OUTLINES OF

MODERN FARMING

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VOL. I.—SOILS, MANURES, AND CROPS

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PREFACE.

The following pages are really what their title imports—*outlines merely* of an art, an explanation of the principles and practice of which would take a much more extended space to do justice to, than the limits of the present series admit of. In so far as these limits are available, the Author has endeavoured to convey a fair notion of the general features of Modern Farming as practised in this country. How far he has been successful in this, the work itself will be its own best testimony. The Author is fully aware of the difficulties which have surrounded him in the execution of his task: difficulties mainly arising from the fact, that, agriculture not being a fixed science, in the ordinary acceptation of the term, but its practice being modified and controlled by a wide variety of circumstances,—as soil, climate, and locality,—the experience obtained, or mode of farming practised, in one district, is no index of, or guide to, that obtained or practised in another. Hence arises a very wide, and, in many cases, a startlingly contradictory variety of practice. So that to give an absolutely correct and comprehensive view of farming as practised in *Great Britain*, a digest of the modes pursued in its various districts would be imperatively demanded. This digest it is obviously impossible here to give. There are, however, general principles which regulate the practice of farming, and it is to an outline of these the Author has devoted the following pages. He would, however, impress upon the student the importance of bearing continually in mind the numerous modifying influences which affect the results of farm practice. To these his attention will be directed from time to time in the text, as occasion seems to demand. Agriculture abounds in "vexed questions," some of which appear to be as far from settlement as ever, after years of keen and vigorous discussion. To many of these disputed points special reference is made in the text, and on some of them the Author has not hesitated to give opinions of his own. These he puts forth with the utmost diffidence; and wherever he is proved to be wrong, he will be glad to be set right. He may say, however, for them, that they are the result of a somewhat extended observation of farming, as practised both in this country and abroad, and of some experiments conducted personally.

Outlines, therefore, of Modern Farming, as the present treatise claims only to be considered, it is necessary to refer the reader to larger and more comprehensive works, where he can obtain a full and exhaustive treatment of the subject.

The present volume, as its title-page indicates, is devoted to the consideration of the points connected with Soils, Manures, and Crops. The *Second Volume* will take up those connected with the Breeding, Rearing, and Fattening of Cattle, Horses, and Sheep; while the *Third Volume* will be devoted to the Management of the Dairy, of Poultry, and of Pigs.

Many of the subjects closely connected with farming, and farming economy, will be described in a Companion Volume to the above, entitled, "Historical Outlines connected with Farming and Farming Economy." The First Division of this volume will take up the consideration of points connected with the theory and practice of agriculture which have not been discussed, or but briefly alluded to, in the volumes "Outlines of Modern Farming:" as the history of our *Farm Crops and Stock;* the rise, progress, and present position of *Agricultural Chemistry and its various theories;* of *Drainage* and *Steam Culture.* The Second Division will be devoted to those subjects which exercise an important influence upon the economy of the farm, and which are now receiving keen discussion, as *The Labour Question—Cottages—Wages—Agricultural Education and Statistics.*

The *Reclamation of Waste Lands,* the *Utilisation of Town Sewage,* and *Irrigation,* will form the subjects of a separate volume.

OUTLINES OF MODERN FARMING.

DIVISION FIRST.

SOILS: POINTS INFLUENCING PRODUCTIVENESS OF—VARIETIES OF.—ROTATION OR SUCCESSION OF CROPS.—EXHAUSTION OF SOILS.—PREPARATION OF SOILS FOR VARIOUS CROPS: PLOUGHING—DEEP CULTURE.

SECTION I.—SOILS: PRODUCTIVENESS OF.—ROTATION OR SUCCESSION OF CROPS.—EXHAUSTION OF SOILS.

THE subject of Soils having been taken up and extensively treated by another writer in the series* of which our present work forms a part, comparatively little will be said here in connection with it. The knowledge, however accurate and comprehensive, of the geological features of any particular locality, will not enable us to predicate with certainty the nature, composition, and productiveness of its soil. So many circumstances of locality come into operation tending to alter the composition of the soil, that although we know, for instance, that as a rule a sandstone formation will give a sandy, and a limestone formation a calcareous soil, we cannot be so sure of the exact nature of these soils, the position of the strata, and the mixing of the detritus of these. The action of water upon a soil, and its shifting

* "Clay Lands and Loamy Soils," by Professor Donaldson.

from one locality to another—as from a position on the hill side to that in the valley—will tend to introduce elements of difference; so that the soil from a sandstone formation, for instance, in one locality may be very different indeed in its texture and productiveness from the soil produced from a sandstone formation in another locality. Nor is distance of one locality from another an essential requirement to bring about this diversity of soil. Very often, indeed, is it found that the soil of one part of a farm gives no index to the nature of the soil on another part; the same diversity, in fact, is often noticed in a more marked manner in one field, the soil of which is not homogeneous, but which in two not very distant parts is made up of different soils. So singularly diversified, in truth, is the soil of a locality in many instances, that the mind is puzzled to account for it; and finding nothing very satisfactory in many of the theories which attempt to account for the peculiarities of soil, he who wishes information is apt to rest content with a knowledge of the facts. One lesson of worth which the student of agriculture may learn from the facts is, that a diversity of soil introduces, naturally, a diversity in its farm treatment. But he would be in error if he drew from this, as a corollary, that the treatment of similar soils would be in all respects the same in different localities. And an important influence here comes into play, bringing about another cause for a diversity of practice. We refer to *climate*, which possesses a remarkable influence in the practice of farming, the treatment of soils, and on the *choice* and cultivation of the crops suited to them. On the subject of climate it may be of interest to give here what two authorities say of it, namely, Mr. Acland and Mr. R. Russell.

"It seems that in certain seasons the effect of climate is greater than that of manure; so that, according to the old proverb, seasons beat judgment. A well-manured piece of land may sometimes fare worse than another which has been only cleaned and left to nature. The importance of rain or of sun at certain particular seasons is well known to the practical farmer. The absence of rain during the time when plants are forming their leaves, or cool weather while the seed is being filled, will modify all the farmer's calculations, and must, in like manner, be taken into account by the agricultural chemist. Mr. Lawes tested the power of the soil to produce crops without manure, as a means of judging of the effect of atmospheric influences alone; and he found that the lowest weight of the bushel and the greatest amount of straw corresponded with the season in which there were the lowest summer heat and the greatest number of rainy days. The least amount of straw corresponded with the driest season, and the finest quality of grain with the hottest summer. He also found that the effect of season on a great number of plots, treated with various kinds of manure, corresponded with that upon the unmanured spots. All these facts he has minutely registered and compared, and they lead to the conclusion that no variation in the quality of manures will enable the farmer to overcome the effect of climate, but that something may be done, by a careful study of the laws of atmospheric action, to adapt the management of the land to the conditions under which it is placed, and so to take advantage of what is favourable, and to avoid what is the reverse." *

"In all countries and ages," says Mr. Russell, "climate has exercised the most important influence on the art of cultivation, and has undoubtedly tended much

* "Meat, Milk, and Wheat; an Elementary Introduction to the Chemistry of Farming." London: G. Ridgway. 2s.

to retard the advancement of agriculture as a science, for the experience of one country could not be taken as the guide for another; but since the principles are becoming better understood the harmony of the different systems are readily traced. Many of the rotations of crops which are pursued over Great Britain can be distinctly traced to the influence of climate. The four-course shift, which is practised so generally in Norfolk, does not extend much to the northward; the rotation which goes under a similar name in Berwickshire is totally different in its nature and characteristics. The system of Scottish husbandry agrees closely with the Welsh and Irish in many particulars, where the meteorological phenomena have also many points of resemblance; but the Norfolk husbandry is distinct and peculiar in its requirements, corresponding with its climatic conditions.

"Agricultural results will always be dependent on the character of the seasons. This, in some measure, attaches an amount of uncertainty both as to the quality and amount of the produce; but as the art of cultivation advances, crops will be raised with far greater certainty. When the agriculture of a thickly populated country is at a low ebb, with few vegetable productions the gross produce is more dependent on the nature of the seasons than where a greater variety of products are raised. This variety serves both to spare the natural forces of the soil, and to secure abundance, for when one crop is deficient another is frequently plentiful." *

From what has been said above, the student will have perceived that there is a reason why that diversity of practice exists amongst farmers; which has not seldom been taken notice of by those unaware of the facts of the case, as if it were a reproach to them as a com-

* "Cyclopædia of Agriculture," vol. i. p. 483, article "Climate."

munity; but it should never be forgotten that, as we have elsewhere remarked, "agriculture is not a 'fixed science;' there is no such thing yet as an agricultural theory adapted to all varieties of practice; there are so many peculiarities tending to throw in disturbing elements, that the dictates of theory, however applicable to one locality, are found to be totally inapplicable to another. Hence the danger which arises to the real progress of agriculture from the facility with which some accept new notions, simply because they are new, and endeavour to make them applicable to all circumstances of soil, climate, and locality; and hence, also, the reason why—a fact which is extremely puzzling to many—farmers who have been invariably successful in all their operations in one locality, should so signally and totally fail in another."

If a farmer could tell what is precisely the condition of his soil, in what constituents it was deficient, and in what it abounded, and how they acted upon one another, and how they acted on the plant; and if, moreover, he could find out by the aid of chemistry the analysis of the plants he grew upon his soil, so as to balance exactly what the plants required by what he had in his soil to give them, chemistry applied to farming would be an easy thing; but the truth is that neither chemistry nor physiology have yet been able to tell the farmer what really is the cause of fertility, how fertilising matters are assimilated, and how what is in the soil, or what are given to it, give life to the plants. Up to a certain point, in all our investigations connected with our crops, everything is clear and definite; but just as we approach the point in which we are most interested, and about to grasp the secret, we find that all certainty vanishes, and nothing is left us but the crudest of conjectures. We know that the same soi can grow turnips, wheat, and clover, but how the soil should in one case give us a turnip, and in another ears of wheat, and what are the precise agencies by which each is produced we know not; hence at the threshold of the house we wish to enter we are sternly stopped. A multitude of questions arise to vex and puzzle the inquiring farmer: he is at a loss to know how the results obtained one year from a process are totally different in another, and a succeeding one; how the manure which succeeds in one soil fails in another; nay, further, how the manure which succeeds in one year, should, on the very same soil and under the same circumstances, fail in another; and on all these points chemistry or physiology may give him little or no information. But although much doubt surrounds almost all agricultural questions, and gives rise to much dispute, still it is essential to the student that he should know the generally received theories of agriculture—theories which up to a certain, and a practically valuable point, tend to explain the facts of agriculture as eliminated from daily practice. It does not militate against agricultural *science* that it does not satisfactorily explain *all* the facts of agricultural *practice*. Science admittedly has done much; its most cautious friends generally believe that it is calculated to do more to forward the interests of practical agriculture.*

As to the nomenclature of soils, scientifically and practically classified and described, we beg to refer the reader to the work on "Clay Lands and Loamy Soils"

* A *resumé* of the various questions which have been discussed amongst agricultural chemists and scientific farmers will be found in the companion work to the present, entitled "Historical Outlines of Farming; and Farming Economy, Scientific and Practical, in the Chemistry of Crops, Soils, and Cattle Food, Manures, Drainage, Steam Cultivation. Seeds and Sowing, Leases, the Labour Question," &c., &c.

before alluded to; but it may serve some useful purpose here to give the popular nomenclature so well put by a recent first-rate authority on British farming. The popular definitions of soils, and to which it is safest for practical farmers to adhere, have respect to their obvious qualities. Thus they are designated from their composition as *clays, loams, sands, gravels, chalks,* or *peats;* or from their texture, in which respect those in which clay predominates are called *heavy, stiff,* or *impervious,* and the others *light, fragile,* or *porous.* From the tendency of the former to retain moisture they are often spoken of as *wet* and *cold,* and the latter, for the opposite reason, as *dry* and *warm.* According to their measure of fertility they are spoken of as *rich* or *poor.* The particular crops for the production of which they are respectively considered to be the best adapted have also led to the clays being spoken of as *wheat* or *bean soils,* and the friable as *barley* and *turnip soils;* this latter mode of discriminating soils is, however, becoming every day less appropriate, as those of the lighter class, when sufficiently enriched by suitable manuring, are found the most suitable of all for the growth of wheat, while the efforts of agriculturists are now successfully directed to the production of root crops on those so strong as heretofore to have been reckoned unfit for the purpose."*

Rotations.—No fact connected with agriculture seems so well established as this, that if a succession of crops of the same kind be taken from the same soil, each crop becomes deteriorated in value, until ultimately the soil would refuse to produce the crop, or if producing it, producing it in a very worthless form. Hence the

* "British Farming. A Description of the Mixed Husbandry of Great Britain." By John Wilson. A. and C. Black, Edinburgh. 12*s.*

necessity for changing the crops which are to be produced by the same soil. The necessity for the change, as we have said above, is well established; not so, however, the theories which presume to account for it. Of all the theories which have been brought forward from time to time, the following is that which is the most generally received.* If we analyse the ashes of certain plants, we find in their constituents certain inorganic substances, as phosphates and the like, which substances analysis also shows to be contained in the soil. These substances are drawn from the soil by the plants, and are therefore termed the "food" of the plants. But this food is withdrawn from the soil in very different proportions by different plants. This is well shown by Mr. J. Jekyll, of Louth, who gives the following table of the chemical composition of fertile and barren soils, and the classification of the various agricultural plants.

Composition of Fertile and Barren Soils.

	Barren land.	Barren peat.	Good black sandy mould.	Good loam.
Water	2·0	4·55	3·42	2·47
Organic matter .	1·80	89·14	9·30	9·11
Phosphoric acid .	—	—	0·31	0·27
Sulphuric acid .	—	—	0·11	0·14
Potash	—	a trace	2·23	2·73
Soda	—	—	1·98	1·39
Lime	·60	1·15	1·34	2·27
Magnesia . . .	—	·17	0·96	1·05
Alumina . . .	·80	·58	10·25	17·69
Silica	92·50	4·18	67·29	58·14
Chlorine . . .	—	—	0·68	0·54
Oxide of iron .	2·84	0·23	2·13	4·20
Totals . .	100·54	100·00	100 00	100·00

* A notice of the various theories of rotation, and the opinions of eminent authorities on the subject, will be found in the volume entitled "Farming, and Farming Economy," in the present series.

Agricultural plants are thus divided by Mr. Jekyll:—

1. Silica plants; as wheat, oats, barley, and rice; in which silica forms more than 50 per cent. of their ash.

2. Lime plants; as peas, beans, clover, lucerne, and the potato herb or top; in the ash of which there is more than 50 per cent. of lime.

3. Potash plants; as turnips, beet-root, and potato tubers; some of which have 70, and others more than 80 per cent. of alkaline salts in their ash.

