do well upon the second growth of rape. Teggs or dry sheep generally do not suffer so evidently, but in no case is this later growth so wholesome as to render it desirable. It is true that in seasons of drought, such as occurred in 1887, farmers may be induced to allow the roots to remain. They have such an amount of hold upon the ground that they are sure to produce a fair amount of keep. On the other hand, in such dry seasons turnip-seed will not germinate, and therefore there seems to be a reason for falling back upon the expedient of allowing the rape to grow up a second time. The objections to this second growth are also supposed to be removed by allowing it to stand over until the spring, when the frosts of winter have restored it to a healthier condition. We shall on the whole be disposed to conclude that the better plan is to plough up the rape, either for early wheat, or with the object of re-sowing with turnips.

Rape is considered to be a very fattening crop, and I have heard it remarked by a first-rate Northumberland farmer, that fatting sheep should go into rape last, because they will not do so well upon any other food.

In the best sheep districts of the south of England it is rarely fed alone, but is used in combination with other fodder crops, such as cabbages, vetches, aftermath clover, and even early turnips.

THOUSAND-HEADED KALE.

Few crops have of late years attracted more attention than the thousand-headed kale. Public attention was first attracted to the importance of this fodder crop by Mr. Robert Russell, of Horton, near Dartford, who read a paper upon "Green Crops for Sheep-feeding," before the London Farmers' Club, in March 1876. In April 1871, Mr. Clement Cadle had read a paper upon "Cabbage and Kindred Crops," in which no mention was made of thousand-headed kale, and the discussion which followed Mr. Robert Russell's paper showed clearly that the plant was a stranger to his hearers. Mr. Russell did not introduce the crop as a novelty, but without any preparatory remark as follows:—"AUGUST—Firstly we sow 20 acres of thousand-headed kale, to be fed off in the end of April."

The thousand-headed cabbage, which is probably identical with what we now speak of as kale, is described in Morton's *Cyclopædia of Agriculture*—"The thousand-headed cow cabbage is grown in Flanders, and to a small extent in

England; but it does not appear to be so well suited for general cultivation as the drum-head. It does not "heart," and a mass of leaves, which is all it supplies, is not a convenient thing to harvest, except in the case of small farms, where the daily food of the stock may be stripped and brought in every morning."

Since 1876 increased attention has been given to this plant, and it now ranks high in the estimation of farmers—Russell's stock being preferred by seedsmen.

Thousand-headed kale may be described as a borecole, or open-headed cabbage, possessed of an extraordinary constitution, and capable of throwing up a copious crop of fodder for several years if not allowed to run to seed.

In the *Times* of Oct. 22, 1887, we read—"This practice of making thousand-headed kale stand down from three to five years on poor land otherwise hardly worth cultivation is likely to come rapidly into favour. Indeed the plan has been successful in several instances, and the roots of the kale penetrate to such a depth, especially where there is a chalk subsoil, that the plant becomes independent of rain, and therefore invaluable for such seasons as the last two have been." As just indicated, thousand-headed kale may be grown on poor chalky soils, although like all plants it will thrive better on land of good quality. Mr. Russell says—"This plant ought to be sown on strongish land not subject to chickweed." As Mr. Russell has however farmed all his life upon the chalk formation, his statement does not contradict the assertion that it prefers a calcareous or chalky soil.

It is no doubt best grown by raising it in a seed-bed, and planting it out upon the same principle as cabbages (*see* p. 183).

For feeding purposes the seed is sown in the first week of August, and is transplanted into a prepared and dunged field in October and November. A top-dressing of nitrate of soda dropped around each plant produces a rapid growth, and the crop is in perfection for folding in the following July and August.

Two methods are adopted in feeding it. First, it is close folded with sheep, care being taken that the stems are not too closely eaten, or peeled by the teeth of the sheep. If this precaution is taken the stumps will soon throw out new leaves, and produce a second crop in the following April. By careful feeding—*i. e.* by not injuring the stocks by too close feeding—the roots will continue to live and supply fodder food, as above stated, for several seasons. A better system, so far as the plant is concerned, although involving more trouble and expense, is to cut the heads, leaving three or four of the bottom leaves, and cart them off for feeding on pastures. When it is desired to raise seed, the plan pursued is to make a seed-bed in April, plant out in July, and the crop will then flower and produce seed in the following summer.

Kale may also be sown in the field. Thus Mr. Russell says—"We sow in August 20 acres of thousand-headed kale, to be fed off in April or the beginning of May in the following year. And again towards the end of April we drill in the celebrated 'thousand-headed' kale-seed, using 4 to 5 lbs. per acre." He then speaks enthusiastically of the merits of this crop as follows—"This is the least known and most desirable of any green crop I have ever seen. It is a plant that produces more feed per acre than any other, does not disagree with any stock, and does not impoverish the land; moreover, with us it has never caused the sheep or lambs to blow * or scour. Eighteen perches of this plant per day, with a little oat-straw, have kept 270 sheep for

* That is, to become distended with wind. This is not only highly dangerous to the life of sheep, but very injurious to ewes in lamb, and is often prevalent upon rape and luxuriant clover.

three months, without the loss of one." I can add my own testimony as to the hardihood and free habit of growth of this crop when grown on poor chalk soils in the county of Hants.

Besides thousand-headed kale, sprouting broccoli is another hardy description of hardy open-headed cabbage, and is recommended for sheep-feeding. It throws out a number of purple clusters, resembling "majors," together with a mass of leaves, which make excellent fodder. What is known as curled kale is also useful, and yields good sheep feed late in winter and early spring, when other forms of green food are scarce. The common Scotch kale is unbranched, and carries large plain leaves, thick and close-set, of light red or purple colour, and grows to the height of two feet.

CABBAGES.

No one knew the value of cabbages better than the great economist, Cobbett. His dictum regarding this useful plant was, "Cut a cabbage and plant a cabbage," by which he meant to express both the usefulness of the crop and its power of producing at all periods of the year. To the cottage gardener it always has been invaluable, and it is now more appreciated than ever as a field crop. Many of the advantages here claimed for cabbages are equally realized from the cultivation of the kales. These crops open up a new prospect for clay-land farmers, who have until recent years suffered from their inability to cope with light-land occupiers in the production of meat. What the turnip and swede is capable of doing for the light lands, the cabbages can do for our heavy clays. The principal reasons for this fact are—first, that cabbages revel in clays. That they will flourish on an extensive range of soils has been often pointed out as a reason for their more general cultivation, but although capable of giving excellent results on the thinner and lighter soils, there is no doubt that the heaviest crops are grown on rich deep clays. Secondly, the system of raising in seed-beds and planting out in the autumn is peculiarly suitable to these more difficult and critical soils. At no period of the year do clays work so mellowly as after harvest. It is then that they can be best cleaned, dunged, and ploughed, and every clay-land farmer knows that the plastic and gluey character of these soils is least apparent at this season of the year. The cabbage then is prepared for while it is still growing in its nursery, and is planted out when the clay fields are in a fine state of tilth. Thirdly, cabbages are (or may be) consumed upon the land from June to October, during the period in which clay lands may be stocked with sheep without injury, but with great benefit. Fourthly, they are by this system cleared off in good time for wheat. With the aid of a system in which rape, thousand-headed kale, and various sorts of cabbages find a place, there is no doubt that clay lands may be cultivated without the intervention of the bare fallow; and there is no reason why a certain area of turnips, swedes, and mangel-wurzel should not also be judiciously introduced so as to complete the series of stock-feeding crops.

There are many sorts of cabbages, but we take the following as among the most useful for farming purposes:—

The Large Late and the Early Drumheads are among the best known and most highly esteemed, to which may be added the Dwarf and Robinson's Champion Drumhead. They are the heaviest croppers per acre, and grow to the largest individual size, instances having been known of them attaining a weight of 70 lbs., while the weight per acre has exceeded 50 tons. The large Savoy Drumhead is another variety of the cattle cabbage, and is, like all Savoy cabbages, characterized by a wrinkled, dark green leaf, and great hardihood or power of resisting frost. A certain amount of frost is indeed required in order to make the leaves of these plants tender. Being of large growth, and requiring space, the large Drumheads are fitted for good land, and prefer those which are of a strong character. If there is any objection to them, it is the length of time they occupy the ground,* namely, one year. Drumheads grow vigorously during the early summer, although planted out the previous autumn, and do not "turn in" or make solid heads until August. They furnish admirable sheep or cattle food in autumn or winter. A large number of the named varieties of cabbages may be considered as well represented by the Imperial, which is of much smaller size and different shape to the Drumhead. These cabbages are heart-shaped, the point being upwards, and of a size which fits them for use as a vegetable for the table as well as for sheep-feeding. In seasons when there is a demand these cabbages may be marketed with advantage; or, when there is an abundance, and the markets are fully supplied, they may be fed upon the land, or carted on to pastures for cows and other descriptions of cattle. Closely resembling the Imperial are the Nonpareil, the Enfield Market, the Wheelers, and the Early Battersea. The Early Sheep-fold is more oval in shape, and the leaves are longer, smoother, and more strap-shaped than the rounder and more puckered leaf of the Imperial and its allies.

Cabbages have been often divided into close and open-headed varieties, but we have already devoted our attention to these latter under the heading of kale. It may be well to again refer to the subject in speaking of the varieties of the cabbage in order to mention the tree cabbage described in Lawson's *Manual* as a strong, upright plant, attaining a

* Drumhead cabbages may, however, be sown in seed-bed in March for planting out in May or June, and these plants will be ready for consumption in October or November.

height of from 5 to even 10 feet. It throws out numerous branches of a hard texture, excepting near the ends. It is grown in Jersey and the north of France under the names of *Chou cavalier*, *Chou à Vaches*, and is known in England as Branching Cabbage and Jersey Kale.

This plant is not to be confounded with the Thousand-headed cabbage, or Kale, which is also a branching variety, but of a more compact habit of growth, and having leaves of a greener and more wrinkled appearance.

The preparation of the land for cabbages should be undertaken immediately after harvest. It consists in a thorough system of cleaning such as has already been described under the heading of turnip cultivation. As the land we have especially under consideration is clay land, we recommend a liberal allowance of dung and a deep furrow. In districts where the land-presser is a familiar implement it may be used—ploughing and pressing the land. This system gives distinct lines or markings which are subsequently employed for the cabbage-rows. When the presser is not used, the same result will be obtained by marking out the line of the rows by means of a drill with the coulters set at the required width. If the drill be used a second time by crossing the first series of lines at right angles, the plants may be set at the points where the two systems of lines intersect, and thus a square system of planting is possible in which the horse-hoe can be used in two directions.

The seed-bed is generally made upon a headland, or upon a piece of vacant land in a corner of a field. It is well ploughed, and if possible dunged, and worked down to a fine state. The cabbage-seed is then drilled in rows, 9 to 13 inches apart, with 3 cwt. per acre of superphosphate of lime. The best period for sowing cabbage-seed is stated by various practical men as July 20th, the last week in July, and the first week in August. The later date is to be preferred, as early-sown cabbages are liable to run to seed. Four pounds of cabbage-seed will be required for half an acre of seed-bed, and we may consider that for every acre we intend to plant out, 1 lb. of seed will be required for the seed-bed. Some writers have recommended 8 oz. of seed as sufficient to furnish cabbage-plants for one acre, but it is not advisable to risk the success of the crop by sowing thinly. On the other hand, too thick seeding of the seed-bed is to be avoided.

Unless the season is harsh and droughty, we may expect a supply of young plants by the beginning of October, and planting may proceed at all periods when the weather is open, up to the end of November. We have indeed persevered in planting through February with success. The roots of cabbage-plants may be immersed in a cream of superphosphate and water before planting, with benefit. Care must be taken that the tap-root is not doubled upon itself, and it is a good plan to pull off the extremity of the root to prevent this accident. Planting may be let as piece work at 10*s.* per acre, or more or less according to the distance between the plants, in and between the rows.

The distance between the plants depends upon the quality of the land, and the sort of cabbage. When large Drumheads are grown they must have room, and where a heavy crop may reasonably be expected one cabbage-plant per square yard is sufficient. This would be one yard between the rows, and the same space apart in the rows, and would require 4840 plants per acre. In more ordinary cases 24 to 27 inches between the rows, and 15 to 18 inches between the plants in the rows, might be thought more suitable distances. When the Imperial or Sheep-fold cabbages are grown, 18 inches between the rows and between the plants would be suitable, and this would necessitate about 20,000 plants per acre. The advantage of growing our own plants is very considerable.

Cabbage-plants are easily marketable, and bring from 6*d.* per 100 to 2*s.* 6*d.* per 1000, and large quantities can be usually sold at 2*s.* per 1000. A good seed-bed will therefore not only supply a sufficient number for the home requirements, but a surplus which may pay for the expenses of raising the plants and of the seed purchased. On the other hand, 20,000 plants purchased means an expenditure of £2 per acre, which of course is an initial outlay of a serious nature, and amounts to 50*s.* per acre when the cost of planting is added.

My own rule with reference to cabbage-planting is that the plants are set by means of a dibble, and that they should be so firmly fixed that the plant will not lift when the leaf is taken between the finger and thumb and gently pulled. The leaf ought to break; but if, instead of breaking, the plant comes up, we find fault with the planters. When the soil is dry each plant should be fixed by the heel of the planter as he proceeds with his work, and this is called "heeling." A man will plant 5000 cabbages in a day, if the plants are laid out for him; and if timed, a good man will be noticed to plant 11 or 12 cabbages per minute, which on the first given figure would give a speed of 5940 plants per day of nine hours.

After setting, the plants are left until the spring, when they should be flat-hoed, and afterwards horse- and hand-hoed, these operations being often repeated. A dressing of 1½ to 2 cwt. of nitrate of soda per acre dropped around the stem of each plant is an excellent stimulus to growth. A well laid off and thriving piece of cabbage is not only an agreeable sight, but a highly profitable piece of cultivation, calculated to rejoice the heart of a flock-master, or to raise the hopes of a suburban farmer who meditates selling his crop.

Cabbages may either be cut or close-folded, and in either case a second crop may be looked for. Cabbages fed off with sheep in June or early July will shoot out again with vigour, and produce three to five small heads on each stalk. In an exceptionally growing season I have seen a third growth produced. It is usually considered that the best means of producing a satisfactory second crop is to cut off the heads, leaving the lower three leaves, and from these the heads will spring with greater vigour and regularity than after the stumps have been gnawed by sheep.

To ram-breeders this crop is simply a necessity, and the success of his annual sale, or of his season's career in the show-yard, depends not a little upon his cabbage crop. As a rule, the area devoted to this crop is not large, but upon a 500-acre farm 15 to 20 acres of cabbages is not too large a breadth.

Dairy cows thrive well upon them, and when grass runs short in the hot months of the year, a few cabbages spread about the pastures assist to keep up the milk, and do not (unless given in excessive quantity) injure the flavour of the milk. Where cheese is made we suspend judgment as to the advisability of giving any food but grass. It was the opinion of the late Dr. Volcker that "no kind of green food cultivated on a large scale on farms contains so much nutritious matter as cabbages."

Fatting bullocks do well upon cabbages, but the crop cannot be stored with the same satisfactory results as the root crop. Still, if stripped of their outer leaves, and well protected by straw, drumhead cabbages will keep for several weeks; but the best system is to cart them direct from the field for consumption either on pastures or in yards.

KOHL-RABI (BRASSICA-CAULO-RAPÆ).