The following analyses, made by chemists of repute, showing the per centage of silica, lime, and potash presented in the ash, render the distinction clear:—

	Salts of potash and soda.	Salts of lime and magnesia.	Silica.
SILICA PLANTS.			
Oat straw with corn . .	34·00	4·00	62·00
Wheat straw	22·00	7·20	61·05
Barley straw with corn .	19·00	25·70	55·03
Rye straw	18·65	16·52	63·89
LIME PLANTS.			
Pea straw	27·82	63·74	7·81
Bean straw	34·00	54·51	6·78
Clover	39·20	56·00	4·90
Potato herb	4·20	59·40	36·40
POTASH PLANTS.			
Turnips	81·60	18·40	—
Beet-root	88·00	12·00	—
Potato tubers	85·81	14·19	—

From the above Mr. Jekyll deduces the reason why different crops exhaust the soil, and the necesssity that exists for a rotation of crops. This is so well put that we deem it best to reproduce his remarks here.

"One kind of crop requires a heavy amount soluble silica, while some other crop requires li or none of that compound. By taking a crop requiring silica, time is given for its accumulation in the soil. Some plants rob the land of its nitrogen, others increase it. Some gain their support from the surface-soil, while others strike deep into the subsoil, and draw from it a rich store of mineral wealth, which can be returned to the land as manure, to supply those which feed in surface-soil only. One class of agricultural plants requires for their well-being an excess of silica; a second an excess of the salts of lime and magnesia; while a third will not flourish without an extra amount of the salts of the alkalies. Thus, by alternating the several kinds of crops, land is maintained in a productive condition for a greater length of time at less cost. But while this is clear, is it not equally and unmistakably evident that land must ultimately be more entirely exhausted by this system, unless all manurial ingredients are added in the same proportion as that in which they are removed by the different crops? Yes, to maintain land in its original fertility, every manurial element or compound—nitrogen, phosphorus, lime, &c.—removed in a crop, must be restored in some form. Every sack of corn, pound of beef, mutton, or bone, truss of hay or straw, carried off the farm, reduces the productive capabilities of that land by exactly the amount of the nitrogen, phosphorus, potash, &c., which has been extracted from the soil by those agricultural productions; and every load of manurial matter returned to the farm restores productiveness in exact proportion to the amount of these chemical substances which it contains. It matters not from what source is the nitrogen, lime, potash, or phosphorus, so long as these substances are in an available form, or readily become so in the soil. But they must be returned to the soil, or sterility will sooner or later overtake the best land ever cropped."

But although giving large and continued supplies of manure to the soil would restore its elements of fertility, and do away, as some maintain, with the necessity for a rotation, still it is evident that—looking at the above classification of plants—as wheat, for instance, takes more of one substance, as silica, than it does of another, as potash—a succession of crops of wheat on manured land would leave in, and cause to be accumulated in, the soil a quantity of substances which would be just so much waste. Hence the economic reason for a succession of crops—so that one plant shall take up and assimilate the substance or substances not used by that which has preceded it. Further, while the demands of the population for bread, &c., render it necessary to raise large crops of wheat and other cereals or grain-producing plants, the demands for other agricultural products—as meat, butter, cheese, milk, &c., &c.—must also be met; and this can only be done by giving due attention to the culture of root crops of herbage and of forage plants. Hence another reason for carrying out a rotation or succession of crops, the two grand divisions of which are grain or white crops, and root, forage, or green crops. Still another reason for a succession of crops remains to be given; that it is advisable to alternate with the narrow-leaved cereals, as the wheat, oats, barley, or rye, those broad-leaved plants, as the turnip, the mangel-wurzel, or the cabbage, which are especially fitted to draw from the atmosphere the carbon, the hydrogen, and the oxygen, so required to form the organic parts of all the crops. Again, as shown by Dr. Cameron, a rotation is necessary, from the fact that "each kind of plant differently affects the growth of weeds." The oldest rotation is known as the "Norfolk or Four-course System," and which, as originally introduced was as follows:—

First Year	Turnips.
Second Year	Barley.
Third Year	Clover.
Fourth Year	Wheat.

As students have, in their first initiation into the art of agriculture, a difficulty in understanding the exact way in which a rotation is carried out, it will perhaps be useful to the tyro if we give here tabular diagrams illustrating the mode of carrying out a four-course rotation, as given above in a farm divided into four fields. Commencing with the first year, the crops which the four fields will bear will be as follows:—

CROPS OF THE FOUR FIELDS THE FIRST YEAR OF ROTATION.

Field No. 1.	Field No. 2.	Field No. 3.	Field No. 4.
Turnips.	Barley.	Clover.	Wheat.

CROPS OF THE FOUR FIELDS THE SECOND YEAR OF ROTATION.

Field No. 1.	Field No. 2.	Field No. 3.	Field No. 4.
Barley.	Clover.	Wheat.	Turnips.

CROPS OF THE FOUR FIELDS THE THIRD YEAR OF ROTATION.

Field No. 1.	Field No. 2.	Field No. 3.	Field No. 4.
Clover.	Wheat.	Turnips.	Barley.

CROPS OF THE FOUR FIELDS THE FOURTH YEAR OF ROTATION.

Field No. 1.	Field No. 2.	Field No. 3.	Field No. 4
Wheat.	Turnips.	Barley.	Clover.

From this scheme may be deduced the following facts in farm practice worthy of being remembered by the student: First, that barley is a good crop to succeed turnips; Second, clover to follow the barley—(note here that the clover is sown either with the barley or broadcasted and harrowed in afterwards, the clover being left to grow on the land after the barley crop is taken off); Third, that wheat is a good crop to follow the clover.

But a rotation is more perfect, in the opinion of some eminent authorities, where the grain and green crops themselves alternate. Thus in place of having, as in the above scheme of rotation, wheat to succeed itself in the fourth field every fourth year, it is desirable to have some other grain, as barley, to follow wheat in the fifth year, oats in the ninth year, and rye in the thirteenth year. Again, with the green crops after turnips, which open the rotation as above, the rotation should begin in the fifth year, say with mangel-wurzel instead of turnips, potatoes in the ninth year, and cabbages in the thirteenth year. Thus in place of the first, fifth, ninth, and thirteenth years of the field No. 4 being always wheat, a better succession will be wheat, barley, oats, and rye.* In like manner in place of field No. 1 being in the first, fifth, ninth, and nineteenth years turnips, a better succession will be turnips, mangel-wurzel, or kohl kali, potatoes, rape, vetches, or cabbages.

Satisfactory as the mineral theory of rotations is which we have above described, "it does not," as Dr. Voelcker remarks,† "afford in all instances, nor indeed in the majority of cases, the means of explaining the benefits of a good rotation of crops. . . . In giving a

* For peculiarities which limit the growth of rye, see a succeeding division of the present work treating of cereals.

† Article "Theory of Agriculture," p. 260, vol. ii. "Encyclopædia of Agriculture," edited by J. C. Morton, Esq. Blackie and Son, Glasgow and London.

satisfactory explanation in this respect, a great variety of circumstances, as for instance, the natural habits of plants, the physical condition of the soil, the climate, &c., must be taken into consideration." The editor of the Cyclopædia from which the above is taken adds the following suggestive note. "We add to these remarks by Dr. Voelcker the practical inference that, whatever the cause of the increasing poverty of the land under repeated crops of corn, it may be so enriched by the artificial application of manure, and even by such cultivation as shall enable the full use of natural sources of fertility, as entirely to counteract the exhausting influence of any method of cropping that it may be advisable to adopt. So that while adherence to a well-defined rotation of crops may practically be a security for the permanent value of the land, that can be ensured by the intelligent cultivator under any method of cropping which markets may suggest for his adoption." On this same point, as indicative of the modifying circumstances of soil, climate, and locality on rotations, we may give the following from an eminent authority :—"Among the many, the golden rule of farming is that no two white crops shall follow in immediate succession, but the successful practice of a *contrary* system in some districts may teach us how vain it is to prescribe the same rules for totally different circumstances. . . . . . The true test of any system is its continued success." But while it is true that a careful farmer may to some extent be independent of a rotation, it should be remembered that in the diseases which attack crops when repeated too often upon any soil, there is another argument in favour of a rotation or change of crop, and which ought to influence farmers in carrying out a plan of culture. Change is written everywhere on the face of nature, and we are inclined to believe that where the lesson thus taught us, is neglected or overlooked, we pay the penalty for it in diseases which materially reduce the product of the soil. This consideration has indeed a close bearing upon diseases which have long been the scourge of certain crops—as clover sickness, finger and toe in turnips—and should alone make us pause when we wish to get rid of a rotation of crops. The following remarks by an eminent authority on the "four-course rotation," already described, will be useful.

"No better rotation has been devised for friable soils of fair quality than the well-known four-field, or Norfolk system. By this course half the arable lands are in grain crops, and half in cattle crops, annually. It is indeed true that, in the way in which this course has hitherto been annually worked, both turnips and clover have recurred so frequently (every fourth year) on the same fields, that they have become subject to disease, and their produce excessively precarious. But the excellence of this course is, that its main features can be retained and yet endless variation be introduced in its details. For example, instead of a rigid one-fourth of the land being each year under turnips, barley, clover, and wheat, or oats, respectively, half only of the barley division is frequently, in practice, now sown with clover seeds, and the other half cropped in the following year with beans, peas, potatoes, or vetches. On the same set of fields coming round again to the same point, the treatment is reversed by the beans, &c., and clover being made to change places. An interval of *eight* years is thus substituted for one of *four*, so far as these two crops are concerned. Italian rye-grass, unmixed with any other plant, is now frequently taken instead of clover on part of the division usually allocated to it, and proves a grateful change both to the land and the animals which consume it

In like manner, instead of sowing turnips invariably every fourth year on each field, a portion of the annual division allotted to this crop can advantageously be cropped with mangel-wurzel, carrots, or cabbages, care being taken to change the site occupied by each when the same fields again come in turn. The same end is even so far gained by alternating Swedish with yellow or globe turnips. It is also found expedient, either systematically or occasionally, to sow a field with clover and pasture grasses immediately after turnips, without a grain crop, and to allow it to remain in pasture for four years. A corresponding extent of the other land is meanwhile kept in tillage, and two grain crops in succession are taken on a requisite portion, to equalise the main divisions both as respects amount of labour and the different staple products. A closer cover of grasses and a better pasture is obtained in this way than by first taking the customary grain crop *after turnips, the land is rested and invigorated for* future tillage, the outlay on clover and grass seeds somewhat diminished, and the land better managed for the interests of all concerned than by a rigid adherence to the customary rotation."—(*British Farming.*)

Such may be taken as the generally received opinion on the subject of rotation. It is right, however, to state that some maintain that a rotation is not essential; that a succession of wheat crops, for instance, may be taken from off the same land without the addition of manure; that, in point of fact, the supply of inorganic substances in the soil is inexhaustible, and that the organic substances may be derived from the air by a process as simple as it is effective. For a description of a plan of growing wheat on this principle we refer to the Third Division of the present volume.

Closely connected with the subject under consideration is the question now agitating the agricultural community, as to whether the system of cultivation now in use is calculated to prevent the *exhaustion of the soil,* and its ultimate impoverishment. The reason why this question has been raised is obvious enough, when we consider that all the investigations and practice of recent years have shown that plants "cannot exist without an efficient supply of inorganic matters," which are obtained alone from the soil, in addition to the organic constituents, ammonia, carbonic acid, and water. Now if the reader turns to the table already given, showing the inorganic constituents of plants, and that now to follow, he will at once see how small a proportion these form of the bulk of the soil, and how pregnant with interest is the question—can the supply of those constituents be kept up? The answer to the question has been given by Professor Anderson, in a recent paper in the "Transactions of the Highland and Agricultural Society of Scotland," and with such lucidity that we deem it advisable to give here a *resumé* of what he has stated.

"In order that we may have definite data to go upon, let us in the first instance consider the cause of the exhaustion of soil and the different modes in which it may be brought about. It is to be observed, then, that all plants require for their growth an adequate supply of carbonic acid, ammonia, nitric acid, sulphuric acid, chlorine, and silicas, which are all indispensable, although some of them are required in larger quantities than others. They are divisible into two classes,—one including the first four substances, which, being all either gaseous or volatile, are found not only in the soil but in the atmosphere; the remainder are confined, at least in quantity, to the soil. These two great classes are usually distinguished as the organic and inorganic elements of the plant food, by which it is to be understood that the former, though they are in a chemical sense inorganic, are the source of the organic or combustible part of the plant, while the latter supply the constituents of the ash. They may also, however, and with more advantage, be described as the movable and the immovable elements of the plant; because the former, existing in the air, are conveyed backwards and forwards by the wind, while the latter, being fixed in the soil, cannot be removed and replaced by ordinary natural causes. It is sufficiently obvious that if a crop be grown for a succession of years, and be systematically removed from the soil, the quantity of these substances must be gradually diminished, and, if this course be persisted in, the soil must eventually become incapable of supporting the life of plants. The period at which this will occur must necessarily differ very greatly in different soils, and depend on the quantity of available plant food, for the air constantly shifting is always prepared to yield a practically inexhaustible supply of the movable elements, so that the exhaustion must in all cases be due to the removal of the fixed or mineral substances; and, consequently, when it is wished to restore to the soil its power of supporting vegetation, it is not *necessary* to add to it all the elements of the plant, but it will suffice to give those which it cannot otherwise obtain—that is the fixed substances—and leave it entirely to depend on the air for a supply of those which can be derived from it. We do not mean here to discuss whether this method would reproduce the highest degree of fertility, but only to point out that a soil thus treated would regain more or less completely the power of supporting plant life, of which it would have been deprived by the supposed system of management.

"In point of fact, then, the complete exhaustion of a soil in its natural state must always be due to the want of mineral matters; because, practically, no method of treatment can deprive it of those which the air supplies. As far, also, as these matters are concerned, it must be obvious that they would rarely, if ever, be exhausted simultaneously, but that in general, some one substance being present in relatively small proportion, the soil becomes incapable of supporting the life of plants when it is entirely withdrawn, although there may still be an abundant supply of all the others. If, for example, a soil contain a sufficient quantity of potash to yield say twenty full crops of wheat, and of the other constituents of that plant enough to yield forty crops, the excess of the latter will be unavailing, and the soil would be exhausted by twenty crops. If, now, we added to such a soil a supply of potash, it would again become capable of producing a crop, and would go on doing so until some other substance had been entirely consumed, when it also would have to be added; and so on until all being removed, the soil would at length end in a complete infertility, which would duly be retarded, and not prevented, by this mode of operation. To maintain during an unlimited series of years an uniform amount of produce, it would be necessary to add, year by year, a quantity of the elements of plant food equal to that which the crop removes; and the necessity for doing this is so obvious that it cannot be controverted, and may be safely asserted, that it is a point on which all scientific and practical men are entirely at one.

"This being the principle on which the exhaustion of the soil is to be avoided, we have only to carry it out a little further to draw the conclusion, that if we add to it a larger quantity of the elements of plant food than is requisite to replace what has been removed, its productive capacity must be increased, and it will become capable of yielding a larger crop than it did in its original state. This is, in fact, the foundation of the use of manures; and if it were possible to carry out these theoretical principles in their integrity, the soil might be made to produce, during an unlimited succession of years, a crop greatly exceeding anything known in actual practice. Practically, however, there is a limit which cannot be exceeded, and this depends upon several circumstances. In the first place, the effect of a manure is not due to its composition alone, but is dependent, to no small extent, upon the different constituents existing in it in a state in which they are readily available to the plant. And in the second place, the composition of manures is not entirely under our control. Although farm-yard manure, which is, and will always continue to be, the foundation of agricultural practice, is a mixture containing all the elements of plant food, and generally in proportions not very far removed from those in which the plant requires them, yet it is impossible not to recognise the fact that differences occur in it, and that part of its constituents are not directly available to the plant, but only become so by virtue of certain changes which occur in it after it has been deposited in the soil, and do not necessarily proceed exactly as we could desire. It is a familiar fact that, owing to these decompositions proceeding in an imperfect manner, manure may, and often does, accumulate in the soil, and remains there in an inert and dormant condition. If from this or any other circumstances the supply of one or more of the substances required by the plant is deficient in the manure, then either the crop is thereby limited, or it is forced to derive the requisite supply of that substance from the natural resources of the soil itself. In fact, a manure which is deficient in any one element of the crop does not improve the soil, and though it may produce a greatly increased crop, its effect is merely temporary, and eventually it only causes its more rapid exhaustion. In the case of farm-yard manure, which necessarily contains all the elements of plants, this is of course less likely to occur than in special manures containing only one or two of these substances. Thus, for example, the opposite effect would be conspicuously seen in the case of a soil manured during a series of years with a salt of ammonia. In that case, though the crop might be greatly increased in any one year, the total amount of produce would be no larger than it would have been without that addition, but it would have been obtained within a shorter period of time.

"The general conclusion to which all these considerations lead is, that we can only maintain the fertility of the soil by returning to it all the substances which the crop removes, and that we can increase it by applying these in larger quantity; but when the mixture supplied is deficient *in any one substance, it does not prevent but hastens exhaustion.*"

The question still remains, however, whether in the use of artificial manures now so largely adopted—as guano and bones, which only contain certain constituents of the soil, as ammonia and phosphoric acid—we not only do not restore all the elements of fertility, but actually all those which encourage the crop to draw more largely than it would otherwise do on the productive resources of the soil. In answering this, it will not do to take it up as a question simply of this or that manure; but the question resolves itself into ascertaining whether, throughout the country, there is a proper balance between the crops removed from the soil and the manure returned to it. To determine this it is necessary to know the average produce of the crops, and of the valuable or fertilising matter which they remove. The following table gives a statement of these quantities:—

Product.	Produce per imperial acre.	Total weight in lbs.	Total mineral matters.	Potash.	Soda.	Lime.	Mag-nesia.	Chlo-rine.	Sul-phuric acid.	Phos-phoric acid.	Silica.	Nitro-gen.
WHEAT.												
ain . . .	28 bush. @ 60 lbs. ℔ bush.	1680	34·12	10·11	1·20	1·04	4·80	—	0·32	16·22	0·43	29·20
aw . . .	1 ton 3 cwt.	2576	114·48	20·70	2·84	8·53	2·23	—	3·55	3·16	73·47	16·13
Total			148·60	30·81	4·04	9·57	7·03	—	3·87	19·38	73·90	45·33
BARLEY.												
ain . . .	33 bush. @ 33 lbs. ℔ bush.	1089	44·24	9·40	0·30	0·76	3·10	1·12	0·85	15·52	13·19	34·98
aw . . .	18 cwt.	2016	99·14	11·24	1·14	5·81	2·75	1·30	1·10	7·22	68·58	6·03
Total			143·38	20·64	1·44	6·57	5·85	2·42	1·95	22·74	61·77	41·01
OATS.												
ain . . .	34 bush. @ 40 lbs. ℔ bush.	1360	48·89	11·00	—	5·31	4·04	0·20	—	26·07	2·27	27·54
aw . . .	1 ton.	2240	143·53	30·71	6·10	10·29	5·50	5·55	5·18	7·35	72·85	14·10
Total			192·42	41·71	6·10	15·60	9·54	5·75	5·18	33·42	75·12	41·64
ANS & PEASE.												
ain . . .	*25 bush. @ 60 lbs. ℔ bush.*	1550	55·97	30·00	0·31	3·01	4·00	—	1·76	16·65	0·24	46·10
aw . . .	1 ton.	2240	108·51	48·61	13·14	29·37	3·74	7·00	2·07	0·74	3·84	26·88
Total			164·48	78·61	13·45	32·38	7·74	7·00	3·83	17·39	4·08	72·98
nips . .	13½ tons	30,240	213·75	57·35	44·71	28·60	4·65	10·35	39·02	22·57	6·50	60·48
atoes . .	3 tons	6720	55·58	28·92	2·85	1·20	2·11	3·21	10·24	5·76	1·29	26·00
y . . .	2½ tons	5600	391·31	129·79	4·30	35·46	9·62	39·61	16·57	21·79	133·67	56·22

Taking now a six-course rotation—as turnips, wheat, hay; oats, potatoes, and wheat—the quantity of valuable matter removed by the crops of the rotation is calculated as follows:—

	lbs.		lbs.
Potash . . .	319·4	Sulphuric acid .	78·7
Soda	66·6	Phosphoric acid.	122·3
Lime	100·0	Silica	364·4
Magnesia . . .	39·9	Nitrogen . . .	274·0
Chlorine . . .	58·9		

All prospect of the exhaustion of the soil is certainly not immediate, when we consider how very small the quantities removed are when compared with what exists in the soil; and when also we consider that even if the soil contains only a quarter per cent. of phosphoric acid, it would maintain the crops of such a rotation—exhaustive as it comparatively is from two white crops finding a place in it—for two hundred and seventy-six years. The other point, however, in the solution of the question, namely, the estimating of the elements of fertility restored to the soil through the agency of farm-yard manure, is not so easily decided on; not only from the difficulty there is of estimating the quantity ordinarily applied to the crops, but also from the imperfect knowledge we yet possess of its average composition. The following, however, may be taken as a fair average estimate of the quantities of fertilising matter in applications of 12 tons, 16, and 20 tons, the first named of these figures being selected as an average, the second and third as an occasional application:—

	12 tons.	16 tons.	20 tons.
Potash	201	268	335
Soda	67	89	111
Lime	337	449	561
Magnesia	35	47	59
Chlorine	12	16	20
Sulphuric acid . .	84	112	140
Phosphoric acid . .	108	144	180
Silica (soluble) . .	269	358	447
Nitrogen . . .	165	220	275

Without going further into an analysis of these facts, we may here state the conclusion of Dr. Anderson, that—so far as farm-yard manure is concerned—if any exhaustion is to be feared, it must be due chiefly, if not entirely, to the loss of potash, phosphoric acid, and chlorine. The latter can be abundantly and cheaply supplied by the application of common salt; phosphoric acid, to the extent of 50 to 100 lbs. in every 3 cwt. of guano, can be obtained; so that the only element which the present system of manuring does not supply adequately is potash. Although this opinion is liable to the objection that it is founded on data open to doubt as to their accuracy; and as, moreover, a large proportion of the crop is not restored to the land in the shape of farm-yard manure, but is consumed by the people and sent into our sewers, and thus lost to agriculture;* nevertheless—duly considering the facts that as much of our town sewage is used directly to the soil, and that as much of it owes its existence to the use of imported corn, which, as it never grew upon, cannot in any way be said to be exhaustive of our soil, and that, moreover, as there is a large field of fertilising substances in the waste products of our manufactures, of the sea, &c.—Dr. Anderson comes to the conclusion that "at the present moment we cannot anticipate the exhaustion of the soil," and that at all events the fact, pregnant as it is with meaning, is patent enough that, "so far as we at present see, the soil is not becoming exhausted."

* The whole subject of the economisation of the excretæ and waste substances of our towns is treated of in the volume on "Irrigation, Utilisation of Town Sewage, and Reclamation of Waste Lands," which forms part of the present series.

SECTION II. — PREPARATION OF THE SOIL FOR THE BEARING OF CROPS :— DRAINING — TILLAGE — DEEP CULTURE — STEAM PLOUGHING.

Draining.—The first, and not the least important, operation to be performed in bringing our soils into the condition best calculated to enable them to produce fine crops is draining. The practical* and historical† points connected with the subject, the reader will find in the under-noted volumes. It only remains for us here to point out briefly the agricultural advantages obtained by carrying out efficient modes of draining. The clearing land of wet adds to the temperature of the soil. Where wet is allowed to remain, the heat of the sun, in place of warming the soil, is only expended, or in great part expended, in evaporating the excess of moisture. Drainage enables heavy clay land to be more easily worked, as it makes it open and friable; in like proportion it increases its fertility by making it pervious to the air, and sets free the otherwise inert stores of fertilising substances. Further, the organic matter contained in soils is not assimilable by plants till it is converted into water, carbonic acid gas, and ammonia (see Division Second, Theory of Manuring), and this is only done by allowing the air to come in contact with the organic matter and decompose them. Drainage facilitates this contact with the air, as named in the last sentence. Hence drainage enables us to gain the fullest advantage from the manure which we supply to our soils. So much for the benefits obtained from

* "Drainage of Land, and Drainage and Sewage of Towns and Buildings," by G. D. Dempsey, C.E.

† "Historical Outlines of Farming and Farming Economy—Scientific and Practical."

draining in our crop-bearing soils. Its advantages are not less marked in our pastures and meadows, for when properly carried out it makes the aquatic, marshy, and useless grasses and plants disappear, and enables the best and most nutritious, to be cultivated with ease and economy.*

Tillage or Working of the Soil.—The object of tillage is twofold—to get rid of weeds and noxious plants, and to pulverise the soil, fitting it to bear the plants cultivated for their produce. These are done more or less effectually in proportion to the careful zeal of the farmer by the operations of ploughing, grubbing, harrowing, and rolling. These operations, with the implements by which they are carried out, are fully described in the under-noted work.† One of the most important questions of modern agriculture now undergoing discussion amongst scientific and practical men is, whether "deep culture and thorough pulverisation of the soil are beneficial or not?" The subject is of the highest importance; and as it closely interests the future of agriculture, we may be permitted to give, in connection with it, the following from an article lately contributed by us to the "Journal of the Bath and West of England Agricultural Society," entitled "The Lessons of the Machinery Department of the Great Exhibition of 1862."

"The opinion is gaining ground daily, that in deep culture of the soil lies the future of agriculture, and that the problem which must be solved by our

* The operations of paring and burning, trenching, &c., are described in the volume of the Rudimentary Series on "Irrigation, Utilisation of Town Sewage, and Reclamation of Waste Lands."

† "Field Implements and Machines," by Professor John Scott, in the present series.

agricultural mechanics is the means, best and cheapest, by which this deep culture can be secured? As this deep-culture question is one which is at present attracting much attention, and likely for some time to attract *more*, and as some of the points involved in its consideration have a very close and intimate bearing upon the subject of agricultural mechanism, we may, perhaps, be permitted to give now what we have given elsewhere about it. 'As to the value of a thorough pulverisation of the soil, agriculturists long divided are now fast approximating in opinion. Few, indeed, are ignorant of the immense advantages resulting from allowing the atmospheric influences to act upon the soil; but some still incline to the opinion that it may be carried too far, more especially when in combination with thorough drainage; this opinion being held in consequence of supposing that in the case of heavy rains the soluble matter will be washed out and conveyed to the drains, which then, in point of fact, will act as sewers to carry off the fertilising matter from the land in the same way as street drains carry off the exuviæ of towns.' This objection is at once met by the now recognised absorptive properties of soils, which enable them to take up and assimilate such fertilising matter as may be given to them; and it is especially worthy of notice that this absorptive power is greatly increased when the soils are subjected to the action of the atmosphere. Now, this action cannot be brought into operation until the soil is deeply stirred and thoroughly pulverised. Where the soil naturally or artificially is in this deep condition, we find that the roots of plants penetrate deeply into it; and we may therefore predicate with some degree of certainty that this penetrative power of the plant is its normal condition; and that where the condition of the soil is such as to prevent it exercising this power, its healthy condition and fructifying capabilities are in like proportion increased. Some doubt the truth of this; but there is abundant evidence in the reason of things to prove that it is correct. Mr. Stephens, in his 'Deep-land Culture' treatise, puts it in a clear light. 'In common practice,' he says, 'the surface-soil devoted to the use of plants seldom exceeds seven or eight inches in depth, and of that space a good manuring of farm-yard dung occupies a considerable proportion. This, assisted by a special manure, stimulates the growth of the roots of the cereal plants to an expansion beyond what the space of soil allotted to their growth affords room for. Roots in a confined space, supplied with manure, become crowded together, decline in health, and their growth is checked. The plants may still bring forward their produce to a fine degree of quality; but it will neither be so large nor so valuable as the manure bestowed and the labour spent on the soil would warrant the expectation of. Whence, then, does such an unexpected disappointment arise? From the subsoil, though thoroughly dried, being left in a hard state. Were it in a state of pulverisation, like the surface-soil, the roots whenever stimulated by the manures would strike down into the subsoil, and the more they were encouraged in growth the larger they would become; their fibres would increase in numbers, and they would stretch out and reach the bottom of the pulverised subsoil; the crowding of the roots in the surface of the soil would be entirely avoided, and the baneful consequences of loss of health and stuntedness in growth of the plant would be replaced by vigour of stem and leaves, strength of constitution, and capability to yield the largest quantity of produce. Were farm-yard dung buried deep in the pulverised subsoil, and the embryo plant encouraged in the pulverised soil by means of a special manure, the limits of the growth of the entire system of the plant—stem, leaves, and roots—would then only be restrained by the power of the local climate, or the general character of the season.'