Mention has already been made of this plant. Although by no means so generally cultivated as it deserves, it holds a respectable position in the estimation of agriculturists. It of the stem or stalk. This is as if blown out into a spherical shape, either round or oblong, and from this central enlargement leaves are thrown out, which as they fall during the growth of the plant leave characteristic scars. Similar scars are to be seen on cabbage-stalks. The principal varieties of kohl-rabi are the Green Round, the Green Oblong, the Purple Round, and the Purple Oblong. There are also the Artichoke-leaved, and the Neapolitan curled leaved varieties, which are described but not often offered for sale.

The soils for which kohl-rabi is best adopted have been already mentioned, but beside these it may be grown on most descriptions of land suitable for swedes. The preparation of the land also has in many respects been anticipated, as the same cultivation might be adopted indiscriminately for turnips, swedes, or kohl-rabi. I shall therefore pass on to the consideration of the peculiarities of treatment required in raising it.

Kohl-rabi may either be grown in seed-bed for transplanting out, or it may be drilled in the field and singled out the same as turnips. It has been remarked that four or five tons per acre more may be obtained after drilling than after transplanting. The seed-bed is, however, useful, as few crops are better suited for filling up gaps among mangel-wurzel or swedes, or for planting upon the sites of dung-heaps, lambing-pens or field-yards after the manure has been removed. Within gateways of fields it may also be employed to complete the cropping with a view to economizing every square yard of surface.

In cultivating for kohl-rabi the soil must be brought into a fine state of tillage by autumn cultivation, and ploughing in the farm-yard dung before winter. It should be cultivated (grubbed) in the spring, and a dressing of Peruvian guano and other nitrogenous manures, such as blood manure or sulphate of ammonia, should be then broadcasted over the surface and harrowed in. The plants if raised in seed-bed should have been sown as follows, so as to secure a succession of plants :—

1st sowing, March 1st, for transplanting in May.
2nd „ April 1st „ „ „ June.
3rd „ June 1st „ „ „ July or August.

It is stated that a seed-bed six yards by six yards will suffice to produce plants for one acre, and that 8 oz. of seed will be sufficient for this acre. This extent of seed-bed would, however, probably be found insufficient, and twice the seed and area would in most seasons be required to furnish the necessary number of plants.

The seed is sown in rows one foot apart, after thorough cultivation and dunging, and if necessary should be watered. The plants are allowed to grow to the height of 6 to 8 inches before they are transplanted. After planting out, the crop requires a period of 25 weeks before it is mature.

In the field the plants are dibbled 16 to 18 inches apart, in rows 27 inches apart. The drill may be employed to mark out the land, as in the case of cabbage cultivation (p. 186). Messrs. Lawson direct that for main crops, in May the plants should be set 18 inches apart; for June planting they should be placed 16 inches apart, and in July and August 14 inches apart.

If drilled at once in the field, the work should be performed in the middle of April, and the crop in all cases must be kept thoroughly horse- and hand-hoed. Kohl-rabi may be expected to yield 25 tons per acre of produce, including leaves, and 35 to 40 tons have been grown. Specimens are annually exhibited at the Smithfield Cattle Show weighing from 12 to 17 lbs. each.

The best method of consumption is undoubtedly feeding upon the land with ewes and lambs in the spring. They may also be stored after stripping off the leaves, and keep remarkably well. For cattle feeding the bulbs ought to be pulped and mixed with chaff, or cut into slices, and when so treated they form an excellent food both for oxen and milking cows.

The nutrient properties of the various crops considered in the foregoing chapters are indicated in the following tabular view. They are also all agreeable and mild in flavour, and are eaten with evident enjoyment by every sort of stock.

	Water.	Ash.	Albuminoids.	Crude fibre.	Carbo-hydrates.	Fat.	Comparative value, taking meadow hay as = 1.
Turnips	**92**	**0·7**	**1·1**	**0·8**	**5·3**	**0·1**	**0·09**
Rape	87	1·6	2·9	4·2	4·8	0·4	0·23
,,	87	1·6	2·5	2·4	8·2	0·4	0·26
White cabbage	89	1·2	1·5	2·0	6·0	0·2	0·17
Kohl-rabi	87	1·0	1·3	1·1	9·5	0·1	0·14
Carrots	,,	,,	,,	,,	,,	,,	0·16
Parsnips	,,	,,	,,	,,	,,	,,	0·16

According to table above given, rape, cabbage, and kohl-rabi are all superior in feeding value to turnips, and rape stands prominently forward as of superior excellence. The high feeding value of rape has been already insisted upon, and on comparing its analytical value with that of even such rich roots as parsnips and carrots, it will be seen to maintain its superiority; while comparing it with turnips it appears to be of about three times their value.

CHAPTER IX.

SUMMER FODDER CROPS.

Catch Crops and other Fodder Plants—Rye as a Corn and Fodder Crop—Winter Rye—Winter Barley and Oats—Italian Rye Grass—"Trifolium"—Vetches—Wiltshire Rotation—Manuring Vetches—Consumption of Vetches—Growing Seed Vetches—Trefoil as a Catch Crop—Mustard for Green Crop Manuring—Maize as a Fodder Crop—Not Adapted to this Country—Fodder Crops of Minor Importance—Gorse and Prickly Comfrey.

FODDER crops include all crops cultivated for their leafy herbage for fodder purposes. They are very numerous, as all the clovers and grasses may be properly described under this head.

It is, however, convenient to arrange them under three divisions, the first including those fodder crops that form a part of the system of fallow-land cropping; the second including the clovers, grasses, and other plants which are employed for hay or pasturage in rotation, or alternate husbandry; the third including the various grasses and plants recommended for the making of permanent pastures.

The plants included in the first of these sections are cultivated during the first year of the Norfolk rotation, which is often briefly expressed by the word "roots." They are, however, not included in this term, but either take the place of the root crop, or precede it as "catch crops," as, for example, when winter rye is taken before turnips.

All the crops described in the last chapter might be considered as fodder crops, with the exception of kohl-rabi, which cannot be properly classed either as a root or a fodder crop as here defined. They are, however, so closely allied to the turnip crops botanically, and their cultivation is so similar, that I have dealt with them in connection with these crops. The catch crop section includes :—

Winter rye, Winter barley, Winter oats } cereals.
Italian rye grass.
Crimson clover, or "Trifolium", Yellow clover, or "Trefoil", Cow grass } clovers.
Vetches.
Mustard.

In addition to this we must briefly notice :—

Furze.
Brome.
Buckwheat.
Lupins.

This list might be prolonged, as there is no class of crops which has received greater attention from seedsmen, or regarding which there have been a larger number of suggestions than this. Maize, Sorghum, Spurrey, Hungarian forage grass, and other plants have been recommended, but have not been as yet generally adopted. Detailed descriptions of these crops will not be given in the present work, as it is wished to give a true picture of agricultural practice rather than to lend prominence to certain plants which are proposed as substitutes to our existing farm crops.

The cultivation of fodder crops is altogether simpler than that of the crops already described. In this respect the fodder crops present a striking contrast to the root crops, which are both difficult and expensive to grow. These are easily and cheaply produced, and are rarely manured with special fertilizers. My task will, therefore, chiefly consist in describing the various plants and the objects for which they are cultivated, and this being the case they may be treated with greater brevity.

WINTER RYE.

Rye is chiefly employed as a fodder crop. It is known botanically as the *Secale cereale*, and is one of the four cereals which are cultivated in this country. As a corn crop it occupies a very minor position as compared with wheat, barley, and oats—some 50,000 acres only being allowed to ripen its seed in the whole of the United Kingdom. Of this small area about 45,000 are grown in England, and are probably chiefly destined to supply seed. Rye was at one time more extensively grown as a bread corn, and is occasionally sown with wheat for the production of a mixed crop known in Newcastle and Hexham markets as "maslin." Our population is however too prosperous to be content with rye bread, and the wheaten loaf has entirely superseded it. On the Continent of Europe rye is still extensively grown. It is the "korn" or "rogen" of the Germans, and throughout both North and South Germany is still extensively cultivated.

As a fodder crop its chief merit lies in its extreme earliness. It furnishes the first green food of the opening year, and hence is highly valued as constituting the first of a series of crops which furnish food for sheep throughout the spring and summer. There are two special varieties besides the ordinary rye—namely, Giant Rye, a plant of free-growing habit, and St. John's Day Rye, which is sown about midsummer, and comes in earlier than ordinary rye.

Rye is usually sown after wheat, and is well adapted for preceding a full crop of turnips, as it is fed off in March and April. In a mild autumn I have fed it in November, and again in March, and it is not uncommon in the south of England to see it fit for folding in February. The preparation of the ground may entail cleaning of the stubbles, according to the process described (*see* p. 47) under the treatment of the turnip crop. When this is done we should regard the extra cultivation as undertaken on behalf of the root crop rather than of the rye. When the stubble is clean the preparation is of the simplest character, and consists in ploughing about four inches deep, thoroughly harrowing, and drilling two to three bushels of rye seven inches apart between the rows. A stroke of the harrow concludes the work.

Rye ought to be sown in September, and the earlier in the month the stronger will be the plant, and the sooner will it be ready for use. October sown rye seldom does well even in the extreme south of England, so that earliness in sowing is an important point in securing a good plant. The surface is best left harrowed and unrolled, as a rolled surface becomes hard and battered during the winter. This is the entire cultivation of rye, so that all that is now required is to wait for spring.

Rye is usually eaten by sheep, and it is, for this purpose, at its greatest value before it sends up its flowering stalk or stem. It is usually eaten in combination with swedes or mangel, and these are either clamped upon the headland or scattered in smaller heaps over the field. Where water-meadows exist rye is usually eaten with such meadows in April. The usual plan is for the ewes and lambs to be folded in the rye, where they also receive a few roots "thrown about" or cut into troughs, and repair to a fold on the meadows during the middle of the day. In such favoured localities the flocks may be noticed passing along the roads from the rye to the meadows about ten o'clock, and returning about three in the afternoon. By this process the land under rye becomes enriched by the sheep-droppings, and brought into condition for supporting a good crop of early turnips or swedes.

Rye at a later stage may be cut for horses. It may also be passed through the chaff-cutter when fully "shot out" and mixed with chopped wheat-straw. Mr. Samuel Jonas, of Chrishall, Cambridgeshire, is accustomed to cut rye and straw together, and throw the "chop" back into a barn, where it slightly heats, and makes a sweet fodder for cattle. Rye is considered to be a wholesome and somewhat binding food for sheep.

WINTER BARLEY.

Flock-masters are accustomed to bridge over the difficult and trying period which occurs between winter and spring by means of winter rye, barley, and oats. One of the best farmers in North Wiltshire (the late Mr. John Plumb) told me that by the cultivation of these crops he could always rely on two months' keep. Winter barley differs from ordinary malting or summer barley, being specifically distinct. It is known as the six-rowed-barley (*Hordeum hexastichum*), on account of its possessing six rows of spikelets arranged around the central rachis or spike. The grain is thin and skinny, and although cultivated in high latitudes as a corn crop, its use in England is entirely restricted to fodder purposes.

Winter barley is later than rye, and it is usually sown next a breadth of the earlier crop, so as to supply food when the rye is finished. The fold is then broken up for turnips or swedes.

WINTER OATS.

These are also known as Russian, Dun, or Tawny oats, from the colour of the grain. They are hardy, and are grown so as to form a series with the last two fodder crops. They are, however, later in producing a fold, and cannot always be relied upon to form a succession. They are less suitable for catch-crop purposes, and can only be followed with late turnips.

The cultivation of all these crops is identical, so that a large field is often seen to be drilled with a breadth of each, lying one next the other, all to be folded in succession, and broken up for turnips as fast as the ground is cleared by the sheep. Winter oats may also be mixed with trifolium seed with advantage, as the two crops arrive at perfection about the same time, *i. e.* late in May or early in June, and the oats assist to make a full covering to the ground, when the trifolium happens to be weak.

ITALIAN RYE-GRASS (LOLIUM ITALICUM).

This famous plant is capable of yielding heavy crops of fodder. It is of all plants the best adapted for sewage-farms, and when irrigated has been known to yield as much as 50 to 70 tons per acre. I have seen it 8 feet long upon the Croydon sewage-farm, and as it gives three or four cuttings in one season, it has been known to have produced from 11 to 13 feet in length of grass, placed end to end, in a single season. It is not, however, in this connection that we are considering the crop at present, but as a fodder crop cultivated under ordinary circumstances.

This grass was obtained from Lombardy, where it is grown on irrigated lands, and the best seed is imported every year from Northern Italy. It is stated to have been first introduced into this country by the Messrs. Lawson of Edinburgh in 1830, from seed obtained by Mr. Thomson of Banchory, at an agricultural exhibition at Munich. It is readily distinguished from common rye-grass (*Lolium perenne*), by the presence of an awn or hair which prolongs the seed at its free extremity. Care should be taken in selecting the seed, as the worthless *Bromus mollis*, soft broom grass or "lop," as well as couch-grass, are often present in samples. Selected seeds may be purchased, and are further classified as Giant Evergreen, Improved Italian, and ordinary Italian rye-grasses. I shall have occasion to refer again to rye-grass when dealing with this plant and ordinary rye-grass, under the head of "mixed seeds." When cultivated as a fodder crop it is sown alone, and the best method is to scatter the seed broadcast upon wheat in the month of April. It germinates and grows under the wheat, and at harvest is left in possession of the ground. The Italian rye-grass gives a fold for sheep in the following April, and will produce a second and third fold if allowed. Such a course may be followed, or the grass may be cut as hay. To allow it to occupy the land too long would, however, prevent us from obtaining a root crop, and if this system is to be followed the rye-grass ought to be broken up in June or July, and the ground worked down for turnips. It is evident that so far as cleaning the ground is concerned, Italian rye-grass is inferior to the cereals already described, because as it is sown upon the previous corn crop there is no opportunity for cleaning the stubbles after harvest. As an alternative, the seed may be sown in the spring upon a cleaned and worked field, and a crop of hay or of green fodder will be obtained early in the summer. When this course is adopted, the better plan would be to allow the rye-grass to remain down the entire season, and to forego the root crop.

About four bushels of Italian rye-grass are required to seed one acre of land. They are sown either by hand or by the broadcast-barrow on a smooth harrowed surface, and are then rolled, or gently harrowed in. Italian rye-grass grows with a broad blade, and is remarkably quick and vigorous in development. It, like all the *gramineæ*, is very much benefited by dressings of nitrate of soda, Peruvian guano, soot, and other nitrogenous substances. When top-dressed immediately after cutting, or in the case of sewage-farms, when watered, it grows with surprising rapidity, and yields an extraordinary weight of produce. When sown upon a medium quality of land, and not top-dressed, the crop is of much less substance, and does not present any features of remarkable excellence, but takes its place as a well-recognized and useful crop. It has also been recommended for sowing upon stubbles after a summer which has proved unfavourable for the growth of turnips, as a means of providing early spring keep.

CRIMSON CLOVER (*TRIFOLIUM INCARNATUM*).

This crop is chiefly cultivated in the southern counties, and is in fact little known either in the north of England or Scotland. It is a true clover, but is not suitable for grazing purposes, nor for forming a constituent part of ordinary mixtures of clovers and grasses. It is, therefore, sown alone, and the land is broken up immediately after it has been close-folded with sheep. Crimson clover is a plant of beautiful appearance, as the flower is composed of an elongated spike, carrying florets of dark rich colour, resembling the richest crimson velvet. The bright green of the stems and leaves contrasting with the fine colouring of the flowers, produces an effect which it would be difficult to excel by the choicest products of the flower-garden. The plant exists in three forms—(1) early, (2) medium, and (3) late, and there is even a white-flowered variety of the plant, and by using these sorts the period during which it is used may be prolonged.