"On this same point, on the importance of deep culture, Mr. Smith, of Bletchley, throws out the following, which is suggestive. 'If it were not foreign to the question, it would certainly lead me to too great a length to enter upon the inquiry how far this deeper cultivation promotes a greater deposit of dew, checks the evaporation of moisture from the surface, and supplies the place of the evaporation which does take place from the stores of moisture beneath the surface.' These considerations are far from irrelevant to the immediate subject of our paper; they bear, indeed, very closely upon it; they involve what may be called the question of what shall be the principle of future cultivation of the soil? It is no use to say, as has been said, that this deep pulverisation of the soil is not required, because all experience wherever it is adopted shows, that it has been eminently successful in raising lands from the lowest condition of sterility to the fullest degree of fertility. If examples are required, go to the fields of Flanders; or if evidences are desired as to what deep cultivation can do, go to the lands of Yester, or of Bletchley. There is, in truth, no more important problem awaiting the solution of the agricultural machinist than this of deep cultivation of the soil—how best, most quickly, and cheaply to do it. But the solution will certainly be assisted if agriculturists will decide quickly what is the best condition in which the surface should be left. While some maintain the importance, nay, absolute necessity, of having the soil laid over in slices, all at a determinate angle,* others hold that it is quite immaterial how it is laid, so that it is well comminuted;—that it be, in point of fact, well pulverised; that this being secured, it is a point of indifference as to the condition or form in which it is left to serve as a seed-bed. It would really help forward the solution of the problem above stated, if agriculturists would, or could, decide as to the best way of securing a good seed-bed. One lesson, at all events, to be learned from a review of what has been done during the last eleven years is, that in the deeper pulverisation of the soil, and in the finer preparation of its surface, we have a means of increasing its fertility, and that if we have not yet a complete set of implements able fully to secure these points, we have some which to a certain extent meet our wants."

The following is Mr. Stephens' summary of the advantages of "Deep Culture," as given in his work above alluded to, p. 135:—

"The porosity of the subsoil should assist in a marked degree the desiccating power of drains, and promote the circulation of air through its mass. Its capillarity should supply moisture from the effects of the drains below to the roots of plants growing in the upper soil, in proportion to the intensity of evaporation of the moisture from the surface in dry weather. In its comminuted state it should absorb moisture from the dews, and from the lower portion of the atmosphere at night in a period of drought. In its change of colour to a darker hue, from drainage and deep

* For a brief *resumé* of the points at issue between the advocates of the plough and other systems for preparing the soil for seed, see "Historical Outlines of Farming and Farming Economy."

ploughing, and by commixture with the surface-soil and manures, it should absorb a larger portion of solar heat and light than in its unchanged state. In its aluminous character it should absorb the free gases from the atmosphere, as well as from the air and rain which traverse it. The mixture of the constituents of the surface-soil and subsoil should induce action of the electric element. The great depth of pulverised subsoil should afford an extensive field for the food-searching fibres of enlarging roots of plants to grow in; and it should place a large portion of the subsoil itself beyond the reach of the ever-changing conditions of the seasons. Its general dryness should place the roots of plants in a medium safe from frost; its divisibility should render every species of labour performed in it of easy execution. The variety of its constituents, consisting of organic and inorganic materials, of minerals, metals, and salts, should be ready to co-operate with any of the ingredients of the manures used in the surface-soil, and which may find their way into the subsoil by means of rain or otherwise, as they are let loose by decomposition, and be there retained for the use of the roots of plants."

Steam Culture. — Tillage operations are generally carried out by horse-power; of late, however, steam-power has been made practically available, and promises to be of immense service to the farmer. The reader desirous to obtain information on this most interesting department of farming economics, will find a notice of the history of its introduction, from the earliest up to the latest times, in the volume under-noted.*

* Rudimentary Treatise, "Historical Outlines of Farming and Farming Economy—Scientific and Practical."

DIVISION SECOND.

PRINCIPLES OF MANURING.—MANURES, VARIETIES OF: FARM-YARD MANURE—LIQUID MANURE—ARTIFICIAL MANURES.

SECTION I.—PRINCIPLES OF MANURING.

BEFORE giving our remarks on manures, it may be useful to glance very briefly at the principles of manuring as generally received. All plants are composed of two distinct parts, the *organic* and *inorganic*, or *mineral*. The organic part of plants is made up of carbon, oxygen, hydrogen, and nitrogen. The organic parts of plants are capable of being totally consumed or burnt and dissipated. If we take a plant, as a turnip or an ear of wheat, and consume it, so much of it will be dissipated, and the part remaining, known as the "ash of the plant," consists of the "inorganic, or mineral," constituents. These are sulphur and phosphorus, potash, soda, magnesia, lime, and iron. These do not exhaust the list of constituents; the remainder will be found in the table given in the preceding chapter where treating of the exhaustion of the soil. The constituents we here name are, however, sufficient for our purposes. On consulting the table above referred to the student will be surprised to see the small proportion which plants contain of these inorganic constituents; but, small as the proportion is, it bears most closely on the welfare of the plants. They are, indeed, essential to the life of plants, and if not present in the soil, or in the manures which we supply to it, they would not attain to maturity; and

:hey are all *equally* essential, the absence of any one of :hem being fatal to the development of the plant.

Of the organic part of plants the principal elements, :arbon and nitrogen, are derived mainly from carbonic ıcid and ammonia. *Carbonic acid gas* is being perpetuılly formed around us; when we breathe we send out :arbonic acid; when we burn our fuel we prepare it; vherever decay in vegetable or mineral matter goes on, .here carbonic acid is evolved. Plants take up carbonic ıcid by their roots, and by their leaves: it is absorbed 'eadily by water. On placing the seed of a plant in .he ground, it, in process of time, sends down tiny 'ootlets into the soil beneath, and runs its tiny leaflets nto the atmosphere above. These absorb carbonic ıcid from the soil and moist air, forming gradually the tem and leaves; these latter as they grow are furıished with innumerable mouths, so to speak, from vhich the evaporation of the moisture in the plant akes place—the carbonic acid, by a wonderful process,)eing changed or decomposed, the carbon remaining in he plant, the oxygen passing off by the sporules, or nouths, of the leaves. *Ammonia* is a combination of wo gases, hydrogen and nitrogen, in the proportions f 14 lbs. of nitrogen to 3 lbs. of hydrogen. Hydrogen s one of the two elements of water, oxygen and hydro:en, and when 1 lb. of it is combined with 8 lbs. of xygen, 9 lbs. of pure water is the result. Water ossesses, therefore, a great affinity for ammonia, so much hat it is capable of absorbing from 600 to 700 times its ulk of ammonia, hence the value of water in enabling s to avail ourselves of the store of nitrogen which is resent in the atmosphere. The principal source—we ıay here say the natural source as opposed to the rtificial source—of ammonia within the reach of the farmer is the urine of the animals, the stock of his farm. The principal artificial source is the manufacture of coal gas, the products of which yield our principal store of the salts of ammonia. Wherever decomposition takes place ammonia is evolved. Ammonia is also found in immense quantities in rain-water. Water, therefore, plays an important part in the development of plants charged with carbonic acid or ammonia. It has the power of dissolving "some of the ingredients which are necessary to the existence and health of plants, thereby bringing them, as Dr. Daubeny has observed, from a dormant into an active state."

The inorganic, or mineral, constituents of plants are derived from the soil alone, and they exist there in the form of salts. If an acid, as carbonic acid, combines with a base (alkali), as pure lime, it forms a "salt"—the carbonate of lime—which possesses neither the properties of an acid nor an alkali, but has a property essentially distinct from both. If the acid, in place of being carbonic acid as above, is sulphuric, the salt is a "sulphate of lime;" if muriatic acid, the salt is a muriate of lime. Phosphate of lime is the salt produced by the combination of phosphoric acid and lime. Carbonate of ammonia is the salt formed by the combination of carbonic acid and ammonia; muriate of ammonia, muriatic acid and ammonia. Nitrate of soda is the salt formed by the combination of nitric acid and soda. So much for one important property of a "salt;" the next remains to be noticed, namely, the "properties of bases and acids neutralise each other in *fixed* proportions." To form the salt termed a "sulphate of ammonia," 40 lbs. of sulphuric acid must combine with 17 lbs. of ammonia; a "carbonate of lime" is made by combining 28 lbs. of lime with 22 lbs. of carbonic acid, and so on. "The practical consequences," says Mr. Acland, of whose lucid exposition of the chemistry of farming the above is a very rapid *resumé* or brief digest of the parts relating to plants—"the practical consequences involved in the constitution of salts deserves a moment's attention. It follows that a great variety of changes may be going on in the soil, and in the manures which we use. In most soils there is an abundant store of minerals, which if well managed may be made gradually available to plants, if ill managed may either be locked up in an inert state or washed away by rain. In like manner some of the elements of manure are volatile, and will soon escape in the absence of the precaution needed to fix them, that is, to retain them in the solid or the liquid state. But the proper securing of these materials depends on a practical application of the properties of salts which may either be volatile or fixed, either soluble or insoluble, according to the chemical proportions in which they may happen to be combined, or to the circumstances under which they may be allowed to decompose."

From the organic and inorganic elements plants are formed, says Baron Liebig, by the "vital process, when the atmosphere and soil supply them at the same time in suitable quantities and in the proper proportions. The atmospheric elements do not nourish without the simultaneous action of the elements of the soil; and the latter are equally valueless without the former. *The presence of both is equally required for the growth of the plant.*" From what we have given it will be evident that there is in nature no such division or distinction between the parts of a plant as the "organic" and "inorganic," both being absolutely indispensable to its full development, it being formed or made up of certain constituents of the air and water, these being present in large quantities, and of certain constituents of the soil, these being present in small quantities. The division then of "organic" and "inorganic" substances of plants, is simply made for the purposes of convenient classification.

We have thus seen that the plant derives its nutriment at once from the soil and the air; the questions, therefore, naturally arise at this stage of the investigation, to what extent can we draw this nutriment from the soil? and to what extent can we derive it from the atmosphere? The answer to these questions has given rise to a discussion which for years agitated, and still agitates the agricultural world, concerning the value or truth of Liebig's and Lawes' doctrine or principles of manuring.* "The practical question at stake in this controversy" is thus stated briefly by Mr. Acland:—

"1st. *As to wheat;* the followers of Lawes maintain that nitrogen is the true food of wheat (whether as ammonia or nitric acid), and that phosphates do not increase the crop.

"The followers of Liebig maintain that certain minerals, and especially phosphates for the seed, silicates for the straw, are the true manures for wheat.

"2ndly. *As to turnips;* the followers of Lawes maintain that in the case of turnips ammonia only increases the leaf, but that a special addition of phosphate is necessary to increase the root, even although there may be a considerable supply of phosphate in the land already."

On this point Liebig shall speak in his own words. "It is impossible to believe that the effect . . . . can

* A *resumé* of the different theories of manuring which have been promulgated from time to time will be found in the companion volume, "Historical Outlines of Farming and Farming Economy."

have depended on the newly-added phosphoric acid, as Mr. Lawes concludes." Again, "It is out of the question, after the facts now related, to assume that the excess of the phosphoric acid was necessary, or was the cause of the increase."

The controversy has arisen out of the views promulgated by Professor Liebig, in which he insists upon the importance of the "mineral constituents of the soil, or of manure supplied to it, maintaining that the ammonia and carbonic acid are supplied from the air." Thus he says, the "crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in the manure." Again he says, "If these mineral elements are present in sufficient quantity, and in appropriate proportion, the soil contains the conditions which render *the plant* capable of absorbing carbonic acid and ammonia *from the air.*" . . . . It must, he says, be the principal task of the agriculturist to "supply and restore *all the elements required in the soil, and not only one,* as is so frequently done: the ingredients *of the air,* carbonic acid and ammonia, the plants can in most cases procure without man's interference." Then again, as between the value of mineral and nitrogenised manures, Liebig maintains that, when "the ammonia is absent from the manure, the plants extract their nitrogen from the ammonia of the air." Again, "The supply of ammonia is unnecessary for most of our cultivated plants, and it may even be superfluous, if only the soil contain a sufficient supply of the mineral food of plants, when the ammonia required for their development will be furnished by the atmosphere." Again, "Ammonia is necessary as food to all plants; but a supply of it *in manure* is not useful to all cultivated plants."

On the other hand, as opposed to these views, the experiments of Mr. Lawes showed that "in the ordinary cultivation of the land, the *nitrogen,* and *not the minerals,* would generally be found deficient." Mr. Lawes does not hold that the mineral constituents can be dispensed with; on the contrary, he quite agrees with what he calls "so evident a truism," that they are essential; but he believes that ordinarily they exist in the soil in abundance, relatively to other constituents. Yet, notwithstanding this abundance, "the main valuable products of the farm in *cereal grains,* are utterly incompetent to yield a full agricultural crop, unless there be specially provided *within the soil itself* a liberal supply of available nitrogen, normally the atmospheric food of plants."

This is not the place to enter into all the details of the controversy. A pretty full *resumé* of it will be found in the companion work, "Historical Outlines of Farming, and Farming Economy, Scientific and Practical." According to Dr. Daubeny there is probably little real difference of opinion between Lawes and Liebig. "In so far, indeed," says this authority, "as relates to the relative advantages of mineral and ammoniacal manures, I presume there is little room for controversy, for although most soils may contain a sufficiency of the organic constituents required by the crop, it by no means follows that the latter are always in an available condition; and hence it may well happen that in most cases in which land has been long under cultivation, the former class of manures becomes, as Baron Liebig asserts, a matter of paramount necessity. Now that the same necessity exists for the addition of ammoniacal manures can hardly be contended, when we reflect, that at the first commencement of vegetable life every existing species of plant must have obtained its nourishment solely from the gaseous constituents of the atmosphere, and from the mineral contents of the rock in which it vegetates.

"The only divergence of opinion, therefore, that can arise relates to the degree of their respective utility in the existing state of our agriculture, and to the soundness of Baron Liebig's position, that a plant rooted in a soil well charged with all the requisite mineral ingredients, and in all other respects in a condition calculated to allow of healthy vegetation, may sooner or later be able to draw from the atmosphere whatever else is requisite for its full development. . . . . Still the practical question remains, whether, admitting the theoretical truth of Baron Liebig's position, a larger expenditure of capital will not be *required* for bringing a given farm into a condition to dispense with ammoniacal manures, than for procuring those materials which contain that ingredient ready for use. And here experimental researches, such as were conducted on so extended and liberal a scale by Mr. Lawes and Dr. Gilbert, and in aid of theory, stand as it were midway between the abstract principles which science points out to the farmer, and the traditional usages with respect to his art which have been handed down from one generation to another."