Trifolium allows of a simpler and less expensive cultivation than any other crop. All that is required is to harrow in the seed upon a corn stubble. Such is an accurate description of the process, but we shall enter upon the details at somewhat greater length.

Trifolium thrives in the southern counties upon all loamy, warm, and gravelly soils, and on soils of somewhat heavier character. It will not grow upon white chalky land, and is not adapted for extremely poor or sandy soils. For its successful cultivation it requires early sowing, and the best period is during the month of August and early in September. It is not adapted for exposed or high-lying situations. A clean stubble in a sheltered situation, and of loamy character, having been selected, it is well worked in two directions with the heavier form of harrows, known as drags, drawn by four horses. The seed is sown at the rate of 20 lbs. per acre with a broadcasting-barrow, and well harrowed in. The surface is then rolled with the heavy Cambridge or other heavy iron roller, and left.

As trifolium is liable to be eaten off by slugs, it is advisable to sow a mixture of vetches, trifolium, and winter oats in the following proportions—

16 lbs. of Trifolium.
½ bushel of Winter vetches.
½ " " " Oats.

These vetches being sown early grow strongly, and with the oats help to fill up blank spaces, and make a good mixed fodder.

Trifolium requires a firm seed-bed, with a shallow surface cultivation. This condition is obtained by harrowing the stubble, and by heavy rolling after seeding.

The trifolium makes its appearance in a very few days after sowing in the form of two broad and thick cotyledon leaves. These are somewhat liable to be attacked by slugs, but if the seeding has been accomplished early the second trifoliate leaf shortly appears, and the plant becomes established. It stands the winter well, and in early April begins to grow rapidly.

Trifolium comes in for sheep-keep between winter barley and vetches, and yields a thick luxuriant crop, which is improved by the admixture of vetches and winter oats, already recommended. Its best use is, no doubt, that of close-folding with sheep, but it may also be cut for horses and cattle for soiling in stables and yards. There is something in the sight of trifolium ready for folding, or cut and thrown on to carts, which appears to give the feeling of returning summer, and perhaps the country never looks more charming than when it is in bloom. What handsomer sight can strike the farmer's eye than that of a good lot of black-faced, close-woolled, Hampshire Down lambs turned into a fold of trifolium on a fine May morning? Both the sight and smell of the fodder are delicious, and the sheep complete a pleasing picture.

As a hay crop it is not so successful, as the stalks are tough, and the character of the hay is stemmy rather than leafy. Still, it is sometimes made into hay, and where there is a superabundance of area of this crop, it is the best course to pursue.

Trifolium does not spring a second time, and after once folding, the ground is broken up for swedes or yellow turnips, for both of which crops it is a good precursor. It usually leaves land clean, being what is called a "smothering crop."

VETCHES OR TARES (*VECIA SATIVA*).

The common vetch (*vecia sativa*) is a universal favourite. It is the main fodder crop of the summer months, and is available from May to September inclusive. The crop just described leads up to vetches, as will have been noticed by the reader. Good sheep managers usually have at least two fodder crops ready at once for their flocks. Thus rye is used together with water-meadows, or late turnip greens. Rye and winter barley; winter barley and trifolium; trifolium and vetches. The sheep thus not only enjoy a change of food daily, but are spared the disadvantage of sudden changes from one description of food to another.

Similarly, vetches are alternated with early rape, cabbage, or second crop clover, so that the same system of dovetailing is carried out with all the principal forage crops.

Vetches belong to the order *Leguminosæ*, and to a family which is well represented among our wild flora. Its principal varieties are the winter vetch and the spring vetch, which are indistinguishable in appearance, but differ from each other in hardihood and rapidity of growth. Spring vetches are the more delicate of the two, and the quicker growers, but the winter vetch is more dependable, and many good farmers continue to sow them up to March.

Vetches are sown so as to yield a succession of food throughout the summer, and this is accomplished by making a series of sowings, at intervals. The general method of cultivation consists in cleaning wheat stubble, applying a coating of about twelve cart-loads per acre of dung, and ploughing it in with a four-inch furrow. Nothing now remains but to harrow the land four times, or as many times as may seem requisite, in order to break the furrow and produce a fine tilth. The seed is then drilled at the rate of two and a half bushels per acre, and the operation is concluded by a single stroke of the harrows. Vetch seed should be mixed with a small quantity of winter barley, winter oats, wheat, or beans, as these upright-growing plants give a timely support to the weak and crawling vetches. If pure vetch seed is used the crop settles down so closely to the ground that the bottom portions of the haulm become rotten.

The first sowing of vetches should be got in as soon as possible after harvest. If a piece of clean wheat stubble can be found, the preliminary cleaning operations may be dispensed with, and the tillage reduced to the simple acts of dunging, ploughing, harrowing, drilling, and harrowing.

The acreage of vetches cultivated on farms differs widely according to circumstances. On some farms, especially of stiff character, a few acres only are grown for soiling in yards in the height of summer. It is on the wolds and downs of the chalk and the oolitic limestone that vetches are most widely grown. The vetch is a true limestone plant, and grows luxuriantly on the soils of the upper chalk without the aid of farmyard or any other manure. This luxuriance of vetches on comparatively poor chalk soils has sometimes given rise to too favourable an opinion of their fertility, which future crops have unhappily disappointed.

What is termed growing vetches "in succession" consists in making successive sowings so that the crops shall follow each other and furnish green food over a protracted period. If, for example, a field is to be devoted to vetches, a portion may be cleaned, ploughed, and drilled in September, which is as early as we may reasonably expect to accomplish the sowing of the first breadth. A second and contiguous portion is then made ready, and drilled towards the end of October, and a third portion in November. After the end of November there is no advantage in making further sowings until after the middle of January or early February, when a further sowing may be made, and this system can be continued with spring vetches up to May.

For "catch cropping," vetches are not so suitable as winter rye, barley, oats, or trifolium. They occupy the ground too long, and, unless in the case of the earliest sowings, the land is freed too late in the summer for securing anything but a poor crop of turnips. In Wiltshire it is the custom to take what are there called "backward," or late turnips, after vetches, for the purpose of producing a good show of turnip greens for ewes and lambs in the spring. After these have been fed off, the fold is broken up and the land is reduced to a fine state, after which "forward" or early turnips are drilled. This system of double root cropping, or "bringing in forward turnips after backward turnips," is much practised on the chalk hills of Wilts and Hants, and forms a very good preparation for wheat. Even the poorest "bake" or down land will produce a bumper crop after such treatment, and the land is still good enough to carry a full crop of barley. The best qualities of malting barley are grown in this manner—the rotation appearing as—

1st year. Vetches close-folded by sheep, and followed with late (backward) turnips.

2nd year. Early (forward) turnips, also folded with sheep.

3rd year. Wheat.

4th year. Barley.

During the next four years the cropping returns to a modified form of the Norfolk rotation. Thus the barley stubbles are cropped with winter rye, barley, and trifolium, which in turn give way to swedes and turnips. The succession is continued thus—

5th year. Winter rye, barley, oats, and trifolium, folded, and followed with swedes and turnips for main crop.

6th year. Barley or oats.

7th year. Clover and bents (rye-grass).

8th year. Wheat.

The eight years' course thus written out is as close a representation of what is called the Wiltshire rotation as can be given.

In the spring of the year vetches require rolling, and few crops respond more quickly, by improved colour and rapid growth, to this simple act of tillage. Vetches are liable to lose plant in the spring if rolling is neglected.

With reference to manuring the vetch crop, it, in common with most of its order, exhibits a certain inertia towards fertilizers. It is very difficult to touch the *leguminosæ* in the right place with any application. Farm-yard dung, it is true, is an exception, as it may always be relied upon to produce an effect, but vetches are, as a rule, left unmanured.

Peruvian guano also may be top-dressed over young vetches at the rate of 1½ to 2 cwt. per acre, and some good farmers employ nitrate of soda with good effect.

Professor Wagner, of Darmstadt, claims for vetches and some other plants of the same order, the power of abstracting nitrogen from the air and appropriating it to their growth. He maintains that after a certain stage of growth has been arrived at the vetch becomes independent of the soil for its nitrogen, and takes its supply from the air. He thus accounts for the rapid growth and rich green colour of vetches as the season advances. They have acquired the faculty of appropriating atmospheric nitrogen. Before this stage of growth is arrived at, the young vetch seeks its nitrogen in the soil alone, and during the earlier period a dressing of nitrate of soda or ammonia salts is said to be useful. Practically it matters little whether the plant takes nitrogen from the air or from the soil, and the topic has become a battle-ground for agricultural chemists rather than a question for farmers. Agriculturists will remember that forty years ago the great Leibig taught broadly that minerals were supplied from the soil, and that carbon, nitrogen and hydrogen came from the air. Since then we have been assured that the soil is the immediate source of nitrogen, and that atmospheric nitrogen is of comparatively small importance. Of late years a tendency has been exhibited to revive the idea of the direct absorption of atmospheric nitrogen through the leaf, or root, or both. Practice, however, is unaffected by these conflicting views, and probably will remain so, as agriculturists will continue to be guided by their experience as heretofore, and there is generally a way of reconciling theory with practice, whatever the prevailing hypothesis may be.

Vetches require warm weather, and make no rapid growth until early May. The earliest sowings will be fit for consumption during this month, and the succession of food is maintained by the subsequent sowings throughout the summer.

Vetches are in the greatest perfection for feeding when they are flowering, but to secure their maximum value we must commence to consume them rather before this event. The stage at which they are of the highest value depends to some extent upon the description of live stock for which they are intended. Lambs, for example, prefer their vetches young, whereas sheep do better upon rather older vetches, and horses are considered to benefit most from vetches when the pods are filling with seed.

Vetches may be consumed in many ways. The most usual plan is to fold sheep upon them by enclosing a sufficient area to form a bait, and simply allowing the sheep to enter and feed. There is really no objection to this method, although it has been criticised as wasteful. It has been suggested that a better system consists in mowing vetches, and carrying them within the fold, where they are placed in cribs. Another proposal which is also acted upon is to allow the sheep to eat the vetches through a continuous line of hurdles made for the purpose, and constructed with vertical bars. These lines of hurdles are advanced as the sheep eat the fodder within their reach. I am disposed to think that for economy, both of food and labour, and in the interests of the sheep, the plan first mentioned is the best. It is true there may appear to be a certain amount of waste of food; but the system of management upon sheep farms is such that this waste is more apparent than real. All flocks are divided into sections receiving different qualities and quantities of food. There are, for example, the most advanced wether lambs, or it may be ram lambs, which have the best of everything. If this section is allowed to run over a fold of vetches or rape there is no doubt apparently a good deal of waste, as these indulged animals never condescend to eat their fodder clean to the ground. But in the general economy of a sheep farm there are other less pampered animals, which are made to follow the best lot and take their leavings. Finally, there is the ewe flock, which, after the lambs are weaned, do penance during summer by acting as scavengers. These unfortunate mothers of the younger generation are made to "eat up the crusts," or, in farming language, to "clean up" after their offspring. The system may have disadvantages, but it works reasonably well, and certainly prevents waste of fodder. After the old ewes have been over a fold of vetches or rape very little is left which could possibly have been converted into food.

The system of mowing vetches and carting them to yards or stables, for "soiling," is frequently practised. When straw is abundant it may be converted into manure by cattle and horses feeding on cut vetches and clover.

Vetches may be mown as hay, or they may be allowed to stand until they ripen, and they are then classed with beans and peas as "black crops."

Of late years it has been recommended to grow them in combination with oats and beans for ensilage. Some persons consider that such a mixture, if converted into silage, would prove a more suitable crop for clay land than turnips, swedes, and mangel. This Mr. Eckersley has attempted to show, but on account of the high value he placed upon his silage, and the low estimate he formed as to the yield of corn, his calculations are not quite convincing. Mr. Eckersley is, however, still convinced of the practical value of ensiling both clover and corn crops in preference to the usual system of harvesting.

Vetches may be sown in combination with other crops. It has been already pointed out that they may be broadcasted with advantage over rape, and horse-hoed in—the combined fodder being exceedingly good for lambs. Another system, which may easily be adopted, is to plant cabbages, rape, or kale in the autumn upon vetch ground, say in every seventh or tenth row of the young vetches. The plants root easily, and produce a good mixed fodder in the succeeding spring.

For producing the best quality of vetch seed, it is a good plan to sow half a bushel of vetches with $2\frac{1}{2}$ bushels of beans. The two crops grow together, and the bean stalks support the vetches, which festoon from them, and produce a singularly clean and well-grown seed. The two crops are easily separated after thrashing, by riddles. The principle of blending crops is scientifically sound, as the food required as well as the depth and distribution of the roots of two distinct species of plants are different. There is less rivalry, and the ground yields a larger amount of plant food than where one species only occupies it. Upon this principle beans and peas may be mixed together with good result.

TREFOIL (*MEDICAGO LUPULINA*).

The number of synonyms by which this plant is known attests its popularity. It is spoken of as Yellow Clover, Black Medick, Non-such, and erroneously as Hop-clover. It always forms a portion of mixtures of clovers and grasses for alternate husbandry, but it is also frequently sown alone. Trefoil is not a bulky grower, and cannot compare with Trifolium, nor yet with vetches in the vigour and abundance of its produce. Its strong points are its earliness, as it flowers in April and May, and may be cut and carried in ample time to secure a full crop of turnips. It yields a hay of remarkable sweetness and fineness, and this is best produced upon chalky or calcareous soils. On such situations trefoil is often employed as a catch crop between wheat and turnips. The cultivation consists in sowing 20 lbs. of seed by means of the broadcast-barrow upon the young corn, and gently harrowing or rolling it in. The trefoil covers the field after harvest, and after giving one early cut of hay the following spring the ground is broken for turnips as already explained.

Trefoil has also been recommended as a suitable plant for clay ground—the suggestion being that trefoil should be fed off with sheep, and that the ground should then be broken up for turnips, and brought into wheat in the autumn. The objection to such a course being generally adopted consists in the impossibility of winter fallowing or autumn cultivating land sown down with trefoil. Clay soils require complete pulverization and aëration during the autumn and winter, especially if it is intended to grow roots upon them. It therefore appears inconsistent with the best traditions of clay land management to sow it down with trefoil with a view to taking roots afterwards.

WHITE MUSTARD (*SINAPIS ALBA*).

White mustard is one of a group of cruciferous plants which comprises the plant from which table mustard is manufactured.

It is closely allied to the charlock, ketlock, runch, or yellow, which infests corn-fields in most localities and seasons.

White mustard is a quick-growing plant, and produces a fold for sheep in a shorter time than any other cultivated crop. It is usually employed as a means of producing sheep-keep in times of scarcity, as when the turnip crop has failed through drought. In such seasons mustard is sown upon the turnip land, or upon stubbles which are cleared early—a condition which is most likely to occur in hot and dry seasons. Twenty to twenty-five pounds of seed is sufficient for one acre, and this is best sown with the broadcast-barrow upon a shallow furrow and harrowed in. The mustard shortly appears, and soon covers the ground, providing a useful fodder about six weeks after seeding. It is seldom manured, but superphosphate produces a great effect upon it, as may be seen in the larger size of the plants which happen to be growing in the lines in which the superphosphate had been drilled upon turnip land.

White mustard is not considered to be a fattening food, but is useful for store sheep or ewes, as a means of shortening a period of scarcity. It is easily destroyed by frosts, and should be eaten before the end of November.

Mustard has been recommended as a green manure, and as a cleaning crop for land. Mr. Peter Love described a system of fallowing land in which white mustard was introduced with these objects. The plan pursued was to plough the fallows early in the spring, and sow mustard upon them. As soon as the crop was in its prime a roller was passed over it, and it was ploughed under. A second seeding of mustard was then applied, and similarly ploughed in. A third crop of mustard, also ploughed in, completed the process, and Mr. Love found by this procedure the ground was rendered both clean and fertile, and it was then sown with wheat. This plan has much to recommend it. The amount of vegetable matter thus introduced into a clay soil would greatly improve its texture, and the decay of the plants within the soil would supply nitrates for the growing wheat. The system of green manuring has its ardent admirers, and the only objection to it is simply that having succeeded in obtaining a crop it is clearly better to feed it off with sheep than to partially waste it by ploughing it in.

Mustard is supposed to exert a good effect upon land infested with wire-worm, and hence, as mentioned under the head of Sainfoin (p. 241), old sainfoin ground is often sown with mustard before hazarding a crop of wheat.

Mustard may also be sown broadcast over turnip-fields at the same time as they are drilled, as a means of distracting the attention of the turnip-fly, and is afterwards got rid of in the processes of horse- and hand-hoeing when it has accomplished the object for which it was sown.

MAIZE.

This plant may be ranked as of the highest importance in the agriculture of Europe, Asia, and America, but in spite of many efforts to introduce it into English agriculture, it is still chiefly grown for experimental purposes. The climate of England is too temperate for maize. It thrives, it is true, in more northern latitudes, as in Sweden and Canada, and throughout the central regions of Europe. It was cultivated by the North American Indians previously to the introduction of European arts, and is referred to at considerable length in Longfellow's poem of *Hiawatha*, under the Indian name of "Mondamin," in the canto entitled "Blessing the corn-fields." Maize, says Mr. J. F. Duthie, is undoubtedly an introduction from America. It is known botanically as *Zea Mays* (Linn.), and belongs to the genus *Maydeæ*, and the natural order *Gramineæ*. Maize is a cereal grass, and yields a grain known as maize or Indian corn, which when finely ground is sold as corn-flour. It is largely imported into this country as a food for horses, cattle, and pigs, and in America it forms one of the staple stock foods.

It has never been seriously proposed to add maize to our cereal crops, but many attempts have been made to introduce it as a fodder plant. Especially has it been recommended for silage, and indeed few plants are better adapted for this purpose. Instances are recorded in which maize has been successfully grown as a fodder crop, and Messrs. Carter have been particularly prominent in urging its claims upon the attention of English farmers. In this endeavour they have met with a certain amount of support, but it is more than probable that the peculiarities of our climate will in the long run prove adverse to its extended cultivation.

As a fodder crop it meets with many competitors, each of which are better suited to our humid atmosphere and low average temperature, and hence it must not only be judged upon its own merits, but as compared with the root and fodder crops already established among us.

While then maize may be successfully grown in favoured situations, and peculiarly favourable seasons, it will always prove uncertain, and often disappointing. In trials made at the College of Agriculture, Downton, in the exceptionally hot summer of 1887, and again in the cold summer of 1888, the maize, although sown on good alluvial soil in a well-sheltered situation, was vastly inferior in bulk of crop produced to such fodder plants as thousand-headed kale or cabbage, and was inferior even to vetches. Its growth was prematurely checked by the cold nights which occurred, and may always be expected, in September, and it was completely cut down by frost early in October. Like the vine and tobacco plant, it requires more forcing weather and warmer nights than we can hope for in this country, and hence we are not able to endorse the sanguine views as to the value of this plant which have been expressed in some quarters. The descriptions recommended to English farmers are the Caragua Giant and the Horse-tooth maize. They are dibbled in upon well-prepared and dunged land about the middle of May, and grow with considerable rapidity during the months of June, July, and August, or until the lower temperature of our autumn nights checks their further development.

Cobbett endeavoured in vain to acclimatize maize by growing it year after year, and although he produced a hardy variety, capable of ripening its seed under an English sky, it was done at a sacrifice of size both in the stem and cobs, which greatly reduced its value.

GREAT MILLET (*SORGHUM VULGARE*) AND NORTH CHINA SUGAR-CANE (*SORGHUM SACCHARATUM*).

These two descriptions of millet have of late years been offered by leading seedsmen as suitable for foddering purposes. They are, however, essentially exotics, and are open to the same objections as maize. They are, if anything, less adapted to our climate than maize, and although upwards of twenty years ago we remember seeing fairly good specimens of the *S. saccharatum* grown in a garden, our trials in the fields have shown a ludicrously poor result. In 1888, for example, while two varieties of maize reached a height of 4 feet 6 in. the *S. saccharatum* never grew higher than about four inches.

GORSE (*ULEX EUROPÆUS*).

In waste places and poor sandy soils gorse may be cultivated as a fodder crop, and when once a plantation is formed it may be considered as permanent. The usual course is to plough and work the land into a fine state, and sow 20 to 30 lbs. of seed in the latter end of March, in rows 9 inches apart. The young plants must be kept free from weeds by hoeing until they cover the ground. The first cutting will be taken in the autumn of its second year. It is secured by cutting with a heavy hook, and is tied up in bundles of 20 lbs. each—2000 such bundles being considered to be a fair crop. The variety known as *Strictus* is considered to be superior to the ordinary gorse, but cannot be propagated by seed. When this variety is employed cuttings must be obtained, and after they have been struck they may be transplanted to the field, where they may be set in rows 18 inches apart, and 8 inches between the rows. Mr. John Chalmers Morton recommended that every alternate row should be cut each year, so as to harvest half the produce each season, and thus always secure a two years' growth.

Gorse requires to be broken or bruised before it is employed for feeding purposes. This is done by means of an ordinary chaff-cutter, or by a mill in which the gorse is made to pass between fluted rollers. In some gorse mills both of these actions are employed, the gorse being first cut by means of a two-knife chaff-cutter, from whence it falls into a pair of revolving rollers between which it is passed. The rollers are composed of closely set, serrated discs, which meet and pass each other upon the same principle as a curd-mill or cake-breaker. Such a mill is manufactured by Messrs. McKenzie and Sons, of Camden Quay and Ceres Iron Works, Cork, and delivers the gorse in a thoroughly pulverized and shredded condition.

Twenty to twenty-five pounds of crushed gorse, mixed with half the usual quantity of hay, will keep a horse in as good condition as a full supply of hay. It also forms a wholesome food for cattle, and especially for young stock, and is therefore of value on a certain class of poor and weak lands which are incapable of growing most other crops.

PRICKLY COMFREY (*SYMPHYTUM ASPERRIMUM.*)

This is another of those minor crops used for fodder which requires at least a passing notice. It grows wild in damp situations; but in order to obtain the best results, cuttings from good stocks must be obtained, and these are readily procured from our large seedsmen. The most suitable position for prickly comfrey is found in waste corners, low-lying, somewhat swampy places, or on land shaded by trees. The roots or sets are planted in the autumn, and after they are once established they are perennial in duration. The Rev. E. Highton of Bride, Cornwall, gave the following description of his method of growing comfrey in the Journal of the Royal Agricultural Society for 1882. Writing to Mr. Joseph Darby he says, "I only keep a couple of cows and a few breeding sows, and the whole extent of my comfrey is not a quarter of an acre. The land where it grows is to a great extent shaded by large trees, and I could not previously get anything to thrive there satisfactorily. On this account, I consider my growth is below what it would be under more favourable circumstances. Four years since I obtained 200 roots from Messrs. Sutton and Sons, Reading. After digging holes 18 inches deep, and the same in diameter, I filled them with good half-rotted dung, covering it up with the soil taken out. Into each of these hillocks, of which there were fifty to the square rod—about 2½ ft. apart each way—I put a single set, which was covered with about two inches of soil over the top. In May the following year I got a fair cutting, and then more during the season. Every year since I have cut four times, and sometimes five. After each cutting well rotted manure is put round the root." Mr. Mitchell Henry, of Kylemore Castle, Galway, has been very successful in growing comfrey upon black bog, and it is from him that I received my own stock of comfrey.

Comfrey ought to be cut a day or two before using it as fodder, in order to allow the prickles to soften. Although all sorts of stock are fond of it, the taste appears to be an acquired one, as I have frequently seen cows refuse it when first presented to them as a novelty. The best method of using it is to pass it through a chaff-cutter together with a little hay or straw. Comfrey has been up to the present time chiefly grown by landlords, and by those who, like the Rev. E. Highton, keep a cow and a pig. Farmers have not countenanced it to any marked degree, although the crop has now been about a dozen years before the public. For ordinary field cultivation, indeed, it is not to be recommended, as it is very difficult to eradicate when once it gains possession of the ground.

CHAPTER X.

CLOVERS AND GRASS-SEEDS.

"Clover-Sickness," and how it may be Avoided—Clover an Excellent Preparation for Wheat—"Cow Grass"—Alsike Clover—Clover Seeds Compared—White Clover—Yellow Clover and Rye-grass—Is Perennial Rye-grass Permanent?—Dr. Fream's Experiments—Perennial Rye-grass proved to be a Permanent Grass—Sir John Lawes' Testimony as to the Value of Rye-grass in Pastures—Mr. James A. Caird on Rye-grass—Present Position of the Rye-grass Question—Mr. Martin J. Sutton on Rye-grass—Mixtures of Grass-seeds for Alternate Husbandry.

THE remaining fodder plants occupy a different position in rotation to those which have hitherto been before us. With one or two exceptions we have been considering fallowing crops, or those crops which are properly placed in the first position towards a succession of more or less exhausting crops. Those now to be considered occupy the third year of the Norfolk four-course rotation, as is shown when this course of cropping is examined.

1st year.	Roots and fallowing crops.
2nd "	Barley.
3rd "	Clovers and grasses (seeds).
4th "	Wheat.

These crops are not fallowing in their nature, because their cultivation precludes all opportunity of tillage. They are, however, ameliorating from the fact that they are as a rule grazed, or, if mown, eaten by live stock upon the premises. The most important group of these plants is that of the clovers, which in alternate husbandry consists of four species—namely, Red clover, White clover, Yellow clover, and Alsike clover.

RED CLOVER (*TRIFOLIUM PRATENSE*).

Red clover, also known as Broad clover, is a plant of strong growth, and is the most valuable member of the group. If red clover could be depended upon, room would scarcely be found for any other species. It is, however, a plant of only short duration, appearing to the greatest advantage in its first year; and although it puts in an appearance during a second or even a third season, it is never then so plentiful nor so luxuriant.

Red clover is subject to a disease which is usually spoken of as clover-sickness, a term sometimes applied to the condition of the plant, but often used to express the condition of the soil with respect to the crop.

When red clover is grown upon the same land at intervals of four years, as in the Norfolk rotation, and after the course of cropping has been several times repeated, the plant refuses to grow. Although the seed germinates it speedily dies away, often in irregular patches, in spite of the most liberal dressings of fertilizers that can be devised. Although clover sickness has been attributed to fungoid attacks, it is probable that the presence of fungus rather betokens a weak condition of the plant than the immediate cause of the disease. Similarly, the presence of certain thread-worms (*nematodes*), such as *tylenchus devastatrix*, are not to be regarded as the cause of the disease so much as accompaniments of low vitality.

Clover-sickness rarely occurs on chalk soils, or at least we may say that many chalk soils are able to carry clover, rotation after rotation, without difficulty.

The memorable plot of red clover in the kitchen-garden at Rothamsted, which has been kept up for the last forty years, is a standing example of the possibility of growing red clover continuously on ground sufficiently rich in nitrates and mineral food.

I am strongly disposed to view clover-sickness as an instance of insufficient nutrition. Red clover is provided with an exceptionally long tap-root, which is capable of abstracting food from a depth of at least 54 inches below the surface. If then either soil or subsoil are deficient in fertilizing matter, we may expect to find an arrested growth, followed possibly by the dying off of the plant. The whole subject is one of considerable difficulty, involving problems in agricultural chemistry as well as in vegetable pathology which we cannot enter upon at present.

Although it is difficult, and perhaps impossible, to make clover grow on clover-sick land, yet the evil may be avoided by certain simple expedients. One of these consists in the interpolation of other crops instead of red clover, whereby the interval between the red clover crops may be extended to eight or twelve years. If, for example, we are afraid of sowing a field with clover, it may be sown with peas. The next time it comes round we may take vetches, or Italian rye-grass; or we may take a crop of turnips.

By these expedients there is no difficulty in placing an interval of years between clover crops, and when this is done clover-sickness will not trouble us. Dressings of lime, of chalk, and liberal treatment generally, will also act as preventatives, although if land is really clover-sick it will be necessary to have recourse to the changes in cropping suggested.

Red clover thrives best upon clay soils rich in lime, potash, and nitrates. On such land exceedingly stout crops of this plant may be grown alone or associated with rye-grass. If sown alone, 20 lbs. of seed per acre is sufficient, sown by the broadcast-barrow upon young wheat in March or April. The surface should be first well harrowed, to prevent the seed from disappearing down the cracks with which clay lands generally are fissured, and, after sowing, a light touch with a grass-seed harrow, followed with a roller, completes the cultivation. On land of this description a heavy cut of hay may be obtained by sowing—

14 lbs. of red clover, and
1 bushel of Italian rye-grass.

Such a mixture will, however, only stand one year's mowing and grazing, and should be broken up in autumn for wheat.

In mixtures which are intended to remain down for two, three, or four years, the amount of red clover should be successively reduced, and its place taken by white Dutch and Aliske clovers, both of which are permanent in character, and a portion of the Italian rye-grass would in such cases be replaced by perennial rye-grass and other grasses.

As a preparation for wheat, red clover is unrivalled. The mass of its roots and their deeply penetrating power exert in the first place a mechanical effect upon soils, and as they decay they add to the store of organic or carbonaceous matter in the soil. Not only this, but they store up nitrogen in the surface soil, which they leave collected in the deeper layers, and as many think from the air, through the medium of the leaves and stem. The fall of the leaf also during growth forms a top-dressing upon the surface of the soil rich in nitrogen, and hence the substance most urgently required by the wheat is left by the clover.

This is one of the best illustrations of the use of rotations, and stamps the Norfolk rotation as a scientific succession of crops. The fact that clover mown is often followed by a better wheat crop than clover grazed, is due to the greater development of the plant under the former system; and a still more striking fact is, that even clover allowed to stand for a seed crop is followed by a better crop of wheat than clover closely grazed.

The variety of red clover known as cow grass, and perennial red clover, differs from ordinary red clover in its duration, which may be spoken of as permanent.

It is by no means easy to distinguish cow grass from red clover when growing, and the seed is so precisely similar that we can only rely upon the assurances of the seller. Mr. Martin John Sutton, in his work upon *Permanent and Temporary Pastures*, gives a description of cow grass (*T. pratense perenne*) which we quote at length. He says it "differs from broad clover in having a somewhat taller, smoother, and except in its very young state, a less hairy stem, and a stronger, less fibrous, and more penetrating root. It carries its flowers some way above the foliage, surpasses broad clover in succulence and weight of crop, and stands frosts much better."

This plant ought to form a part in every mixture for permanent pastures. The Rothamsted experiments have proved it to be more decidedly perennial in its nature than ordinary White Dutch clover (*T. repens*), and there can therefore be no doubt as to its fitness for forming a part of all mixtures for this purpose. Buyers require to be particularly careful in purchasing this seed, as too often ordinary red clover is sold under the appellation of cow grass.