So completely have the conclusions arrived at by Mr. Lawes been accepted by the great majority of practical farmers in Great Britain, that their chemical theory may be put in the words of Mr. Thompson,—"*Nitrogen* is the principal characteristic in a manure for *corn*, and *phosphorus* in one for *turnips*." The whole question, in its *practical* aspect, is so well put in a recent article in the *North British Agriculturist*, that we deem it likely to be useful to give it here :—

"It has been stated by Liebig 'that of all the elements furnished to plants by the soil, and ministering to their nourishment, the phosphate of lime, or rather the phosphates generally, must be regarded as the most important.' No one has directly questioned the soundness of this statement, although several have endeavoured to prove that the presence of the nitrogenous element in the soil was of equal, if not of greater, importance to the growth of the cultivated plants, particularly those raised for their seeds. Experiments have shown the general correctness of this opinion, but these experiments have not upset the soundness of Liebig's statement, that the phosphates are the most essential for plant life. When the nitrogenous element is applied to the growing cereal grasses, the effects are most marked; but the action of the nitrogenous element is dependent upon the presence of the phosphates in the soil, and which must be present in sufficient quantities for the wants of the crop, otherwise the seeds are not formed. Plants obtain nitrogen from the atmosphere as well as from the soil, while the phosphates are alone furnished by the soil; and they must always be present to secure a healthy vegetation. The phosphates contained in the soil may have been furnished by manures previously applied to preceding crops, or may have existed in the soil previous to its cultivation, and hence the application of the nitrogenous manure was all that was required to produce a luxuriant growth of the grain-yielding crop. The frequent repetition of nitrogenous manures would necessarily exhaust the soil of the phosphates, and produce a partial sterility —were such a course of manuring long pursued. The practice of applying phosphatic manures, such as guanos, bones, super-phosphates, to the green crops, apart from the phosphates returned to the soil in the farm-yard manure, tends to maintain the balance; and the application of nitrogenous manures to the cereal grasses grown during the rotation is all that is required to raise full crops.

"With regard to the phosphatic manures properly so called, it is generally admitted that in cultivating what are termed root crops the application of a manure containing the phosphatic element is essential for the full maturing of the crops. It is found that the action of the phosphatic manure is increased when there is present in the manurial application a certain amount of the nitrogenous element, and also in some cases of the alkaline element—the presence of the nitrogenous element tending to produce a rapid growth at the earlier stages of plant life. For instance, a manure containing a certain portion of organic matter, capable of yielding nitrogen, or of nitrogen present in the form of a nitrate or sulphate of ammonia, produces a much more rapid growth of the leaves than when a purely phosphatic manure has been applied, which development usually tends to hasten the formation of the tubers or bulbs. An excess of the nitrogenous element in the manure not unfrequently causes a too great development of the leaves, to the injury of the tubers or bulbs, both as to size and nutritive qualities. Hence the importance of studying the requirements of the crops, and the condition of the soil, with the constituent elements of the manures.

"Manures which furnish the nitrogenous and the phosphatic elements in the forms most readily assimilated by the plants are usually the most profitable to apply; the profitableness being chiefly dependent upon the immediate returns."

Mr. R. Russell, the editor of the "Highland Society's Transactions," an authority in points connected with advanced agricultural science, as well as farm practice, has expounded views on plant life and manures which are worthy of the earnest consideration of all agriculturists. Thus, on the *dictum* already alluded to, "phosphorus (phosphates) for the turnips, nitrogen (ammonia) for the corn," he points out the influence of the season on their action, as here particularised. Thus, in summer the supply of ammonia *in the manure* is not so necessary to plant life as it is in early spring, inasmuch as it would appear that in summer, when the temperature is high, the amount of ammonia *in the air* is greater than when the temperature is low, as at spring; and further, that the leaves of plants have at this period greater powers for the absorption of ammonia *from the air.* Phosphates also appear to be more beneficially applied to plants in the summer, or late in the season, than when applied early. From these facts Mr. Russell draws this *dictum,* "ammonia for spring, phosphates for summer." Again, Mr. Russell, while agreeing with Liebig as to the atmosphere being a source of carbonic acid and ammonia, points out that plants differ materially in their power to absorb ammonia from the atmosphere: annuals draw less from the air than perennials. But the same is not true as regards the soil: the reverse is the case—annuals drawing most from, or exhausting the soil; perennials drawing less from, and in fact improving the soil, by bringing to it a supply of fertilising matter, in consequence of their longer growth and hold upon the soil, and the decay of their roots and leaves on it adding to its mass of organic matter. From these facts is deduced the rule that annuals succeeding annuals, as turnips, mangold, and the like, are liberally manured with manures rich in ammonia. Again, perennials, although exhausting the land less than annuals, have nevertheless greater facilities for withdrawing fertilising matters from the soil than those possessed by annuals; thus perennials, grass and clover, do not as a rule require phosphatic manures, for being sown thick, and remaining *for a comparatively long time in the soil, they send* out abundance of roots, so as to draw their supply of phosphates from it. But an annual, as the turnip, requires abundance of phosphates in the manure applied to it, as there is a very small quantity in the seed. Further information on the interesting points here involved, will be found in the companion work, "Historical Outlines of Farming and Farming Economy."

SECTION II.—VARIETIES AND PECULIARITIES OF MANURES.

From the following list, given by Dr. Voelcker, the reader will have some idea of the numerous substances useful for manurial purposes. In this list, Dr. Voelcker follows the arrangement of Stockhardt, the German chemist, in his work, "Chemical Field Lectures." This arrangement is made "according to their action and composition, in an order which begins with the most powerful, and ends with the weakest manure. Some of the materials occur under several heads, which is an indication that they contain more than one chemical compound, and therefore act in more than one way."

1. *Nitrogenised Manures (forcing Manures).*

a. Substances containing ammonia (very quick-acting manures).
  Ammoniacal salts.
  PERUVIAN GUANO, soot.
  Putrid and animal substances; for instance, blood, flesh, wool.

Ammoniacal water of gas-works.
Putrid urine, putrid liquid manure.
SHORT DUNG, particularly sheep and horse dung.

b. Nitrogenised matters which pass easily into putrefaction (tolerably quick in their action).

Horn shavings, glue.
BONES, dissolved, steamed, or finely-powdered.
OIL-CAKES of all kinds, malt-dust.
Fresh urine, fresh liquid manure.

c. Nitrogenised manures, which decompose with difficulty (slowly-acting forcing manures).

Half-inch bones.
Woollen rags.
LONG DUNG.

d. Substances containing nitric acid (quick-acting forcing manures).

Saltpetre.
Chili saltpetre (*nitrate of soda*).
Nitre earth.

2. *Carbonaceous Manures* (*Humus forcing Manures*).

COMMON FARM-YARD DUNG, straw, leaves of trees, &c.
Sawdust, green manures.
Peat, or vegetable remains of all kinds.

3. *Manures containing much Potash* (*strongly-forcing Manures.*)

Potash, nitre, malt-dust.
Urine, wood ashes.
Leaves, and green manures.
Road scrapings, compost.
Burnt clay, some kinds of marl.

4. *Manures containing principally Soda* (*less effective Manures*).

Common salt.
NITRATE OF SODA, urine.
Several minerals.
Soap-boilers' refuse.

5. *Phosphatic Manures* (*Grain or Seed forcing Manures*).

Burnt bones, animal black, refuse of sugar manufactories.
Phosphate, apatite, coprolites.
Saldanha Bay guano.
Fresh bones, bone dust.
ALL SORTS OF GUANO.
Animal matters of all description.
Oil-cakes, malt refuse.
HUMAN EXCREMENTS, FARM-YARD MANURE.
Urine of carnivorous animals.
Wood ashes, straw, leaves, &c.

6. *Manuring Matters containing Sulphuric Acid (partly Manures themselves, partly Fixers of Ammonia).*

Gypsum, sulphuric acid.
Green vitriol.
Coal ashes, peat ashes.

7. *Calcareous Manures.*

Burnt lime, chalk marl.
Gypsum, coal and peat ashes.
Road scrapings, gas lime.

8. *Siliceous Manures.*

Coal ashes, peat ashes.
Farm-yard manure, sand, straw, &c.

It is of course impossible, in the short limits of the present treatise, to give a description of the peculiarities of all these manurial substances. We can only find room to do this for the most important of these. The first to which we direct the reader's attention is *Farm-yard Manure.* This is the most important of our manures, *containing, as it does, all the fertilising constituents* essential to the growth and fructification of plants. It is made up of the excretæ—liquid and solid —of the animals of the farm, and of the straw or litter on which they are bedded, or which is supplied to them in the court-yards. The formation of manure through the excretæ of the animals is a beautiful exemplification of the adaptation of one part of the economy of animal and vegetable life to another. The nitrogenous compounds of the plants partaken of by animals go to form flesh and muscles, and are finally passed from the animal in the shape of manure, which, again applied to the soil, yields up the constituents which form the nitrogenous parts of plants. The constituents are alike in both, only they differ in the plant and in the animal as regards their combination. The non-nitrogenous compounds of food are given back to the atmosphere through the lungs or through the skin, and again are taken up by the plants. Thus the circle of changes and operations is complete. The following is an analysis of fresh and well rotted dung, as given by Professor Tanner in the Journal of the Bath and West of England Society :—

	FRESH.		WELL ROTTEN.		Price.
	Number of lbs. in each Ton.	Value.	Number of lbs. in each Ton.	Value.	
		s. d.		s. d.	*Per lb.*
Water	1482¼	—	1689¼	—	
Soluble organic matter .	55½	2 0	83	4 0	ammonia 6*d.*
,, inorganic matter :—					
Soluble silica . . .	5¼	0 0	5¾	—	
Phosphate of lime . .	6¾	0 5	8½	0 6½	¾*d.*
Lime	1½	—	2½	—	
Magnesia	¼	—	1	—	
Potash	12¾	3 3¾	10	2 9	3$\frac{3}{10}$*d.*
Soda	1¼	—	½	—	
Chloride of sodium . .	¾	—	¾	—	
Sulphuric acid . . .	1¼	—	1¼	—	
Carbonic acid and loss .	4¾	—	2¾	—	
Value of soluble matter	—	5 8¾	—	7 3½	
Insoluble organic matter	577	6 9	287¼	4 3	ammonia 6*d.*
,, inorganic matter :—					
Soluble silica . . .	21¾	—	32	—	
Insoluble silica . . .	12½	—	22½	—	
Oxide of iron and phosphates	13¼	0 6½	21¼	0 8¾	bone earth ¾*d.*
Lime	25	—	37½	—	
Magnesia	3¼	—	2	—	
Potash	2¼	0 7½	1	0 3¼	3$\frac{3}{10}$*d.*
Soda	½	—	¾	—	
Sulphuric acid . . .	1¼	—	1½	—	
Carbonic acid and loss	10¾	—	29	—	
	2240	7 11	2240	5 3	
Value of insoluble matter	—	7 11	—	5 3	
Value of soluble matter	—	5 8¾	—	7 3½	
Total value of a ton of manure	—	13 7¾	—	12 6½	

The fertilising ingredients of farm-yard manure bear but a very small proportion to the whole mass. Thus, in 20 cwt. of well rotten dung there are 15 cwt. of water, 4 cwt. of other materials, and only 47¾ lbs. of fertilising ingredients. Hence one of the objections which have been made to farm-yard dung—the expense of moving so much dead weight of matter with so little of manurial value. But this bulk is just one of the advantages possessed by farm-yard manure, as it exercises a beneficial *mechanical action* in light soils by binding them together, and in heavy soils by loosening them.

As a rule, the methods in use for the saving and treatment of farm-yard manure are characterised by great wastefulness, and a thorough ignorance of, or at least indifference to, the principles which should regulate them. Dr. Voelcker has fully investigated the subject, and has published the results of his investigation, so that farmers have no longer the excuse of ignorance of the scientific truths of the subject to justify their wasteful neglect of this most precious mainstay of the farm in keeping up the fertility of its fields. The conclusions to which the experiments of Dr. Voelcker lead are in the words of Dr. Anderson, another able chemist, who has himself done no little towards teaching farmers how to save and treat farm-yard manure:—

"Farm-yard manure in its fresh state contains but a small quantity of ammonia, most of its nitrogen being there as insoluble nitrogenous matters. But as the decomposition advances the ammonia increases, and a quantity of organic matters becomes soluble. For this reason the manure should be preserved in such a manner as to prevent the escape of the soluble portions, which are the most valuable. This can be effected by keeping it in water-tight pits, or under cover; but, in the latter case, the manure, particularly if it contains a large proportion of litter, is not sufficiently moist to admit of its ready fermentation, and water must be added in sufficient quantity to promote that change. The worst of all modes of keeping manure is to pile it in heaps in the corners of the fields, for under such circumstances it is most liable to loss; and if the manure must be carted out, it is better to spread it upon the soil at once, because, when this is done, fermentation is stopped, and as there is very little free ammonia, the loss is small, and the soluble matters are uniformly washed into the soil by the rain. Dr. Voelcker is of opinion, that the most advantageous mode of applying the manure would be in all cases to leave it on the surface to be washed into the soil, by which means its distribution is more uniform than if it be ploughed in. The most disadvantageous mode of making manure is to produce it by cattle in open yards, for in this way at least two-thirds of the valuable matters are lost after a year's exposure."

It is right, however, here to note that Dr. Voelcker's opinion, that it is more advantageous to spread the manure on the surface than to plough it in, is directly at variance with what may be called the general or universal practice amongst farmers. Nor is the opinion held by many other chemical authorities. It is evident that, to obtain the advantages of the "washing in" which Dr. Voelcker deems advisable, rain must follow the application of the manure to the soil; if it is applied, and rain does not follow, the loss of ammonia is almost inevitable. Dr. Voelcker, it is true, maintains that farm-yard manure contains but "a mere trace" of ammonia in a free state, or in those readily formed salts which can be easily dissipated; and that during fermentation the total amount of nitrogen suffers but little diminution. Both these opinions are controverted by other authorities. It seems to us that if the practice of allowing farm-yard manure to lie exposed in a dung-pit, or of making manure in open yards, is unsound, the practice of allowing it to lie spread out on the soil must be unsound also, even although, as Dr. Voelcker maintains, farm-yard manure deteriorates by exposure to the air, not because its ammonia is dissipated in the air, but because the soluble matters are washed out by the rain. It seems doubtful whether the ammonia is retained, as Dr. Voelcker maintains it is; we know that we can smell the evolving gases of a manure heap, and this smell is evidence of the escape of either carbonate of ammonia or of sulphuretted hydrogen—both fertilisers. The practice, therefore, of ploughing in the *manure, as generally obtaining amongst farmers, may* therefore be set down as the correct one; but, general as it is, it is but right to state that some farmers adopt the contrary method. Generally, the opinion is in favour of ploughing the manure in at once. Certainly, if to expose manure in the farm-yard is bad, it cannot be good to expose it in the field—at least, reasoning from analogy, it would appear so. Doubtless the fertilising matters are washed into the soil, where they are needed, in the one case; and in the other, they are absorbed by the yard, where they are not. The loss, if loss there is, arises from the evaporation of the ammonia. Dr. Voelcker thinks the loss is trifling, as there is but a "mere trace" of free ammonia in farm-yard manure. But, as Mr. Baldwin, of Glasnevin Agricultural School, well and suggestively points out, although it is a "mere trace," still, in the large bulk used, the value of the ammonia amounts to no small sum. Thus, "in 20 tons of fresh farm-yard manure we have 15 lbs. of free ammonia at 6*d.* per lb. This comes to 7*s.* 6*d.*" This, if really lost through spreading the dung on the field, may well be called a "crushing tax per acre" to the farmer. The whole question of the best mode of treating and using farm-yard manure is in a transition state, and requires yet to be closer and more comprehensively investigated before the points now disputed in connection with it can be considered definitively settled. But in this department, as in others connected with the practice of agriculture, there are so many modifying influences of soil, climate, and locality, that it is difficult to lay down rules applicable to all cases. The farmer must study the peculiarities of his own, and looking carefully out for the lessons which nature may teach him, decide upon a practice fitted to apply to it. Having referred to the escape of carbonate of ammonia from dung-heaps, we may notice here a simple, efficacious, and cheap method of saving or fixing this valuable fertiliser, as recommended by Mr. T. C. Fletcher, in his "Scientific Farming made Easy." It is simply by mixing 1 cwt. of sulphate of iron (common green copperas) with 100 gallons of water, moistening sawdust with the liquid, and spreading this on the floor of the stable, cow-house, piggery, &c. The carbonate is changed by this into a sulphate of ammonia; and the matter obtained, adds to the value of the dung-heap.

Whether the dung-heap should or should not be under cover, is one of the vexed questions connected with the treatment of manure; the weight of scientific evidence is certainly in favour of the covered dung-stand, and the practice of modern farming is gradually, if slowly, approaching the same point. Lord Kinnaird instituted a series of experiments to decide which of the two manures were most valuable—that made in the open-air old-fashioned mode, or that under cover; the result was decidedly in favour of the covered manure. A field of potatoes was manured in one part with the manure taken from a "covered," and in another part with manure taken from an "open" or exposed dung-heap; the produce of potatoes being determined, the whole of the land was then sown down with wheat, and top dressed in spring with 3 cwt. of Peruvian guano per acre. The final results were as follows:—

	Uncovered manure.	Covered manure.
Potatoes	*7 tons* 12 cwt.	11 *tons* 15 cwt.
Wheat grain	42 bushels	54 bushels.
Wheat straw	156 stones	215 stones.

The preservation of the fertilising properties of manure has not had the attention paid to it which its importance deserves. Payen instituted experiments which showed that by mixing *fresh* dung with lime, loss of ammonia is prevented. Two per cent. of lime will be sufficient. His experiments showed the importance of mixing the lime with the dung while *fresh*, for if added to putrid dung the mixture was prejudicial rather than beneficial. But if covered dung-stands are not adopted, it certainly is wretched policy on the part of the farmer to follow up the wasteful method of storing up dung—too often witnessed in this country—exposed to the atmosphere, and the valuable liquid which exudes from it allowed to run to waste, if not, as in some instances which have come under our notice, led off by drains, specially made, to some ditch or sewer. The following is a description of Mr. Lawrence's mode of managing the dung-heap, as given in his little manual entitled "Handy Book for Young Farmers."*

* Longman. 2s. 6d.

"Some three or more spots are selected, according to the size of the farm, in convenient positions for access to the land under tillage, and by the side of the farm roads. The sites fixed on are then excavated about two feet under the surrounding surface. In the bottom is laid some three or four inches of earth, to absorb any excess of moisture. The manure is evenly spread and well trodden as the heap is forming. As soon as this is about a foot above the ground level, to allow for sinking, the heap is very gradually gathered in, until it is complete in the form of an ordinary steep roof, slightly rounded at the top by the final treading. In the course of building this up, about a bushel of salt to two cart-loads of dung is sprinkled amongst it. The base laid out at any one time should not exceed that required by the manure ready for the complete formation of the heap as far it goes; and *within a day or two after such portion is built up, and* it has settled into shape, a thin coat of earth, in a moist state, is plastered *entirely* over the surface. Under these conditions decomposition does not take place, in consequence of the exclusion of the air, or at any rate to so limited an extent that any ammonia is absorbed by the earth, for there is not a trace perceptible about the heaps.

"When heaps thus formed are resorted to in the autumn, either for the young seeds or for ploughing in on the stubbles after paring for the succeeding root crop, the manure will be found little diminished in quantity, and unimpaired in quality—in fact, simply consolidated. Decomposition then proceeds within the soil, where all its results are appropriated and rendered available for the succeeding cereal as well as the root crop.

"It would be inconvenient to plaster the heap, were the ridge, when settled, above six or seven feet from the ground level; the base may be formed about ten to twelve feet wide, and the ridge about nine feet above the base, which settles down to about seven feet; this may be extended to any length, as further supplies of manure require removal. One man is sufficient to form the heap; and it is expedient to employ the same man for this service, who soon gets into the way of performing the work neatly and quickly. We have been asked where a farmer is to get the earth to cover his heaps. It may be answered, keep your roads scraped when they get muddy on the surface during rainy weather—in itself good economy—and leave this in small heaps beyond the margin of your roads. This, in the course of the year, will be found an ample provision for the purpose, for it is unnecessary to lay on a coat more than one or two inches in thickness, which should be done when in a moist state. The soil left on cleaning the roots for the stock at the stores will contribute much for this purpose. Farmers who have not been in the habit of bestowing care on the manufacture and subsequent preservation of their manure, and watching results, have no conception of the importance of this."

Much has been written about the value of manure obtained from the stock, and somewhat elaborate calculations have been made to show the value of the manure obtained from feeding cattle on different varieties of food, the assumption being that a certain fraction of the food remains in the manure—as for instance, 33 per cent. of linseed or oil-cake. The warning, however, of Dr. Anderson, chemist to the Highland Agricultural Society of Scotland, is worthy of being remembered—that the farmer will be safer if he places no positive reliance on these assumptions, and simply calculates the expenses of feeding, irrespective of the manure heap; if a profit results, good and well; if not, the loss is at the cost of the manure; and it should be his object in such a case to see that this cost does not exceed that for which farm-yard manure or artificial manures can be purchased elsewhere.

There are two theories held at present on the subject of farm-yard manure, namely, that propounded by Liebig, which maintains that its value depends "most undoubtedly on the amount of the incombustible ash-constituents of plants in it, and is determined by these;" and that propounded by Boussingault and Payen, which maintains that manure is "more valuable in proportion as the quantity of nitrogenous organic matter is greater than the non-nitrogenous organic matter." In other words, that the quantity of nitrogen determines the value of the manure. The view as to the value of the nitrogen in manure is that generally held in this country. In the last number (49) of the "Journal of the Royal Agricultural Society of England," there is given an extract from an unpublished pamphlet of Mr. Lawes, in which we find some interesting information as to the amount of nitrogen contained in farm-yard manure. Mr. Lawes supposes the case of a 400 acre farm cultivated on the four-course rotation, in which half of the roots and 100 tons of hay are consumed on the farm, and the whole of the straw of the barley, 2,500 lbs., and wheat-crop 3,000 lbs., retained for food and litter; in addition to these, 43,800 lbs. of oats are consumed by 12 horses, and 20 tons—10*s*. per acre—of oil-cake (linseed, rape, and cotton seed) are consumed by feeding stock. The following table shows the composition of the 855 tons of fresh undecomposed dung obtained from the farm under the above circumstances:—

	Total dry matter.	Total mineral matter.	Phosphoric acid reckoned as phosphate of lime.	Potash.	Nitrogen.	Nitrogen calculated as ammonia.
Per cwt.	30·0	2·77	0·50	0·53	0·64	0·77
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Per ton	67·2	62·0	11·1	12·0	14·3	17·3

"But farm-yard manure undergoes very considerable diminution by decomposition, and especially when carted out and formed into clumps. Hence the land would not receive so large a quantity of matter as has been above estimated. The amount of organic matter diminishes very considerably, and in rotten dung the proportion of water is generally higher than above supposed. It also frequently happens that both mineral matter and nitrogen are allowed to go to waste by drainage or other mismanagement. Otherwise, as the organic matter diminishes, the amount both of mineral matter and of nitrogen should increase in proportion to a given weight of the manure.

"The composition and value of the manure is also very dependent upon the quality of the food consumed by the animals that help to produce it. Thus if the same amount of dung had been produced from the same materials above-mentioned, *excluding the* 20 *tons of oil-cake,* the yard of manure would have contained 2,185 lbs. less of nitrogen, equal to 2,653 lbs., or considerably above a ton, less of ammonia; and every ton of the dung would have contained nitrogen equal to only about 17¼ lbs., instead of about 17¼ lbs. of ammonia. In the one case, the dung would be called poor, and in the other, the farmer might congratulate himself on having a yard of moderately good dung. Yet the whole weight of dry substance added by the oil-cake to each ton of dung, would only be about 11 lbs., a quantity which is so small, that neither the man that loaded the cart, nor the horse that drew the dung to the field, would detect it. If 70 tons instead of 20 tons of oil-cake had been employed with the same amount of litter, only about another 11 lbs. of dry substance would be added to each ton of the manure, but the yard of manure would then be equal in quality to rich box dung. In fact, the consumption of £700 worth, or about 70 tons of cake, would only add about 10 tons of dry substance to the manure-heap, whilst the weight of Peruvian guano obtained for the same money would be about 30 tons.

"It is quite immaterial to the growth of the crops whether the additional amount of nitrogen be purchased in the form of oil-cake, and so supplied to the land in the farm-yard manure, or whether it be purchased and applied in the form of artificial manure, provided only that the requisite mineral constituents are not wanting. It is also a matter of indifference to the crops whether the necessary mineral constituents are supplied in the form of the excrements of animals, or of artificial manures. The question is entirely one of economy, depending chiefly on the relative prices of meat and corn, and of cattle foods and artificial manures."

At one period in our agricultural history, so little was known on the subject of farm-yard manure, that all kinds, no matter how produced, were considered of equal value. It was reserved for recent times to show that farm-yard manure was greatly increased in value by giving the animals which produced it highly nitrogenous food. This was clearly proved by the experiments of Wolff (1853), which enabled the proportion of the price of the food to be laid to the manure. Thus, where sheep are fed upon rape cake, and so fed that no great increase of weight takes place, he found that five-sixths of the whole nitrogen of the food and fodder was found in the dung. While five-sixths of highly nitrogenous food of sheep are found in their dung, seven-eighths are found in the dung of cattle. Mr. Lawes has still more recently published a table, which we here give, with his introductory remarks, showing the value of the dung produced by various foods. (See last par. in p. 53.)

"The valuation of the manure resulting from the consumption of different foods is founded upon estimates of their composition, and upon a knowledge, experimentally acquired, of the probable average amount of those constituents of the food valuable for manure, which will be obtained in the solid and liquid excrements of the animals. The following table, founded on these data, gives the estimated value of the manure obtained from the consumption of one ton of different articles of food, each supposed to be of good quality of its kind:—

	£	s.	d.		£	s.	d.
Decorticated cotton seed cake	6	10	0	Indian corn	1	11	6
Rape cake	4	18	0	Malt	1	11	6
Linseed cake	4	12	0	Barley	1	9	6
Malt-dust	4	5	0	Clover hay	1	5	0
Lentils	3	17	0	Meadow hay	1	0	0
Linseed	3	13	0	Oat straw	0	13	6
Tares	3	13	6	Wheat straw	0	12	6
Beans	3	13	6	Barley straw	0	10	6
Peas	3	2	6	Potatoes	0	7	6
Locust beans	2	2	6	Mangold	0	5	0
Oats	1	14	6	Swedish turnips	0	4	0
Wheat	1	13	0	Common turnips	0	4	0
				Carrots	0	4	0

Liquid Manure, Town Sewage, Night-Soil.—These are all important auxiliaries of the manure heap. As the two former will be described, and all the vexed questions connected with them fully discussed in the volume under-noted,* we pass on to a brief consideration of night-soil, or human excretæ. Little need be said here about this rich but singularly neglected fertiliser further than that its use has been greatly narrowed through the difficulty of deodorising it. The most complete method yet introduced, and by far the simplest and cheapest, is that discovered by the Rev. Mr. Moule, and of which the following is a brief description :—

"The greatest, and in most cases the only, agent in this mode is dried surface earth, the extent of the capabilities of which, both for absorption and for deodorising offensive matters, I accidentally noticed about seven months ago, and the truth and correctness of which observation has been proved by daily experience. I have also ascertained that various subsoils, especially clay and silicate of alumina, are equally efficacious as deodorisers, and the latter produces a more valuable manure."

We have tested this mode of deodorising night-soil on a pretty extended scale, and have found it as simply carried out as it is efficacious. Not the least valuable feature connected with the plan is the repeated applications of night-soil to the quantity of dried earth or soil originally employed. Thus a portion may be deodorised, and after it is allowed to lie for some time, another portion may be added, and this will be found to be deodorised as perfectly, to all appearance, as the first portion. We have not yet discovered the limit of deodorising power of the earth used.

* "Irrigation, Utilisation of Town Sewage, Reclamation of Waste Land," forming one of the Rudimentary Treatises.