It is used in arable cultivation in the counties of Berkshire, Oxfordshire, Hampshire, and Wiltshire, and it is there the custom to sow an acre or two of it for cutting for horses. When thus sown it comes in most usefully as green food during the height of the summer, but after mowing it does not give a second crop of any consequence. The variety sold in Salisbury for this special service is described as Imperial Cow Grass.

The true cow grass is stated by Mr. Sutton to have originated in a cross between *Trifolium medium* and *T. pratense.*

Marl grass is another closely-allied clover, partaking more of the nature of *T. medium*, or zig-zag clover. The leaf is narrower and more pointed, and the habit of growth of the stems gives its distinctive English name.

Lord Polwarth speaks in the highest terms of cow grass as an ingredient for permanent pastures in Berwickshire and Roxburghshire.

ALSIKE CLOVER (*T. HYBRIDUM*).

Alsike or Swedish clover is in so many respects similar to both red and white clover, that it has often been asserted to have originated in a cross between these plants. This is, however, by no means certain. It is a native of Sweden, and takes its name from the village of Syke near Upsala. It is said to be indigenous in southern Europe. Alsike clover was originally brought from Sweden by Mr. George Stephens of Edinburgh, and is stated to have been first sown in Meadowbank Nursery by the Messrs. Lawson, April 17th, 1834. It was soon found to be a most valuable addition to the fodder crops of this country, being truly perennial in its nature, and unaffected by clover sickness. Alsike clover is adapted for cold and moist soils, and may be used in mixtures of seeds for both arable cultivation and permanent pasturage.

It is a remarkably free grower, and affords a much larger mass of foliage than the white clover.

Alsike clover is not so generally cultivated as the three staple constituents of all ordinary mixtures—red, white, and yellow clover; and this may be accounted for by the natural disposition of many farmers to adhere to their old practices; and also to the fact that its excellences are not fully brought out upon thin and dry soils. When, however, the situation is suitable, it grows with great luxuriance, and must be allowed a high position as a fodder plant. As Alsike clover is not so well known as some of the other members of its group, I take the opportunity of contrasting it with them.

Alsike clover in its free habit of growth resembles red clover. Its flowers are in some respects like those of white clover, but the outer florets are tipped with pink or purple, so that the words of the poet Burns, "wee, crimson-tipped," which he applied to the daisy, are suitable, so far as colour is concerned, to the Alsike clover. The flower is carried upon a long stalk, in which peculiarity it differs decidedly from red clover, whose globular head rests, without the intervention of a stalk, between two leaves, and is described by botanists as sessile. The leaves are free from the characteristic V-like white markings which are common to red and white clover, and the stipules at the base of the leaves are less closely applied to the stem and more pointed than in red clover. These appendages are generally much less definitely shown in the case of white Dutch clover; the stem of Alsike clover is said to be hollow, but this character cannot be relied upon as distinctive. The seed of Alsike clover is unmistakable. It is small and angular in shape like white clover-seed; but its light and dark green colour, which in a sample exhibits a dark green shade, is quite characteristic. Red clover-seed is much larger, decidedly kidney-shaped, and the colour is usually purple at the larger end, shaded into yellow or buff. White clover-seed, on the other hand, is of a bright yellow colour, turning with age to a darker and duller tint. Alsike clover is seldom cultivated alone except for seed.

WHITE DUTCH CLOVER (*T. REPENS*).

White clover is one of the most generally distributed of all our plants. It occurs on every grass-plot, and in every field. It springs up we know not how, as the seeds seem to lie latent in every soil. It is well known that white clover will appear upon heaths after dressings of lime. The power of the seed to live in a dormant condition for long periods of time is remarkable, and the appearance of large quantities of white clover after the drainage of wet lands and in other circumstances is difficult to account for. Although indigenous all over the country, it does not appear to have been sown separately until the beginning of the eighteenth century.

White clover more than any other plant assists to give compactness to turf, and that closeness of pile, if I may so speak, to the carpet of green which covers our pastures. No clover and no plant is more worthy of a place in mixtures for permanent pasture, and many farmers rely upon it and a good description of perennial rye-grass as sufficient, in the lying down of arable land to permanent pasture.

For arable purposes its uses should be confined to mixtures of seeds intended to give a pasturage for more than one year. During the first season it scarcely appears, and is often completely overshadowed by the red, yellow, and Alsike clovers. The second year, however, brings out the qualities of the white clover, and in all subsequent years during which the land is allowed to lie, the white clover will constitute an important feature. The name *Repens* is derived from *Repo*, to crawl, to couch (hence the application of the same word to couch-grass), and refers to the creeping growth of white clover, which sends out runners that take root and thus spread over the surface. White clover takes its name from its white flower, which smells as sweet as any rose, and abounds in honey, so that bees always do well when it is in bloom. White clover is never grown alone for grazing or mowing, but is exceedingly valuable in mixtures with the one exception, already pointed out, of those intended only for one season's duration.

YELLOW CLOVER (*MEDICAGO LUPULINA*).

Although belonging to a different genus to the true clovers, this plant may well be considered among them. Its many names attest its popularity; and its free habit of growth, and the cheapness of its seed, as well as its own good qualities, will always maintain its position among farmers. It is well known as Yellow Clover, Trefoil, Non-such, and Black Medick, and is sometimes improperly confused with the true Hop clover (*T. procumbens*).

One of the chief advantages of yellow clover consists in its earliness; it flowers in April, and is frequently ready for cutting in May. This quality eminently fits it for catch cropping, as it allows of early removal, and the ground may then be broken up for turnips. Thus in the rotation for clay land proposed by Mr. Stace in the *Journal* of the "Royal" some years ago, trefoil held an important position, half the wheat land being sown down with trefoil, which in the succeeding spring was mown as hay, and followed with early white turnips, which were fed on the land and again succeeded by wheat.

Trefoil makes a singularly sweet and fine hay much esteemed for sheep-feeding, but the quantity produced per acre is not large. Its chief use is undoubtedly found when it is combined with other clovers and grasses, and forms part of a mixture. It may be relied upon for two years, but as it flowers and seeds early, its continuance in a pasture may be indefinitely prolonged. Trefoil is slender in its habit and requires support, without which it assumes a recumbent position. The flower is composed of loosely aggregated yellow florets, the herbage is succulent and recumbent in habit. The seed is flat, and kidney-shaped, and when new is of light yellowish-green colour, and so closely resembles lucerne seed that only trained observers can separate the two.

PERENNIAL RYE-GRASS (*LOLIUM PERENNE*).

No grass has excited greater interest during the last six years than rye-grass. The discussions as to its merits and demerits have at times verged on the acrimonious, and while some writers have condemned its use *in toto*, others have seen in it the most useful of all our cultivated grasses. It is not my object to take sides in this controversy, but rather to lay before my readers certain facts in connection with the rye-grasses, of which there are several sub-varieties.

We have already noticed Italian rye-grass as a fodder crop, and it is only necessary to point out that it is specifically distinct from the grass now under consideration. The awned character of the seeds of Italian rye-grass, and its broad foliage, are enough to easily distinguish it from the perennial varieties. Its short duration is another characteristic which has already received attention. How long Italian rye-grass will last is uncertain, but I am in a position to show a fairly abundant plant of it upon land which was seeded down in the ordinary course of husbandry about six years ago. It has been described as a perennial of short duration, and this probably is as definite a statement as to its length of life as can be given. On the other hand, when Italian rye-grass is grown as a specialty for fodder purposes, on sewage farms, it is found best to re-sow it every year.

Perennial rye-grass may be described as of less luxuriant growth, the herbage blending with other grasses in such a manner that it cannot be easily identified until it flowers. It is then seen to develop a spike carrying numerous florets, the glumes of which are awnless, and arranged in a radiating form in two rows of spikelets. Its older name of ray-grass is still preserved in many markets, notably in the south-west of England, where it is inquired for under the name of "green rays."

That certain varieties of perennial rye-grass deserve their name seems to be abundantly proved. It may at the same time be allowed that upon certain soils which are not suited to the prolonged existence of other sorts of grasses, and which are exceedingly difficult to lay away to grass, rye-grass gradually dies out and disappears. So also there may be sub-varieties of rye-grass of a short-lived nature. Such cases, however, cannot be used as an argument against the use of rye-grass generally, as a constituent of mixtures for seeding land intended for permanent pasture. Mr. Martin J. Sutton, who is one of our best living authorities upon grasses, says, "that this grass is not perennial on all soils, nor under adverse conditions, may be freely admitted, and few if any grasses are. But when true perennial rye-grass is sown on soil that is adapted for it, and its natural requirements are met, it will prove a lasting plant."

The general distribution of rye-grass throughout our English pastures is well known to all observers. It is commonly to be seen as a conspicuous feature in old English meadows when the grasses are in full flower before mowing, and it may also be noticed as a constituent of the grassy herbage of water-meadows, parks, and moors. Rye-grass prefers a moist and somewhat tenacious soil, and especially when closely grazed becomes firmly established as a permanent grass. Even upon chalk downs it is found to be at least as permanent as other grasses, and as a case in point we may quote the experience of Mr. William Stratton, of Kingston Deverill, Warminster, who is of opinion that rye-grass does not die out. Mr. Stratton has laid away many hundreds of acres of down land to grass, and his custom is to introduce 12 lbs. per acre of rye-grass-seed in his mixtures. Such thin chalky soils are among the most difficult to restore to the natural condition of permanent pasturage, and it is an important fact that even on them an experienced agriculturist like Mr. Stratton should find that rye-grass holds its ground.

In 1888, Dr. Fream, of the College of Agriculture, Downton, contributed an important paper upon "The Herbage of Old Grass-lands" to the *Journal* of the Royal Agricultural Society. With the co-operation of agriculturists in various parts of the United Kingdom, Dr. Fream brought together twenty-five specimen turfs, cut from as many pastures of well known excellence in the various localities selected. These turfs were carefully cut, 2 feet long, 1 foot broad, and 9 inches deep, and were sent in boxes to Downton, where they were planted in a bed 72 feet long and 6 feet wide in the botanical garden. A strict botanical examination and analysis of the herbage of these turfs was made during the summer with very interesting results. It is not my object to notice at length the composition of these samples of pasture land, transplanted for the purpose of rigid examination. The chief point of interest is the fact that in the vast majority of these turfs rye-grass and white clover predominated. The following schedule will bear out this observation, and ought to set at rest the vexed question as to whether or not rye-grass is to be considered a permanent pasture grass—

SCHEDULE SHOWING THE PERCENTAGE OF PERENNIAL RYE-GRASS TO THE TOTAL GRAMINEOUS HERBAGE IN TWENTY-FIVE TURFS SELECTED FROM VARIOUS PARTS OF THE UNITED KINGDOM, AS ASCERTAINED BY PROFESSOR FREAM, OF THE COLLEGE OF AGRICULTURE, DOWNTON.

No. 1.	Turf sent by	Mr. James Martin of Wainfleet, Lincolnshire ...	67
,, 2.	,, ,,	Mr. George Button of Tenterden, Kent ...	80
,, 3.	,, ,,	Mr. C. F. L. Sanctuary of Mangerton, Sherborne, Dorset	76
,, 4.	,, ,,	Mr. J. P. Oatway of Little Marston	77
,, 5.	,, ,,	Mr. W. Hancock of Wiveliscombe, Somerset ...	82
,, 6.	,, ,,	Professor Sheldon of Sheen, Ashbourne, Derbyshire	18
,, 7.	,, ,,	Mr. C. R. Morris of North Curry, Taunton, Somerset	90
,, 8.	,, ,,	A pasture eight miles from Thurles, Co. Tipperary	66
,, 9.	,, ,,	Mr. Gilbery Murray, Elvaston, Derby	0
,, 10.	,, ,,	Mr. Robert E. Tucker of Ashburton, Devon ...	82
,, 11.	,, ,,	Colonel Curtis Hayward of Quedgeley, Gloucestershire	83
,, 12.	,, ,,	Mr. Robert McKerrow of Carton, Co. Kildare ...	90
,, 13.	,, ,,	Mr. Frank Minshead, Cloona Castle, Ballinrobe, Co. Mayo	62
,, 14.	,, ,,	County Meath	61
,, 15.	,, ,,	Mr. G. Fairbairn, Dromagh Castle, Co. Cork ...	66
,, 16.	,, ,,	Mr. William Frazer, Johnstone's Castle, Co. Wexford	16
,, 17.	,, ,,	Mr. James Robertson, La Mancha, Malahish, Co. Dublin	86
,, 18.	,, ,,	Mr. P. J. O'Dwyer, Ennistymon, Co. Clare ...	86
,, 19.	,, ,,	A rich old pasture in Buckinghamshire ...	80
,, 20.	,, ,,	Mr. Louis T. Delcomyn, The Old Court, Bredwardine, Herefordshire	88
,, 21.	,, ,,	Courtesy of the Marquis of Bath	88
,, 22.	,, ,,	,, ,, ,, ,, ...	10
,, 23.	,, ,,	,, ,, , ,, ...	86
,, 24.	,, ,,	Mr. Alfred Hutchinson, New Romney, Kent	97
,, 25.	,, ,,	Mr. T. Nuttall, Beeby Manor, Leicestershire ...	67

A

TABLE SHOWING THE PERCENTAGES BY WEIGHT OF GREEN HERBAGE (GRAMINEOUS, LEGUMINOUS, AND MISCELLANEOUS) UPON EACH TURF.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Species present	Lincoln	Kent	Dorset	Dorset	Somerset	Stafford	Somerset	Tipperary	Derby	Devon	Gloucester	Kildare	Mayo	Meath	Cork	Wexford	Dublin	Clare	Bucks	Hereford	Wilts	Wilts	Somerset	Kent	Leicester
Gramineæ .	75	90	80	100	70	32	11	49	18	78	57	65	24	21	36	30	36	44	95	88	95	45	88	79	58
Leguminosæ	11	8	5	—	1	1	—	2	—	6	38	3	6	1	2	30	22	6	5	12	3	3	6	21	42
Miscellaneæ	14	2	15	—	29	67	89	49	82	16	5	32	70	78	62	40	42	50	—	—	2	52	6	—	—
Total . . .	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

B

TABLE SHOWING THE PERCENTAGES OF WEIGHT OF SPECIES IN THE GRAMINEOUS HERBAGE UPON EACH TURF.

Lolium perenne	67	80	76	77	82	18	90	66	—	82	83	90	62	61	65	16	86	86	80	100	88	10	86	97	67
Agrostis sp. . .	—	—	—	8	10	17	—	27	12	5	15	—	36	9	35	59	—	7	—	—	7	6	—	—	6
Cynosurus cristatus .	—	8	5	—	—	11	—	—	7	—	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—
Holcus lanatus . . .	—	—	—	9	5	7	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	15	—	—	—
Anthoxanthum odoratum	—	—	—	—	—	—	—	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dactylis glomerata	20	—	13	—	—	27	—	—	33	—	—	8	—	28	—	—	10	—	—	—	—	—	—	—	26
Festuca ovina et var.	—	—	—	—	—	—	8	—	18	—	—	—	—	—	—	16	—	—	—	—	—	57	—	—	—
Phleum pratense	—	7	—	—	—	—	—	—	—	13	—	—	—	—	—	—	—	—	15	—	—	—	10	—	—
Avena flavescens	—	—	—	—	—	—	—	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Festuca pratensis	—	—	—	—	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11	—	—	—
Other grasses	13	5	6	6	3	7	2	1	3	0	2	2	2	2	0	4	4	7	5	0	5	1	4	3	1
Total . . .	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

In order to give a full opportunity of judging as to the actual importance of rye-grass as a permanent pasture grass, I append the foregoing table showing the general results obtained in the Downton experiments of 1888 after examination of the above turfs.