Next in value to the farm-yard manure is the *Compost Heap*. It is remarkable how much this obvious mode of making a supply of excellent manure is neglected. In the "litter" as it is expressively called, which abounds in every farm-yard, and in the neighbourhood of every farm-house, in the weeds which abound in nearly every farm field, in the "thousand and one" things which are out of place and valueless, and, worse than valueless—offensive—there is a store of fertilising matter which should be taken advantage of, and can only be taken advantage of by means of the compost heap. We do our readers a service by giving here a description of Dr. Bicknell's mode of managing a compost heap; and, as supplementary to it, Professor Skilling's mode of making a supply of what he calls "stimulating manure" out of the waste and refuse of farms:—

"The first thing," says Dr. Bicknell, "is to secure a wide-spreading roof, to prevent the wash of the rain, and the consequent solution and removal of the saline ingredients. Under this roof must be accumulated vegetable refuse, weeds, leaves, turnip-tops, stubble, ditch scourings, &c., and loamy, porous soil (the more porous the better), road scrapings, old mortar, old cob wall, &c., the earthy and vegetable matter being in about equal proportions by bulk. They should be spread about three feet in depth, thoroughly mixed, and well watered with liquid manure. In the course of two or three weeks salt should be added in the proportion of 1 ton to 20 tons or 30 tons of compost; and at this time also material containing lime, but not in a caustic state, forms a useful addition. Lime ashes spread about and exposed for some days, being watered, or old mortar, is the readiest way in which it can be used. After these materials have been well mixed in, the mass, which will have shrunk considerably, must be made into long parallel heaps, about 3 feet high and 7 feet wide, with a small space between each; and thus they must lie watered from time to time with liquid manure or prepared gas-liquor, and moved from time to time with the fork (to maintain their porosity and supply them with fresh air) for eighteen months, or thereabouts, when the principal portion of the chemical changes will have been effected, and the heap will be ripe for use. The more the heap is moved the better, for by frequent motion alone can its porosity be maintained, and the contact of air with the decayed particles of matter. Its movement will form useful occupation for farming men in bad weather, but it should never be neglected too long at a time. In watering it with liquid manure, urine, or gas-liquor, care should be taken not to make it too wet, as that condition is adverse to porosity. The great object to be kept in view in its management is to maintain the constant contact in every part of the mass of air and water, of decaying vegetable matter, and the chemical materials. The prepared gas-liquor may be used at two or three different times; it should be added at least in the proportion of one hogshead to five tons of compost; it will not be easy to add too much of it. The texture of the material should be kept in the condition of moistish brown sugar. Managed in this manner the material will be in a state to supply any crop with all, or almost all, the food required by its roots. To feed the cereal crops it may, however, want one thing, viz., the phosphoric salt. Now there is no cheap source for these most important constituents; they must be supplied either by the addition of super-phosphate of lime, or other known substances containing phosphoric acid."*

The following is from Professor Skilling's work on "Turnip Culture."†

"We have a pit by itself, independent of the general farm-yard pit, for its reception. This pit communicates with, and receives any excess of liquid that may escape from, the large pit; also with the scullery, kitchen, water-closets, &c., &c., receiving everything in the form of manure that is valuable and useful. Into this also is poured, as well as the necessaries connected with it, all ashes from the fires, in many cases from consumption of materials, turf on farm or in the bogs, all sweepings of the houses and yards. It may be mentioned here that all kinds of ashes are perfectly grateful to the turnip. We sometimes add dry peat-mould as the best deodoriser. We use this in the poultry-houses, pig-yards, &c., and when fully saturated add to our heap. All green weeds from farm and garden, before seeding, are likewise added, and, in fact, every vegetable and animal substance that will decompose in time, as the greater the number and variety of substances the better the manure. Occasionally, also, we purchase some town manure from private and cottier houses; this is an excellent addition. All this we collect up to the following spring, when decomposition has made great progress, and the heap is one dark, rich mass. As soon as dry weather sets in—during February or March—we have the pit cleared out, the contents spread in a yard with hard dry bottom, and if the weather be favourable, with frequent turning, it will be dry enough and ready for riddling or

* "Journal of Bath and West of England Society," vol. for 1855.
† Robertson, Dublin. 6d.

screening in ten days or so. This we have carefully done, returning the coarse riddlings to the general dung-heap, and carefully storing the fine stimulating manure in sheds or houses for the purpose, to keep it from wet, and allowing it to remain there until required for use."

Lime.—This mineral is highly valued and extensively used as a manure. It is a constituent of all plants. It is not only useful as a direct manurial agent, but its influence is marked in altering the condition of matters in the soil which are either inert or prejudicial to plants, making them in the former case assimilable, or in the latter destroying their bad peculiarities; hence it is the first agent in giving fertility to boggy, peaty soils. A top-dressing of it to pastures greatly improves the crop of grass, and has a wonderful effect in clearing it of weeds. The proper time to apply it to old pastures is the beginning of winter, so that it may be well washed in before the spring growth commences. For the turnip crop lime is especially valuable—it is the only known "specific" for the disease to which the crop is now unfortunately so liable, namely, "finger and toe." Wheat and barley crops are also greatly benefited by the use of lime, as are also the bean, pease, and vetch crop. It has a wonderful effect on white clover, rye grass, and the natural grasses. Much of its beneficial action depends of course upon the nature of the soil to which it is applied, and of the materials, inert or noxious, which it contains.

In the working of heavy clay soils lime is very valuable. It not only has a chemical effect on them by bringing inert substances in the soil into a condition to be taken up as food by plants, but it has a mechanical effect also—lightening the soil and facilitating its working. A lime compost may be made by first placing a layer of lime, six or seven inches in thickness, spreading over this a similar layer of dung, and above this a second layer of lime, finishing with a layer of road scrapings or earth. If made in winter, it will be ready for mixing up and using for the turnip crop in spring. The addition of common salt to the mixture in the proportion of one bushel of salt to two of lime will add greatly to its value as a top-dressing for pastures, or as a manure for the turnip crop. While lime possesses valuable properties, it should be recollected that it is not meant to be used as a substitute for farm-yard manure; it is a special manure, so to speak, and should be used in conjunction with other manures. The time of their united application should not, however, be simultaneous. Lime should be applied for some time previous to the application of the other manures, to allow of its caustic properties being changed.

Salt.—This has long been used as a manure, but on superficial principles, and without understanding its action; hence its use has been in some cases attended with anything but beneficial results; now, however, that its proper action is being better understood, it is rapidly gaining in favour. For the Swede crop, and for all the *brassica* or cabbage tribe, for the mangolds, and for a top-dressing for meadows and pastures, it is very valuable. Its effects in getting rid of "couch" in lands infested with that pest is something remarkble. It is exceedingly useful for mixing with other manures, with dung, peat, coal ashes, ammonia, guano, nitrate of soda, &c.

In a recent letter to the *Mark Lane Express*, by the well-known writer on agricultural subjects, F.R.S., there are some interesting points touched upon in connection with the use of salt, of which he says few farmers know the use, and with its powers to destroy and revive we are alike unacquainted. F.R.S. states that being troubled in his grass land with a weed which no mechanical means could eradicate, he sowed it liberally with salt, which at once got rid of it. Deriving from this successful experience a hint to make further trial of its powers, he tried it for the purpose of getting rid of the weeds generally on his arable land. In autumn the fields intended for fallow received a heavy dressing of salt—the common refuse of the pans—quite twelve hundredweight. One field in which it was tried had long possessed the reputation for being infested with couch grass, and that worst and most troublesome species of it, the water-grass. Of this the writer graphically states that "hoe would not kill it, the twitch-rake would not gather it, and the children seeking it upon the surface after the harrow had left it exposed, usually secured half of it, and stamped the rest of it into the soil, to perpetuate its kind." But the salt, and the frosts of winter combined, conquered this troublesome enemy, "and when the first spring furrow was turned, the view," says F.R.S., "of the shrivelled enemy—the enemy which had baffled all my ingenuity and kept my exchequer low—was cheering indeed." The land thus treated received one or two furrows, to incorporate the salt with the soil, and at the proper time, and without further preparation, mangold was sown, which yielded a crop 25 per cent. heavier than ever before had grown on the land, even when it was manured with several loads of dung, and had an immense amount of labour bestowed upon it. The following year a change was introduced in the mode of treatment; just as the last furrow was turned, four hundredweight of salt was sown and well harrowed in, just before the mangold seed was dibbled. The crop was heavier and healthier than where the salt was applied in the autumn merely." We have ourselves used salt in conjunction with other manures with marked success.

Guano.—Next in importance to farm-yard is this now celebrated and extensively used manure. It is the accumulated store of the excrement of the sea birds which roost in countless numbers on the rocky islands of the almost rainless zone of the Southern Ocean. The following is an analysis of good Peruvian guano, as given by Dr. Anderson; it is freed from all unnecessary intricacy of detail, and states distinctly—what every analysis should possess—the per centage of ammonia in it:—

Water	13·73
Organic matter and ammoniacal salts	53·16
Phosphates	23·48
Alkaline salts	7·97
Sand	1 66
	100·00

Ammonia	17·00
Phosphoric acid in the alkaline salts = 5·42 phosphate of lime	2·50

Phospho-Peruvian Guano.—This is a manure recently introduced under the highest scientific auspices, and is likely to prove a highly valuable manurial agent. It is a mineral found in some of the West India Islands, very rich in phosphoric acid, which is found in it in a state more available for the use of the plants than it is in bone and other phosphatic manures. When brought to this country it is subjected to a chemical process with sulphuric acid, after which it is sold as phospho-Peruvian guano. Professor Voelcker has a very high opinion of it. He says, "phospho-Peruvian guano being much richer in phosphates, and not containing so much ammonia as to cause too luxuriant a development of leaves at the expense of the bulb, is much superior to Peruvian guano as a manure for turnips, Swedes, mangolds, and potatoes; and I have, indeed, no hesitation in expressing the opinion that, for root crops, the manure which I analysed is by far the most valuable fertiliser, whether natural or artificial, which as yet has been offered to the public."

It is said that the composition of phospho-Peruvian guano would seem to obviate all the objections ever urged against the free use of artificial manures, for it contains, in just proportions, all the ingredients requisite for the rapid and healthy development of our cultivated plants.

Bones, Superphosphate.—Bones, crushed, broken, or ground, have been for many years used as a top-dressing for pastures, in which they have a wonderfully renovating effect. This has been remarkably proved in the worn-out pastures of Cheshire, which have had a new lease of fertility given to them by the use of this material. Crushed bones were also used for the turnip crop. The fine discovery by Baron Liebig—to whom agriculture is so much indebted—for preparing a superphosphate of lime by dissolving bones in sulphuric acid, has however almost superseded bones used in their crushed or ground form as a manure for the turnip crop. A first-rate authority states that in his own experience he has found one bushel of superphosphate—made by dissolving bone-dust by a third of its weight of sulphuric acid—equal to *four* bushels of simple bone-dust. Superphosphate of lime is now made from "coprolites"—a phosphoric deposit, rich in lime—which are found in such abundance in Norfolk, Suffolk, and Essex. Superphosphate of lime made from this source is known in the market as "Lawes' Superphosphate," being manufactured by that celebrated chemist, to whose laborious and painstaking experiments in almost every branch of agriculture the farmer is so much indebted.

To secure good superphosphate made from bones the farmer should make it himself. The following is the method employed by a distinguished agriculturist, and described by him in his recent work, "British Husbandry."*

"A trough was prepared, 7 feet + 3' 4" × 2' 10", made of 2½ inch deal, strongly jointed, and secured at the corners by wooden pegs, as iron nails would be corroded by the acid. This holds conveniently 48 bushels of bones. The heap of bone-dust is then gone over with a barley riddle, and the small dust which passes through this is laid aside, to be used as a drying material for the other portion, after it is subjected to the acid. We find that a third part of the bone-dust passes through the riddle. Three bottles, or carboys, as they are called, of concentrated acid, averaging 180 lbs. each, are then emptied into the trough and mixed with cold water, at the rate of 1½ of water, by measure, to 1 of acid. In practice, the water is poured in first, and then the acid. Into this mixture 48 bushels

* A. and C. Black, Edinburgh. 12*s*.

of bones, previously measured and laid close to the trough, are rapidly shovelled by two labourers, who will do well to be attired in clothes and shoes past spoiling. So soon as the bones begin to be thrown in, violent ebullition commences. By the time that the whole of the bones are thrown in, there will be barely liquid enough to moisten the last of them. The labourers therefore dig down at one end of the trough till they reach the bottom, and then carefully turn back and mix the whole quantity until they reach the other end. The surface is then levelled and covered with a layer of the dry riddlings, two inches thick. In this state it is allowed to remain for two days, when the trough is emptied, and the same process is repeated until the whole quantity is gone over. When shovelled out of the trough the bones are found to have become a dark-coloured paste, still very warm, and emitting a sweetish smell. While one person throws it out, another adds to it its portion of dry riddlings, and mixes them carefully. This mass is heaped up in a corner of a shed, and augmented at each emptying of the trough, until the requisite quantity is obtained. After this the mass is carefully turned over several times, at intervals of five or six days, and is then dry enough for sowing, either by hand or machine. Some prefer moistening the bones with boiling water, and then adding pure acid as they are shovelled into the trough; but by first mixing the acid and water there is greater certainty of all the bones being equally acted upon. There is also great convenience in using the finest portion of the bone-dust for drying the other, as suitable material for this purpose is sometimes difficult to procure." It has been questioned whether the farmer should engage in the making of his own superphosphate. On this point, Mr. A. Sibson, author of a "Lecture on Superphosphates," has the following:—

"I should say, except under peculiar circumstances, certainly *not*, and for the following amongst other reasons: because it is impossible that it can be made so well on the small scale, by persons unaccustomed to the work, as on a large one by skilled hands; or, with the simple apparatus the farmer is able to provide, or to extemporise on the spot, as with the machinery and appliances found by experience to economise labour and improve the result. Again, in places where bones are to be had cheap, acid will generally be dear; indeed, the carriage of vitriol in small quantities is so expensive in consequence of the almost prohibitory rates charged by most of the railway companies for this article, that it can seldom be procured by farmers with advantage. At the present time especially, when so many excellent manures are to be purchased at reasonable prices, the practice of dissolving bones, formerly very common amongst farmers, has now greatly fallen off.

"If, however, any farmer out of curiosity should desire to try his hand at superphosphate making, the following directions may be followed, but it must be understood that I by no means recommend this process to manufacturers for the making of superphosphate generally.

"For a ton of bones, which should be ground small and boiled to extract as much as possible of the fat, the following quantities of acid and water may be used, viz.: 740 lbs. white oil of vitriol, or 850 lbs. brown acid; this is about equivalent to 41 gallons of the former and 50 gallons of the latter.

"1000 lbs., or about 100 gallons of water, are divided equally, one part being used to moisten the bones and the other to dilute the acid. The latter operation should be carefully performed in a large bucket or tub—pouring the acid in a small stream into the water —the latter being well stirred meanwhile. The bones should be thoroughly moistened with water from a garden watering-can, and left for two or three hours, or longer, to get well soaked. The mixing should be made in a wooden trough or large tub; if a sufficiently large vessel cannot be had to receive all the materials at once, it may be done in a smaller one, using successive and proportionate quantities of bones and acid; or the mixture may be made, but not so well, on the ground (with a hard clay surface if possible), a ring being made with ashes (black or red, about equal in weight to the water used), to prevent the liquid flowing away. The acid should be gradually added to the bones, the whole being well stirred with a wooden rake to ensure uniform admixture. As soon as the acid is all added and the mixing completed, the greater part of the ashes may be thrown over the mass, and the whole allowed to stand for some days. The heap may then be opened, and the whole of the ashes well incorporated with it; the mass being then allowed to stand again for a week or so, and if not then sufficiently dry may be broken up again and re-made into a heap, with thin layers of fresh dry ashes. By this means a superphosphate may be got perfectly dry and manageable—the large addition of ashes being, of course, no great objection when, as we are supposing, it is to be consumed on the farm where made. A superphosphate made in this way, with the first quantity of ashes mentioned, was found to contain, 12·27 per cent. of soluble phosphate, and nitrogen equal to 2·07 of ammonia."

Nitrate of Soda, Sulphate of Soda, Sulphate of Ammonia.—These are now amongst the most extensively used of the artificial and special manures. *Nitrate of soda* is obtained chiefly from Peru; it is used principally for the manufacture of nitric acid, its affinity for moisture preventing its use in the manufacture of gunpowder. It is becoming largely used as a top-dressing for meadows; and for the oat crop it is especially valuable. *Sulphate of soda* is formed of soda and sulphuric acid. It is useful as a top-dressing for grain and green crops, and for meadows. *Sulphate of ammonia* is formed by the combination of sulphuric acid and ammonia. It has been found beneficial on corn and grass crops.