With such an array of witnesses in favour of the general prevalence of perennial rye-grass in the grazing grounds of the United Kingdom it could scarcely be expected that any person should remain unconvinced. Although Dr. Fream's method has not escaped criticism, his valuable experiment may be safely left to take care of itself. He is well borne out in his conclusions by Sir John Bennet Lawes, as the following extracts from letters published in the *Agricultural Gazette* of January 28th, 1889, amply prove. Sir John Lawes writes—

After reading Dr. Fream's paper on "The Herbage of Old Grass-lands," in the last number of the *Journal* of the Royal Agricultural Society, I certainly thought that the claims of rye-grass to be considered a very important element in our permanent pasture were fairly established. At the meeting of the Council on December 12th, Earl Cathcart, as chairman of the *Journal* committee, made some remarks in reference to Dr. Fream's paper, calling attention to a manifest conflict of opinion, and asking for explanations in anticipation of the publication of the report of the consulting botanist. Lord Cathcart was followed by Mr. Carruthers, who gave rye-grass a very bad character; and he concluded by saying he believed that Dr. Fream's paper, instead of establishing rye-grass as an important element in our pastures, would throw fresh light on the whole question, cause more attention to be directed to it, and cause the complete elimination of rye-grass from our permanent pastures in the future. I can quite understand that, as consulting botanist to the Society, Mr. Carruthers may have been led to entertain a strong objection to rye-grass, when he found such large quantities of it in the samples of seeds sent to him by farmers who were paying for the most costly grasses. This has, however, nothing to do with the merits of rye-grass as an element in the herbage of permanent pastures. To advise farmers not to sow rye-grass at all because its use opens the door to fraud, is like advising them not to purchase nitrate of soda because it is often adulterated with common salt. Rye-grass, as an ingredient in the mixture of seed to be sown in laying down land to permanent grass, must stand upon its own merits. It is undoubtedly the fact that in a pasture in Leicestershire, which was selected by us for examination on account of its extremely high fattening character, rye-grass was first in amount in eight out of eleven samples taken at as many different periods over four different years, and it came second in order in the other three. It contributed an average of 27 per cent. of the total herbage in the eight samples, and of nearly 15 per cent. in the remaining three, corresponding in the eight samples to about 43 per cent. and in the three to about 24 per cent. of the total grasses. The plant next in order of amount was white clover, which, on the average of the eleven samples, contributed more than 23 per cent. of the total herbage, only very small amounts of any other leguminous species being present. At the times of our examinations the pasture was fattening more than one bullock per acre, without any cake excepting towards the end of the season, and a little given to sheep during the winter. The original examinations were made, two in 1879, six in 1880, and two in 1882; and in July of last year, 1888, we examined a further sample from the same pasture. Rye-grass was still the most prominent species, yielding 36½ per cent. of the total herbage and nearly 42 per cent. of the total grasses. But there was then, doubtless owing to the coldness of the season throughout and the cold and wet July, an unusually small amount of white clover and a greatly increased proportion of *Agrostis vulgaris,* which contributed nearly 26 per and Mr. John Ridley is invaluable, and points to the use of rye-grass even upon poor thin chalk soils. While a difference of opinion may exist as to the use of rye-grass for the thinner soils, there is room for none in the case of the richer and stiffer loams and tenacious clays; that is, upon the classes of land which during recent years have been most generally laid down in pasture. On this point Mr. Martin Sutton is very distinct, and writes—"A burning sand or thin gravel is least suitable for it, but it answers on a gravelly clay, is at home in all loams, and positively revels in tenacious land. Even pure clay is not too stiff for it."

Pacey's rye-grass is the most esteemed of all the varieties described. A large number of these so-called varieties of rye-grass are only selected stocks which do not differ from each other in any important degree. Among the older described varieties not, however, prominently noticed in the published catalogues issued every spring, may be mentioned Russell's, first grown on the Duke of Bedford's estate at Woburn; Orkney, described as excelling in durability; Whitworth's, described as possessing a root which propagates by stolons or underground runners. It is too tenacious of life for alternate husbandry, and is more suitable for permanent pastures, especially in cold, wet, and ungenial positions. These, with Pacey's, and the Devonshire Eaver-grass, are the most distinct varieties of *Lolium perenne*.

Rye-grass is indispensable as a rotation grass, and should always form an important constituent in mixtures of grass-seeds intended for one, two, or three years' duration. It ranks high in nutritive value. The chemical composition of grasses differs so much according to the stage of growth at which they are cut, and the soil on which they are grown, that the analytical test as a means of comparing the composition of grasses must be received with great caution, and for this reason I forbear to produce analyses. All descriptions of stock relish rye-grass, and even the straw left after the crop has been harvested and threshed for seed is alleged to be highly nutritious.

I have now noticed the chief clovers and grasses used in constructing mixtures for what are usually described as "seeds." It remains for us to consider some of the best combinations of these plants, in order to insure a good take of seeds for one or more years without touching upon the larger subject of mixtures for permanent pastures.

The simplest mixtures are required for one year's mowing and pasture, and as the length of time during which the pasture is to lie increases, so does the quantity of seed and the number of species employed increase, until we arrive at the complex mixtures of seeds employed for the sowing down of land for permanent pasture. For one year's duration I can recommend—

14 lbs. of red or broad clover.
1 bushel of Italian rye-grass.

But, as an alternative to be used on land which is not certain to grow red clover—

8 lbs. of red clover.
4 „ yellow clover.
2 „ Alsike clover.
1 bushel of Italian rye-grass.

Although of late years cocksfoot and timothy grass have been recommended in mixtures for one year, I believe that these grasses belong to the group of species which are better adapted to permanent pastures, and that they do not develop with sufficient rapidity to be useful for one-year-old seeds. As a mixture for two years' duration the following grasses and clovers may be sown—

8 lbs. of red clover.
4 „ yellow clover.
2 „ Alsike clover.
2 „ white Dutch clover.
2 „ Timothy grass.

books. It has always been highly esteemed as possessing virtues which may be regarded as medicinal and restorative. It is so regarded by our shepherds, who always are glad of a run for their sheep upon a piece of old sainfoin. Its cultivation may be either of a permanent—or, more strictly speaking, durable—character, or it may be sown among ordinary grass-seeds in alternate husbandry. We would, however, recommend caution in using sainfoin on the latter system, because it is one of those crops which land will only grow in perfection after long intervals of rest or freedom. Once in twenty years, or, as some good farmers have been known to say, once in a "life-time," is asserted to be as often as sainfoin should occupy the same land. On this principle it would not seem advisable to risk the unfitting of a field for sainfoin by introducing it into ordinary mixture for one and two years' pasture. On the Cotswold Hills, where sainfoin takes the place of permanent pasture, it is customary to sow down a field with it, and to break one up from old sainfoin root, every year. If a farmer has a sufficient number of fields the whole farm thus enjoys in succession a period of rest from tillage, and the shepherd always has sainfoin grazing of all ages, as the duration of the plant is from five to seven years. The lasting properties of sainfoin depend partly upon the soil and partly upon the seed, and it is of vast importance to secure a good sort. English is always much more expensive than French seed, and more lasting, and we cannot recommend the cheaper seed when it is intended to leave a field down for several seasons. In selecting English seed we could not do better than procure it from the Cotswolds, from a known grower, as disappointment from the wearing out of the root after the first or second season is not uncommon.

As to an inquiry if sainfoin can be grown in valleys of lias clay, we have no hesitation in saying that it is more fitted for the neighbouring hills of the Lower Oolite. The roots would probably decay after a shorter period and the plant disappear on such cold moist subsoils; but on this point we would not wish to dogmatize, as, after all, experience is the best teacher.

Sainfoin is best sown upon barley or oats at the same time as the seeding takes place. It may be mixed with the barley and drilled with it, or it may be separately drilled across the barley rows and harrowed in simultaneously. The quantity required is four bushels per acre of unmilled seed, or 56 lb. of milled seed. The usual plan is to use the entire seed, and to sow the larger quantity. As a precaution it will be advisable to "wheel in" 6 lb. to 8 lb. of trefoil (*Medicago lupulina*) in order to make a good bottom the first year, as sainfoin does not arrive at its full development until the second summer.

Land should be particularly clean for this crop, especially if intended to lie a series of years. I am also convinced that after the barley is harvested sainfoin should not be fed with sheep. We need not hesitate to feed off clover after harvest in open weather, but sainfoin is more readily injured by the gnawing of sheep. On the same principle I cannot advise spring grazing, but mowing for hay, and after the securing of the crop there is no need for further care, as the sainfoin may be then considered to be established.

Sainfoin intended for hay should be cut when in full flower; and when well secured, yields fodder of exceptionally high quality for sheep. Its value when allowed to lie more than one year is attested by the fact that an allowance is made for sainfoin "root" to away-going tenants according to the age of the plant, and not for the first year only, as in the case of clovers. Old pieces of sainfoin become weedy, full of bents, and infested with wire-worm. It is therefore not desirable to take wheat after sainfoin. The system used upon the Cotswold Hills is to pare and burn the surface, and take a crop of roots or mustard, and to follow with wheat, after sheep have been close folded over the land. Objection has been taken to this system, on the ground that burning dissipates organic matter and nitrogen. It may, however, be argued that the ash resulting from the burning of the roots is particularly suitable for the turnip, and that if a good crop of turnips or swedes is obtained we have by them a restoration of the dissipated products of combustion. Of course, the question arises as to how far nitrogen dismissed in burning can be recovered from the air, but there seems to be reason for thinking that a full crop of roots would restore all the vegetable matter lost through the burning of weeds.

The destruction of wire-worm and of the grubs of the crane-fly and the cockchafer, as well as of other insect pests, and seeds of weeds, is such an evident advantage that the practice appears to be, on the whole, consistent with theory.

One of the most common adulterations in sainfoin seed is burnet (*Poterium sanguisorba*), a plant which belongs to the natural order *Rosaceæ*. In its leaf as well as its seed it resembles sainfoin, although a difference exists in both, which, when once pointed out, serves to easily separate them. The leaf of burnet is serrated or notched, while sainfoin has a plain margin.

The seed-vessel of burnet is four-sided and smaller than sainfoin; that of sainfoin is lenticular, or the shape of a lentil, or doubly convex lens. Both are of the same light buff colour, and are rough or honeycombed on the surface, so that they are easily mistaken for each other unless carefully examined.

LUCERNE (*MEDICAGO SATIVA*).

LUCERNE is one of those partly discarded crops of which we have all heard the praises sung. No one doubts its merits, and yet its cultivation remains restricted. Not being separately returned in the annual agricultural statistics, but included generally as "vetches, lucerne, and green crops," it is impossible to say to what extent it is grown; but we may safely conclude that many square miles of country might anywhere be scoured before a quarter-acre plot of lucerne could be found. On the continent of Europe it is different, and the blue flower of this plant is to be seen enlivening large areas with its presence. There are always two important considerations which control the extent to which a crop is cultivated—(1) its own intrinsic merits; (2) its comparative merits. Take maize, for example. Its intrinsic merits are considerable. It no doubt gives a considerable weight per acre of green fodder, and its admirers see in it a future blessing. When, however, it is viewed comparatively, its weaknesses speedily appear. It will not stand cold nights, and the first touch of frost is absolutely destructive to it. It is particular about the season—requiring a tropical heat with ample moisture. It will not thrive on high-lying situations. The hardy cabbage or rape, the luxuriant kale, and even the vetch, excel it, on the whole. They may be relied upon over a large range of soils, and under many vicissitudes of climate. So it is with lucerne. It does best in a dry climate. Ours is moist. On the Continent its deep roots make it independent of rain. In our insular climate it meets successful competitors among clovers, grasses, vetches, and other green crops. As a special crop for odd corners it is well enough. As a competitor with our established fodder crops it is nowhere. The late Mr. John Towers, of Croydon, was a great admirer of lucerne, and to read his account of its cultivation in *Morton's Cyclopædia*, one would think it was the only plant worth growing for fodder purposes. Mr. Towers grew it upon land which had been recently broken up from permanent pasture, which may partially account for the luxuriance of its growth.

Lucerne loves a calcareous soil, and does well on chalk or brashy limestone. It is permanent in its nature, and yields several cuttings in the course of a season. It is well suited for occupying corners of fields or small enclosures near a homestead, where it will continue for many years to throw up a large amount of very excellent green food.

The proper time to sow lucerne is April. The ground should have been autumn cultivated and winter ploughed. It is desirable, as far as possible, to encourage the germination of all weeds by alternate periods of cultivation and rest. One of the most serious difficulties in getting a plant of lucerne is found in the growth of countless weeds which come up with the seedlings and choke them. A course of previous cleaning, especially with a view to the extermination of annual weeds, is therefore to be highly recommended. Lucerne should be drilled upon a well-prepared and dunged seed-bed in rows nine inches apart. The quantity of seed needed is 20 lb. per acre, and the price is 1*s.* per lb., or 105*s.* per cwt. Lucerne seed is scarcely distinguishable from that of common trefoil, a plant to which it is closely allied.

During the first season the crops should be carefully hoed, and not more than two cuttings may be expected. During the second and subsequent seasons the rows should be kept clear of weeds in the early spring by hoeing, and, after this cultivation, the plants will rapidly develop, and give several cuttings during the summer. For soiling purposes it is invaluable.

KIDNEY VETCH (*ANTHILLIS VULNERARIA*).

This plant appears in seed catalogues, where it is described as "a valuable forage plant." It is recommended for poor, thin soils. A writer in the *Farmers' Gazette* of February 4th says—"I find it the grandest crop for stock. Sheep thrive on it on the poorest land. I grow three tons of good hay per acre." We have seen this plant growing on stiff soils as well as light ones, and perhaps the rule that all plants will grow on all soils is fairly true of it. Like all rules, this one has, no doubt, its exceptions, but statements to the effect that certain plants are only found on certain soils are often misleading. That the kidney vetch finds its most suitable position in light and thin soils we have no reason to doubt. So many new plants have of late years figured upon catalogues of farm seeds, that the appearance of an unfamiliar name does not strike us as strange. It must, however, be borne in mind, that scarcely one of these recently suggested additions to our crops has borne the test of time and experience. Our only object in saying this is to inculcate caution on our readers, lest they should be "run away with" by statements as to results obtained by other people.

The kidney vetch evidently is worthy of trial, and ought to form an ingredient in mixture of permanent pasture seeds intended for the descriptions of soil on which it thrives. As to its forming a crop alone, we believe that it might answer on certain descriptions of land, but we should be sorry to plant it on an extensive area without absolute knowledge gained by the experience of the neighbourhood.

CHAPTER XI.

ENSILAGE.

Introduction of Ensilage—M. Goffart's System—Advantages of Ensilage—Mr. Henry Rew on Ensilage—Antiquity of the Process—Ensilage not an American Process—General Principle of Ensilage—Mr. Whitehead's System—Stack Ensilage—Mr. Johnson's System—Mr. William Stratton's System—Silage Stacks without Extraneous Pressure—Silage as a Substitute for "Roots"—Mr. Eckersley's System of Cropping—Suggested Rotation for Silage Crops—Concluding Remarks on Ensilage.

AMONG the many suggestions of recent years for the advancement of agriculture, none have proved more useful than that of ensilage. Nay more, it stands out pre-eminently as one of the few innovations which are being generally adopted by the farmers of this country.

I can remember the process, as applied to grass, being explained to me by a French nobleman, the Viscount de Hedouville, more than twenty years ago; but at that time the idea of putting fresh grass together did not commend itself as practicable. Later, in 1873, I had the opportunity of seeing many silos in Austro-Hungary, and described the process in *The Journal of the Royal Agricultural Society* for 1874. In the wet season of 1875, I wrote the following letter to *The Times*, which appeared upon the 12th of June:—

"Will you allow me a few lines' space to call attention at this seasonable time of the year to a process of preserving fodder for winter use little known, and, so far as I am aware, never practised in this country? It gives as its product what is known all over the Austrian Empire as sour hay; which, I may add, I have seen used extensively on many large estates. The process of making sour hay is not only simple, but, in the event of a wet season, might be adopted in this humid climate with excellent effects, as neither drying winds nor sun are required. The green grass, green Indian corn, or other fodder, is simply crammed down into graves or trenches 4 feet wide, and 6 to 8 feet deep, until it forms a compact mass up to the surface, and the whole is then covered with a foot or rather more of earth rounded over so as to form a long mound. No salt is used, and the wetter the fodder goes in the better. The preservation is complete, and when cut out with a hay spade in winter, the fodder is of a rich brown colour, and exhales a slightly sour, but on the whole, agreeable flavour. I beg to enclose you a sample made from green maize which I obtained in 1873, while travelling in Hungary for the Royal Agricultural Society."

This letter elicited several private communications, which in the light of recent experiences are not without interest. Mr. Arthur J. Scott, of Rotherfield Park, Hants., took the matter up immediately, and thoroughly identified himself with the movement. On the 15th of June, 1875, this gentleman wrote as follows: "I saw in *The Times* of Friday a letter from you headed 'Potted hay.' I shall be very much obliged if you would kindly give me a short description of the process of manufacturing this fodder. I should like to know if you think it could be applied to tares, lucerne, and crops of that kind. Also, if you think salt would improve it, and whether it wants a ventilating shaft left in the top of the trench. Excuse my troubling you with this, but if you think it would be a useful introduction, I should like to try an experiment under your direction."

In July of the same year I sent the following letter to *The Times* :—

"Early in June you allowed me to call attention to the possibility of storing grass in trenches in a green state. Since then I have received a large number of letters asking for such particulars as would enable the process to be carried out with success. To such inquiries I have answered, that although I had seen the 'potted hay' greedily eaten by stock, it had not been my good fortune to witness the process of preservation carried out practically; but that all agriculturists with whom I had conversed described it as exceedingly simple. The details of the process have been so clearly described by M. Goffart, in a pamphlet upon maize cultivation, published early in the present year in Paris (Masson), that I venture to make you a translation of the passage in which his method of proceeding is given. M. Goffart has preserved green rye and maize both above ground and in trenches after a manner similar to that described by me in a former letter, and there seems to be no reason to doubt that the same process might be applied with equal success to grass in this country. The passage is as follows—'About 60 metres from my stables I opened a trench upon the bank of an old pond, in compact clay, perfectly impervious, and of a hardness such that a pickaxe was required to open it up. The trench was 10 metres long, by 2 wide by 2 deep. I lined it with masonry of half a brick thick, and well cemented it, and the bottom was also paved and cemented. The side walls were made vertical and not inclined, which seems to me only rational; the pressure is vertical, and inclined sides seem to me contrary to the end for which they are intended—to facilitate and not to prevent the settling of the mass. A chaff-cutter by Richmond and Chandler was placed upon the edge of the trench, and being worked by a five horse-power engine, filled it in less than ten hours. The chaffed maize was spread over the area and trodden down (foulé) by two men until it rose about 40 centimetres above the level of the masonry. This raised portion, compressed like the rest, was disposed as a long mound, and was covered with a light coating of long straw, and then with 40 centimetres of well-flattened down earth. I watched the result for several consecutive days, and filled up the fissures so as to prevent any space from forming between the covering of earth and the preserved maize, which would be highly injurious. At the side of this trench I have excavated a less one with vertical sides; but this one I have not lined with masonry, and the maize rests in contact with the soil. I am less sure of a perfect preservation.' Those of your numerous readers, who during this extraordinary wet season may wish to make the experiment of making a little sour or potted hay, may find the above details useful."

The process of ensilage is here completely described, and after all the engineering skill which has been expended upon it, it is difficult to see in what important respect we have improved upon the methods set forth in the first two letters on the subject which really placed the process before the English public.

The first attempts to follow the somewhat crude system employed in Austro-Hungary were not, it must be allowed, very successful. The grass, it is true, came out of the trenches in sound condition, but so sour and rank that it was found difficult to persuade animals to eat it. Samples of such silage were exhibited by me before the Cirencester Chamber of Agriculture, early in 1876. When dry it resembled hay, but the strong acrid smell which clung to it was considered objectionable.

These difficulties were overcome by the building of thoroughly efficient silos, and the application of mechanical contrivances for securing continuous pressure. At one time there seemed to be a danger of the process becoming too

"That the practice of ensilage has been, and is still, largely in use among eastern nations, there is abundant evidence. In Barbary, when the grain is winnowed it is lodged in subterranean repositories, two or three hundred of which are sometimes found together, the smallest holding 400 bushels. In Egypt a similar method has been in vogue for ages. Colonel Burnaby, in his *Ride to Khiva*, and Mr. O'Donovan, in *The Merv Oasis*, both refer to the subject. The former writer records an interesting incident, showing that he found the system applied to green fodder as well as corn. During the ride between Kasala and Khiva, he writes—'We now encountered a party of men and women who were engaged in unearthing a quantity of grass from a deep cutting in the ground. This grass had been mown the previous autumn, and was thus preserved until such time as the owner required it, the extreme cold, or perhaps the dryness of the air, keeping the grass as fresh as the day it was cut.' The natives of South Africa know no other method of preserving grain for consumption than that of burying it in the ground. It is curious that the Kaffir word for a grain-pit is *essisile*, which seems to have an affinity to silo. This, however, is a point for philologists to decide—or to dispute, as the case may be. The South Sea Islanders, according to Mr. J. W. Boddam-Whetham, have long known and practised the same system."

Mr. Rew also tells us that "About a century ago a German named Klapmeyer described a method of fermenting green fodder, and thereby producing a so-called 'brown hay;' and, with some variation, the process of pitting green crops is carried out in many parts of Germany, Austria, and Hungary, as a means of making *sauerfutter* (sour fodder), or *viehsalat* (cattle salad). This process was fully described by Grieswald in 1842, in the *Transactions of the Baltic Association for the advancement of Agriculture*. From this source, Professor J. F. W Johnston obtained the materials for an article in the *Transactions of the Highland and Agricultural Society* for 1843."

Lastly, he refers to my papers on the subject as well as to the valuable assistance in elucidating this subject, rendered by the late H. M. Jenkins, secretary of the Royal Agricultural Society.

It cannot be denied that the idea of adopting ensilage as an important part of our agricultural system slumbered for a time in this country after attention had been called to it in 1875. It was not until 1882 that the Royal Agricultural Society took the matter up, with the result that in 1883 ensilage became the "topic of the year,"—so far as agriculture was concerned. As is always the case, America was well to the front, and a new wave of interest reached us from across the Atlantic. Professor Rogers wrote a sanguine work upon the subject, and somewhat exaggerated views were promulgated as to the immensely superior value of ensilage compared with grass or hay.

I cannot, however, allow that the first silo was made and filled in 1876 in the United States, as silos had been made and filled in this country the previous year. An illustrated description of the "sour hay" process was communicated by me to the *Agricultural Gazette* in 1875, and shortly afterwards agriculturists in this country became aware that the idea had been taken up with great interest both at the Cape and in America. The reaping machine came ostensibly as a mechanical novelty from America in 1851, but it was subsequently found that the Reverend Patrick Bell had invented the original instrument which now is to be seen in the South Kensington Museum. So with ensilage. The actual introduction of the process among the farmers of America and our own country was one of the results of my report upon the agriculture of the "Austro-Hungarian Empire," obtained under the auspices and at the expense of the Royal Agricultural Society of England. Indirectly it was due to the Agricultural Exhibition held in 1873 at Vienna, which was the actual cause of the report in question. The highest praise is to be accorded to M. Goffart, who has been often spoken of as the "father of modern ensilage," but it is also true that while M. Goffart was working out the problem in France, English agriculturists were turning their attention in the same direction. Among these no one deserves more credit than Mr. Arthur J. Scott of Rotherfield Park, Hants, who perseveringly stuck to ensilage from the date of his letter to me, already quoted, down to the present time.

The principle upon which ensilage is based is similar to that involved in the bottling of fruit, storing of brewers' grains, and the preservation of canned meats—namely, the

"On November 20th we visited this gentleman's silage stack at Oakwood, Croft, near Darlington. This was composed of autumn-sown tares, seeds, and clover, and old land grass—all put into one stack, which is 19 feet long, 17 feet wide, and 11 feet to the eaves, and 17 feet high to the peak of the ridge. The system of pressing is the "Ensilage Stack Press," invented by the exhibitor. The general description of the stack is that it is built in the open air, the top peaked and thatched like an ordinary hay-rick; it contains sixteen loads of green fodder, and the cost of the press for the 130-ton stack was £18, which is the selling price. The pressure is obtained by a flexible galvanized iron rope. Mr. Johnson estimated the cost of cutting, carrying, and pressing the stack at about 18*s.* per acre. In general, the silage was sweet and particularly good; there was a vein of about two inches deep across the stack of dark silage—this was after the stoppage of the first Sunday and four following days—and about half-way up the stack a considerable amount of dark silage around the place where the thermometer had been inserted in a tube of boarding four inches square, which would not have been the case if a proper tube had been used. There was a space, on the average, of about eight inches of damaged silage along both sides and ends of the stack; but from the size of the stack and its density we calculated that the waste was not more than about 1½ per cent. on the whole. We gave this outside and dark-coloured silage to the cattle, and they ate it freely. We think the whole system excellent, and fraught with much value for the future of agriculture. We cut a cube foot from the centre of the stack, and it weighed 64 lbs. Mr. Johnson gave us the record of his diary during the time of his working and filling the stack. It appeared from this record that for some time the temperature varied in consequence of the extra pressure being put on. At the bottom of the stack was a layer of very excellent silage made from an acre of winter vetches, which produced 14 tons of green fodder, and is considered now to be equal to 12 tons of really valuable food for any stock—everything, even pigs, eating it, and thriving well upon it. The clover came next, producing nearly 10 tons to the acre, the leaf and flower being wonderfully preserved. The stack was completed with meadow hay, which had turned somewhat dark in colour, but was eaten readily by the cattle. The shape of the top of the stack was arched, and above this was put rough hay and straw, and then thatched in the ordinary manner."

The latest improvement made by Mr. Johnson, in his system of pressure, consisted in the abandonment of the one flexible wire rope, which was laced backwards and forwards at regular intervals over the top of the stack throughout its entire length so as to form a sort of rope saddle. This system might be compared to the lacing of a boot with a single lace, the whole of the pressure being derived from taking up the slack from one end of the rope. This was found inconvenient, and has given way to a number of short ropes, each passing from a drum on one side of the stack to a corresponding drum immediately opposite upon the other side. These drums are made to wind up the slack by means of a ratchet worked by a lever, by which the rope is kept constantly tight.

Having myself inspected Mr. Johnson's stacks at Croft, during the process, I am able to endorse Mr. Rew's remarks as to the simplicity and efficacy of the system.

During the wet summer of 1888, many farmers were induced to try this principle of storing green food for winter's use, and every variety of procedure was adopted. One of the simplest methods was that originally tried by Mr. William Stratton of Kingston, Deverill, Warminster, who—according to his own graphic description of what he did—carted his grass together exactly as if he was making a dung-heap, driving over the heap so as to consolidate it, and well trampling the outsides, keeping the walls vertical. After the heap had reached a height of 10 to 13 feet, the long ends were cut off with a hay-knife and thrown over the remainder, the result being a rectangular heap. He then built a hay-rick on the top and thatched it down.

A silage stack may be added to, at intervals of three or four days, during which time it will quietly settle, and the weight of the accumulations will, as the work proceeds, give the necessary pressure. Many persons now hold that no further mechanical appliance is necessary such as Mr. Johnson employs. Others, after the stack is finished, weight it with boards and earth, or any other substance which is readily available for the purpose.

Silage stacks may be made to yield fairly satisfactory results if made without extra pressure beyond the weight of the silage itself. Such stacks may be thatched with straw, and will be found to contain a mass of useful fodder. Even the portions which have become blackened by exposure to the air are eaten by stock, so that the advocates of this system consider that there is little real waste. On the other hand, a certain pressure upon the stack, either by means of wire rope, pressers, or direct weighting, seems necessary for the protection of the uppermost layers not subjected to the pressure which is unavoidably given by the superincumbent mass. The idea of building silo stacks without artificial pressure is as yet somewhat novel, and requires further elucidation. It is, however, highly satisfactory to notice that the tendency of the latest experience is essentially in the direction of simplicity. The simpler the process the more likely is it to become firmly established among English farmers.

Quoting from personal experience, I may mention that in July 1888 we made excellent silage by carting grass into a long and deep shed, carefully ramming it at the sides, and well trampling it in the middle. The shed was filled during a period of about three weeks, making further additions as the mass settled, and finally weighting it with boards and bags of heavy material. No mechanical contrivance was used except a garden roller, which was employed to assist in the consolidating of the grass as it came in. This silage varied from sweet to sour according to the amount of pressure.

The fresher the grass, and probably the wetter it is put together, the more likely is it to become compressed so as to entirely exclude the air. Half-made hay is not likely to make good silage, and in dry seasons the simple methods last described may be found less satisfactory than in such a season as '88. It is, however, evident that the system in one form or another is within the reach of every one, and that it is not difficult of application to all fodder crops and in all situations.

Ensilage having been demonstrated to be a practical method, deserving the attention of rent-paying farmers as well as of amateurs, the question as to how far it may be substituted for root or corn cultivation immediately arises.

That root cultivation is expensive, complicated, and risky cannot be doubted, but that it is necessary on many classes of soils is equally true. I have already shown that it is scarcely reasonable to expect the root crop to stand its own costs of cultivation, although when the season is propitious, and good yields per acre are obtained, it may be in itself grown at a direct profit. The fact, that during the last five years it has twice proved a failure in many localities, is a sufficient reason for doubting if it may be regarded as a paying crop, and hence suggestions have been made that it is a burden upon arable farming which we should endeavour to get rid of. As long, however, as land is kept in the arable condition, so long will periodic fallowings be necessary, and on all the lighter soils will root cultivation maintain its position.

It is thought by a certain class of writers on agriculture, that mixed fodder crops, such as oats and vetches, or oats and beans, might be grown instead of the root crops, the produce being converted into silage for winter feeding. To a certain extent this may be done, especially on clay soils; but we may well ask how sheep masters could carry their flocks through our long seven months' winter without turnips, swedes, and mangel? On such farms hay, as a warm and dry food, fitting well with roots, is also likely to maintain its position side by side with silage, so that there does not seem to be an immediate prospect of any fundamental change in the management of these soils.

As long as corn growing is continued, it is likely that root cultivation will form an important item in farm management of light lands.

As an example of a modified system of cropping, in which roots still occupy an important place, while crops for ensilage are relied upon to the partial exclusion of corn crops, I take the case of a rotation framed by Mr. N. Eckersley, M.P., submitted in 1886, which runs as follows,—

1st year.	Swedes.
2nd „	Oats, with seeds for ensilage.
3rd „	Clover, first crop made into hay, and second growth into ensilage.
4th „	Oats, harvested.

The rotation with which the above is contrasted, is the ordinary four course rotation, in which, however, wheat and barley are excluded in favour of oats. Elaborate figures are given (see Appendix), in order to show that the system of converting green oats and clover into ensilage, is more profitable than ripening the oats and converting the clover into hay. Inspection of the figures will, however, indicate that too low an estimate is put upon the probable yield of the oat crop when harvested. Forty-four bushels per acre is a miserable yield, as on fairly farmed land such a crop would not reflect credit on the cultivation.

A crop of oats ought to be double that of wheat, and if 30 bushels of wheat may be taken as a fair yield under fair management, 60 bushels of oats would in most cases be the equivalent. On the other hand, Mr. Eckersley's figures are too flattering for ensilage, which he values at fifty shillings a ton when made from green oats, and thirty shillings when made from clover. This is too high for consuming value of a material containing so much water as ensilage, and is out of character with the value which could be put either upon the same produce converted into hay, or the green fodder from which it was derived.

I have therefore made a revised estimate of the figures given, maintaining the costs at the level originally fixed, and altering the values or quantities so as to bring them into accord with more recent and reasonable practice. Mr. Eckersley's figures are valuable in themselves, as indicating how an analysis of costs may be made out. They, however, need revision, and this has been attempted at some length in the Appendix, to which readers are referred both for the original estimates and the amended form.

The process of ensilage has conferred a new value upon succulent green fodder, as, by its means, the crops described in the last section of this work may be held over for winter's use with much of their summer's freshness, and with that increase in their value which must follow their projection, so to speak, from a period of abundant fodder in the summer into the dearthful period of winter.

That ensilage might, in a measure, take the place of root cultivation is not improbable, upon certain classes of clay lands. "Smothering" crops of beans, oats, and vetches, may be grown without a heavy outlay upon these soils, and the land might be freed in time for a half fallowing before wheat sowing. Take, for example, the case of a stiff land field after wheat; the land could be cleaned by steam and horse cultivation after harvest, dunged and ploughed. In February a mixture of two bushels of beans, one bushel of oats, and half a bushel of vetches could be drilled in or broadcasted upon a ribbed or pressed surface.

In July the whole might be cut and converted into silage, and the land could then be broken by a steam cultivator and got ready for wheat. Such a procedure would be quite in accordance with the rules of good clay land management, and in every way superior to the attempt to grow a root crop. The expenses would be less than root cultivation would entail, and the produce might amount to 10 tons of fodder, yielding 9 tons of ensilage, worth about 20*s.* per ton, or a gross per acre value of £8 or £9.

In the foregoing remarks I have not attempted a description of silos, or of the various contrivances which have been patented for carrying out the process. This is a work upon the cultivation of root and fodder crops, and it would be foreign to its purpose to enter upon other large questions bearing upon the general practice of agriculture and stock feeding. The literature of ensilage is fairly extensive, and to it I must refer my readers for absolute information as to details. What I have endeavoured to do is to show that the process is simple, cheap, and effective, and that its ultimate effect will be to increase the area devoted to fodder crops suitable for ensilage, especially upon the clay lands of the country. Also that it is destined to favourably affect the value of our meadows by introducing a method of dealing with grass superior to the older system of hay-making.

APPENDIX.

STATISTICS relating to a farm of 296a. 3r. 20p. of arable and grass land in north-west England, Oct. 30, 1885, by N. Eckersley, Esq., M.P.

August 31*st*, 1885.—Estimated annual value of a farm to the occupying tenant in north-west England.

Total acreage 296a. 3r. 20p. as follows—

a.	r.	p.		£	s.	d.
113	0	24	pasture land, estimated per acre at	114	15	5
79	3	36	meadow land ,, ,,	148	15	1
103	3	0	arable land ,, ,,	136	9	6
			dairy sheds and silos	30	0	0
296	3	20		430	0	0

CROPPING, FOR THE YEAR ENDING AUG. 31ST, 1885.

a.	r.	p.	
113	0	24	pasture.
79	3	36	meadow.
50	0	0	oats.
13	0	15	oats.
10	0	8	clover.
21	0	14	clover mown.
9	2	3	roots.
296	3	20	

APPORTIONMENT OF THE ACTUAL CHARGES ON THE FARM FOR THE YEAR ENDING AUG. 31ST, 1885.

Items.	Total charges on 296a. 3r. 20 p.			Arable 103a. 3r. 0p.			Meadow 79a. 3r. 36p.			Pasture 113a. 0r. 24p.			Live Stock and Produce.			House Account.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Rent	430	0	0	136	9	6	148	15	1	114	15	5	30	0	0	Separate.		
Rates and taxes	82	10	8	27	6	0	29	18	0	20	6	8	5	0	0	...	...	...
Tithes	41	18	9	24	8	9	13	0	0	4	10	0	...	...	...	...	...	...
Trade-bills	80	5	6	47	17	0	22	8	6	...	...	...	10	0	0	...	...	...
Seeds all purchased	126	4	6	126	4	6	...	...	...	...	...	...	...	...	...	...	...	...
Lime and artificial manures	29	16	0	29	16	0	...	...	...	...	...	...	...	...	...	...	...	...
Use of implements	25	0	0	16	13	4	8	6	8	...	...	...	...	...	...	...	...	...
Depreciation of horses	20	0	0	13	6	8	6	13	4	...	...	...	...	...	...	...	...	...
Insurance	6	10	0	1	10	0	...	...	...	...	...	...	5	0	0	...	...	...
Coal and gas	15	0	0	7	10	0	...	...	...	...	...	...	7	10	0	...	...	...
Dairy produce and Bailiff	24	0	0	18	0	0	...	...	...	...	...	...	6	0	0	...	...	...
Bailiff's salary	78	0	0	32	0	0	15	0	0	5	0	0	26	0	0	...	...	...
Wages	555	12	5													52	0	0
Horse keep	165	0	0	304	2	5	153	6	8	33	13	4	150	0	0	27	10	0
	1679	17	10	785	4	2	397	8	3	178	5	5	239	10	0	79	10	0

The value of crops being estimated at consuming prices, and all the produce being consumed on the premises by the farm stock, no charge is made for farm-yard manure, except a nominal one to cover the value of that made by the carriage and saddle horses. The arable land is worked on the four-course system.

COST OF MANURE FOR FOUR CROPS OVER FOUR YEARS.

	£	s.	d.	
20 tons of farm-yard manure ...		10	0	per acre.
Filling, carting, and spreading manure		15	0	,,
3 tons of lime after green crop at 15*s*.	2	5	0	,,
3 cwts. of artificial manure after clover	1	10	0	,,
	5	0	0	

APPORTIONMENT OF THE SAME.

	£	s.	d.	
1st year, root crop	2	10	0	per acre.
2nd ,, oats		16	8	,,
3rd ,, clover		16	8	,,
4th ,, oats		16	8	,,
	5	0	0	

GENERAL EXPENSES PER ACRE—ARABLE LAND.

	£	s.	d.	
Rent	1	7	6	per acre.
Rates, tithes, and taxes		10	0	,,
Tradesmen's bills, depreciation, insurances, and other minor expenses		7	6	,,
	2	5	0	

Note—8 tons of green clover will yield 6 tons of ensilage.
8 ,, ,, oats & seeds ,, ,, 4 tons of ,,

BRISTOL ENSILAGE ANALYSIS, MAY 13, 1886.

Moisture	Sour, dried at 212° F.	Sweet, dried at 212° F.	Hay, dried at 212° F.	Grass, dried at 212° F.
* Soluble albuminoids	2·62	2·43	·56	1·69
† Insoluble albuminoids	3·74	·12	7·06	5·54
Digestible fibre	25·36	27·46	20·88	22·15
Woody fibre	37·44	38·68	35·84	34·86
Lactic acid	·85	·66	—	—
Acetic acid	·66	·26	—	—
‡ Soluble mineral matter	8·67	6·34	5·26	5·45
§ Insoluble mineral matter	3·12	4·05	3·88	3·43
Soluble carbohydrates, Chlorophyll, &c.	17·54	15·00	26·52	26·88
	100·00	100·00	100·00	
* Containing nitrogen	·42	·39	·09	·27
† Containing nitrogen	·59	·82	1·13	·89
Albuminoid nitrogen	1·01	1·21	1·22	1·16
Non-albuminoid nitrogen	·58	·47	·50	·28
Total nitrogen	1·59	1·68	1·72	1·44
‡ Containing silica	1·72	·70	—	·17
§ Containing silica	1·7	2·17	2·22	2·07

The chief points to be noticed in the above table are the diminution of soluble carbohydrates, especially in the sweet ensilage, and the consequently larger proportion of woody fibre. There is an increase in the soluble albuminoids, apparently at the expense of the insoluble albuminoids. Dr. John A. Voelcker, in reporting upon the Bristol experiments, says, "The general result of these experiments appears to be that there is a considerable loss of nutritive material, especially of the non-nitrogenous or fat-forming constituents, in converting grass into ensilage." Without depreciating the value of the process of ensilage, it must be evident that the product is not superior to hay when compared with it upon equal terms, and hence we are doing full justice to the supporters of ensilage, if we value silage as equal to the grass from which it was derived, as the hay which might have been made from it.

Now the loss of weight in converting grass into ensilage was ascertained at Bristol in the experiments already cited.

TABLE SHOWING LOSS OF WEIGHT OF 50 CWT. OF GRASS WHEN MADE INTO ENSILAGE; ALSO PER CENTAGE LOSS.

	cwts.	qrs.	lbs.		loss of weight.
1. Sour ensilage (long)	4	2	$5\frac{1}{2}$	=	9·10 per cent.
2. Sour ensilage (long)	4	2	$15\frac{1}{2}$	=	9·28 " "
3. Sweet ensilage (long)	9	0	22	=	18·40 " "
4. Sweet ensilage (long)	30	1	6	=	60·61 " "
5. Sour ensilage (chaffed)	2	1	0	=	9·89 " "
6. Sweet ensilage (chaffed)	4	3	22	=	4·50 " "
7. Hay	36	3	26	=	73·97 " "

Leaving 4 out of consideration, as it was partially dry before it was placed in silo, the loss of weight during the process is exceedingly small, or in other words, the value of ensilage per ton approximates to that of grass rather than to hay.

One hundred tons of grass would make, according to the above figures, from 82 to $95\frac{1}{2}$ tons of ensilage, or let us say 90 tons.

Now, 100 tons of grass would, if young, make 25 tons of hay, as is, in fact, shown above to be approximately correct. That is, 100 tons of grass would make £75 worth of hay at 60*s.* consuming value. I maintain that the 90 tons of ensilage made from the same grass would also be worth £75, or 16*s.* 8*d.* per ton.

In the estimate already given ensilage made from green oats is put at 50*s.* per ton, but it is not easy to see on what grounds it is placed at a higher figure than that made from clover and seeds mixed. Probably £1 per ton is an outside estimate of the feeding value of ensilage, making every allowance for the fact that it is a succulent food preserved from the summer to a time of scarcity.

We are now in a position to re-value the rotations previously given, which may be done briefly, as it is not necessary to recapitulate the costs in detail.

A RE-VALUATION OF THE PRODUCE OF MR. ECKERSLEY'S SYSTEM, BY THE AUTHOR.

FIRST ROTATION. FIRST YEAR—SWEDES.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To expenses ...	9	17	7	By value of crop	10	0	0
To balance (profit)		2	5				
	£10	0	0		£10	0	0

SECOND YEAR—OATS.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To expenses ...	6	14	6	By 60 bushels of oats at 2/3 per bush.	6	15	0
To balance (profit)	2	5	6	By 1½ tons of straw at 30*s.* ...	2	5	0
	£9	0	0		£9	0	0

THIRD YEAR—CLOVER.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To expenses ...	4	19	2	By 1½ tons of hay at 60*s.* ...	4	10	0
To balance (profit)		15	10	By aftermath ...	1	5	0
	£5	15	0		£5	15	0

FOURTH YEAR—OATS.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To expenses ...	6	19	7	By value of crop as before ...	9	0	0
To balance (profit)	2	0	5				
	£9	0	0		£9	0	0

SUMMARY.

	£	s.	d.
1st year balance or profit ...		2	5
2nd " " " ..	2	5	6
3rd " " " ...		15	10
4th " " " ...	2	0	5
	£5	4	2
Average profit per acre ...	1	6	0½

Next I shall readjust the figures in the ensilage rotation, which was shown to be the more profitable of the two. In doing so I shall be compelled to estimate the value per ton of the silage at a less figure than Mr. Eckersley has adopted; and in order to be as correct as the nature of such a calculation will allow of, I shall take 16*s.* 8*d.* per ton as equivalent to the 60*s.* per ton allowed for the hay. On the other hand, we may, perhaps, increase the estimate of weight of silage produced per acre, as we have already found the loss during the process to be about 10 per cent. of the total weight of green fodder when cut fresh and young.

SECOND (ENSILAGE) ROTATION. FIRST YEAR—SWEDES.

Dr.	£	*s.*	*d.*	*Cr.*	£	*s.*	*d.*
To expenses ...	9	17	7	By value of crop	10	0	0
To balance (profit)		2	5				
	£10	0	0		£10	0	0

SECOND YEAR—OATS AND SEEDS (ENSILED).

Dr.	£	*s.*	*d.*	*Cr.*	£	*s.*	*d.*
To expenses ...	7	17	6	By 8 tons of silage at 16*s.* 8*d.* per ton	6	13	4
				By balance (loss) ...	1	4	2
	£7	17	6		£7	17	6

THIRD YEAR—CLOVER. FIRST CROP MADE INTO HAY; SECOND CROP MADE INTO ENSILAGE.

Dr.	£	*s.*	*d.*	*Cr.*	£	*s.*	*d.*
To total expenses ...	6	11	0	By 1½ tons of hay at 60*s.* ...	4	10	0
				By * 4½ tons of ensilage at 16*s.* 8*d.*	3	15	0
To balance (profit)	1	14	0				
	£8	5	0		£8	5	0

* This weight of ensilage is probably more than would be realized.

SECOND ESTIMATE, IN WHICH THE WHOLE OF THE SEEDS ARE MADE INTO ENSILAGE.

Dr.	£	*s.*	*d.*	*Cr.*	£	*s.*	*d.*
To expenses ...	7	7	0	By $10\frac{1}{2}$ tons of ensilage at 16*s.* 8*d.* per ton ...	8	15	0
To profit	1	8	0				
	£8	15	0		£8	15	0

FOURTH YEAR—OATS HARVESTED.

Dr.	£	*s.*	*d.*	*Cr.*	£	*s.*	*d.*
To expenses ...	6	19	7	By 60 bushels at 2*s.* 3*d.* ...	6	15	0
				By $1\frac{1}{2}$ tons of straw	2	5	0
To balance (profit)	2	0	5				
	£9	0	0		£9	0	0

SUMMARY.

	£	*s.*	*d.*	
1st year's balance or profit ...		2	5	
3rd ,, ,, ,, ...	1	8	0	(second estimate)
4th ,, ,, ,, ...	2	0	5	
	£3	10	10	
Deduct loss on 2nd year ...	1	4	2	
Total gain in 4 years ...	2	6	8	
Average gain per acre ...		11	8	

These figures reverse the verdict previously arrived at, and show that there would be no advantage in revolutionizing our systems of farming to such an extent as to cut our corn crops green, and convert them into ensilage. This conclusion worked out with care would probably be supported by the opinion of any thoroughly practical and successful rent-paying farmer.

FINIS.

Richard Clay & Sons, Limited, London & Bungay.