Artificial manures* are now in great request amongst practical farmers; they are valuable as applying in a concentrated and available form the mineral constituents to land which has become unproductive through long cultivation. They may be classed as "nitrogenous" and "phosphatic;" to the "nitrogenous" belong guano, nitrate of soda, and the various salts of ammonia; to the "phosphatic" various kinds of "superphosphates," "phospho-Peruvian guano," and other phosphatic guanos. Artificial manures owe much of their value to the peculiarities of the soil to which they are applied, "each soil being endowed with its own peculiar capacity for receiving and retaining the fertilising matter supplied to it." Hence the necessity for becoming acquainted with the nature of the soil before deciding on the *kind of artificial manure to be applied to it.* Under the Divisions Third, Fourth, and Fifth of the

* For historical notes connected with the subject of artificial manures see the work in this series, "Historical Outlines of Farming and Farming Economy."

present volume will be found the different mixtures to be applied to the grain crops, the green crops, and the grasses in various soils. The following is taken from an admirably drawn up paper on the application of artificial manures to various soils and crops, read by Mr. Jacob Wilson, of Manor House, Woodhorn, Morpeth, before the Hexham Farmers' Club. "A knowledge of the physical and chemical condition of his soil and manures, the requirements of the crop to be raised, the season of, and the time required for its growth, the state of the weather, and other such points, will occupy the attention of the farmer previous to coming to a decision on this part of the subject. All artificial manures ought to be applied in as finely divided a condition as possible, so as to be the more thoroughly diffused through the soil; and, as a rule, concentrated manures should be mixed with some other more bulky foreign matter, to cause their more even and regular distribution, especial care being taken to crush the small white lumps in Peruvian guano. Manures in which their constituents do not exist in a readily available form, such as rape-cake, bone-dust, shoddy, and such like, should be applied in the autumn, so that the changes which they undergo in the soil during winter will render them fit for use by the plant in the spring. These slowly acting substances will also be of service to an autumn sown crop, for which a ready or soluble manure is not only unnecessary, but objectionable as a top-dressing to cereals or grasses. Guano, superphosphate, and other partially soluble mineral manures, ought to be used early in the spring, say in February and the beginning of March; whilst the more soluble, such as nitrate of soda and the salts of ammonia, may be applied at a still later period. The progress of growth should be carefully noticed, so that the manure may be applied about the time that the young plant is leaving the pickle, and becoming more dependent on the soil for its food; this being the most critical period of the growth of the plant, it is consequently considerably benefited by any assistance that may be given it at this time. Damp weather should also be chosen as most suitable for the application of a top-dressing; and where drill husbandry is employed in the sowing of our grain crops, the manure will be most effectually applied immediately previous to horse-hoeing, which will have the combined effect of destroying the weeds and thoroughly mixing the manure with the soil; of course when applied at seed-time, it ought to be harrowed in at once with the crop, for there is practically a considerably greater increase from guano thus applied, than when top-dressed at a more advanced stage. For root crops artificial manures are best applied at seed-time. Should the land have received a winter manuring of dung, the artificial manure may be sown broadcast, harrowed in, and drilled up ready for sowing; if not, and the dung be applied also at the seed-time, it may then be sown broadcast over the top of the drills on top of the dung, and thus be split in along with it. Bone-dust or superphosphate may be drilled in along with seed, if thought fit, by a combined manure and seed drill, but I emphatically recommend guano, rape cake, and all nitrogenous and alkaline manures to be distributed broadcast, and well mixed with the soil, inasmuch as nitrogenous manures are found to exercise a prejudicial influence on the delicate seed and young plant, and, therefore, ought never to be applied near to it, especially in a dry season."

Before leaving the subject of artificial and special manures, it will serve some useful purpose if we draw attention here to the importance of distinguishing between an artificial and a special manure. This has been so well stated by Mr. Baldwin, that we give a place here to his remarks :—

"There are few subjects so imperfectly understood by the farmer as the *rationale* of artificial manuring. Even the simple terms *artificial* and *special*, as applied to manures, have frequently led to confusion. It may not, therefore, be unprofitable to offer a few remarks on the subject at the present season. An artificial manure is one fabricated by the hand of man, such as superphosphate of lime. A special manure may be defined as a sub-variety of the class artificial, and is manufactured to meet the special requirements of a particular soil or crop. Special manures have been prepared on two very different principles:—1st. In accordance with the analysis of the ash of crops; 2nd. With the united aid of science and practical experience. In the present state of agricultural science we have little faith in manures based on chemical formulæ alone; but knowledge is progressive, and every year witnesses some new and successful application of theory. And although the manures of Liebig and his disciples have failed in our own experiments in producing any perceptible increase, we do not condemn the principle on which they were prepared. The effect produced on soils of average productiveness may be imperceptible, yet they may help to prevent the exhaustion of the land. But no sooner did special manures, prepared in accordance with the analysis of the crops, fail in producing large returns, than a reaction was produced in the minds of practical men --a result which was natural enough, when it is considered that the farmer looks to present rather than future results. Special manures may not always pay a farmer having only a year or two of his lease to run; but the case may be very different under a longer tenure.

"While, however, recognising this principle, we consider it delusive to hold out to the farmers, as some have done, any hope of an immediate return in all cases from manures compounded in accordance with the analysis of soils or crops. And yet an intelligent manure manufacturer says, in a pamphlet just issued from the press, that 'by sending a sample of the soil (a few pounds' weight, taken from various parts of the field), with a description of the crops intended for cultivation, a suitable manure will be compounded.' It is easy to show that this theory is fallacious. If we divide a sample of soil—reduced by previous mixing to a homogeneous state—into two portions, and mix one of them with ammonia or biphosphate of lime, at the rate at which we usually use them in the shape of artificial manures, and then send both samples to a chemist, the per centage of ammonia and biphosphate added to the one is so insignificantly small that, with all the nicety of the modern balance, he will probably give the analysis of both precisely the same. The per centage, *e. g.*, of phosphoric acid added to an acre of soil by a wheat manure containing fifteen pounds of that substance is too small (·0003) to be appreciable in the most delicate balance. It is for this reason that in all their experiments Lawes and Gilbert repudiate chemical analysis of soils as a means of ascertaining the manures that ought to be applied for the production of crops.

"The majority of our artificial manures are fabricated on more rational bases, namely, the attested requirements of practical agriculture. They are, however, generally special in their character. Plants vary very much in their habits of growth. Some have a tap-root as the principal absorbent of nourishment; others have several rootlets. Winter wheat remains ten months or so in the ground; barley about half that period. Green crops, again, have large leaves, which suck in a large quantity of carbonic acid, ammonia, and nitric acid from the air. The cereals have a small system of leaves, and cannot, in the short period in which the seed is formed, obtain nitrogen enough from the air; and the presence of ammoniacal salts or nitrate in the soil at the same period is of essential use in rendering soluble and introducing into the plants the phosphate of lime which so largely enters into the composition of the seed. Artificial manures must therefore be more or less special; but the tenant-farmer, who looks merely to profit, should not blindly adopt every artificial manure suggested by chemists or manufacturers, but wait till its practical value is well tested by some more favoured agriculturist."

DIVISION THIRD.

GRAIN OR CEREAL CROPS: WHEAT—BARLEY—OATS—RYE.—VARIETIES OF SEEDS.—PREPARATION OF THE SOIL FOR THE VARIOUS CROPS.—MODES OF SOWING.—HARVESTING.

WHEAT, the most important of all our cereal crops, is classed by botanists under the genus *Triticum*, and of the order *Gramineæ*, or grasses. In classifying the various species, different writers have adopted different arrangements. The best appears to be that of M. Vilmorin,—and it is adopted by Professor John Wilson, one of the best authorities on farm crops,—who arranges wheat under seven species. Of these it is only necessary to name two, all the others not being generally grown for food purposes. The two most important species are *Triticum sativum* and *Triticum turgidum*. Of these two the first is the most important, the different varieties in cultivation in this country belonging principally to it; the *Triticum turgidum* comprising only those varieties grown in less favoured soils, and which are characterised by their large yield of a coarse quality of grain.

Wheat, then, as cultivated in this country, may be divided into two great classes—the "smooth," as in Fig. 1, at A, B, and C; and "bearded," as in Fig. 2. The most common classification is, however, according to the colour, "white" and "red." The varieties of wheat cultivated are very numerous, so much so that in the present work it is impossible to do more than merely name the most valued of them, and this selection we owe to Professor Wilson's useful treatise on "Our Farm Crops," in which will be found a short description of the peculiarities of each, which we have not space here to extract. The following are selected by Professor Wilson as *exemplars* of the *white* varieties:—(1) Brodie's; (2) Chidham; (3) Dwarf Cluster; (4) Essex; (5) Fenton; (6) Hopetown; (7) Hunter's; (8) Pearl; (9) Spring; (10) Talavera; (11) Uxbridge; (12) Velvet-eared, or Rough-chaffed. Of the *red*:—(1) Barwell; (2) Browick; (3) Bristol; (4) Clover's; (5) Hickling's Prolific; (6) Kissingland; (7) Lammas; (8) Piper's Thickset; (9) Spalding's; (10) Velvet, or Woolly-eared Bearded.

As to which is the best to be cultivated, much

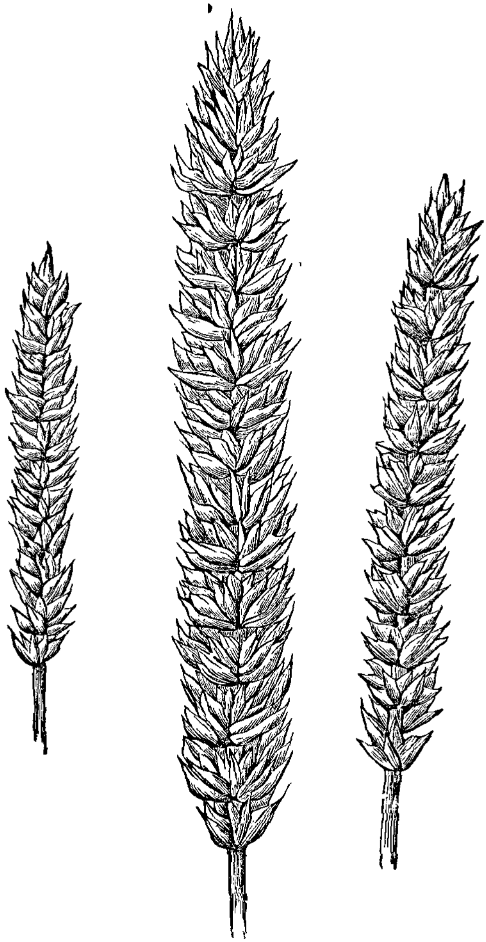


Fig. 1. VARIETIES OF SMOOTH WHEAT.

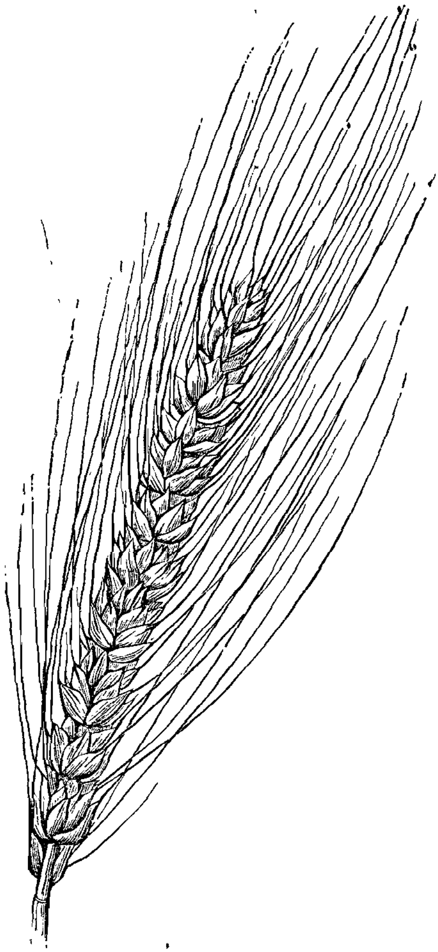


Fig. 2. SHERRIFF'S BEARDED RED WHEAT.

depends upon soil and climate. A writer in the Bath West of England Society's Journal has the following on this point:—

"It is generally admitted that the red varieties of wheat are much less liable to sprout in a season like the past than the white sorts; but my experience, extending over a period of thirty-four years, enables me to say, that where the soil and climate are favourable, and the land in a good state of cultivation, the white wheats pay best, and during the above-named period have not sprouted in the harvest field oftener than once in seven years; and I hold this to be an important fact in the consideration of the subject, and I have thus never been deterred from sowing the best varieties of white wheat upon farms where the soil and climate were favourable."

Wheats often change their colour. Thus, white wheats in poor soils will gradually become darker, and red wheats in rich soils lighter in colour. It is worthy of notice that the straw and chaff are longest in becoming thus affected, the grain first assuming the change of hue; from this we have red wheat with white straw and chaff, and the reverse.

Wheats are also sometimes classed as "winter" and "spring" wheats. This distinction is however rapidly falling into disuse, as by repeatedly growing at any one season a wheat can be easily changed in its habits as regards the time of ripening; all that is necessary for the farmer to attend to is in sowing autumn wheat to secure seed from wheat sown in autumn, and for spring sowing, seed obtained from a crop sown in spring.

The proper place of wheat in the rotation of a farm where the four-course system is adopted, is after the clover; or it follows a root crop, as turnips or potatoes.

Wheat grows best on strong soils; these are, in fact, frequently termed "wheat soils."

The preparation of the land for the wheat crop depends greatly upon the nature of the soil. On the heaviest soils the land is almost invariably prepared by a "summer fallow." In this the land is kept unoccupied by a crop for the whole of the summer, and well stirred and cleaned from weeds. The action of the atmosphere, the frosts, and the rains generally mellow the soil, and make it fit to receive the seed in the autumn. Now that machinery has come to the aid of the farmer, the summer or open fallow is gradually becoming disused, and the land, in place of being allowed to lie idle, bears a crop of roots or clover. As above stated, where the four-course rotation is adopted, wheat follows the clover, that forage plant being well adapted to put the soil in the best condition to receive the wheat. Heavy adhesive clay lands should not be harrowed after the seed is sown, so much as to bring the surface to a fine "tillh," or pulverised condition. However "nice" and "ship-shape" a field treated this way may look, it acts prejudicially on the progress of the plants, inasmuch as from the absorptive nature of the soil, it gradually assumes a pasty nature, which encrusts the surface. In treating heavy clayey soils the great point is to get them ready in good time before the heavy rains of autumn set in, to avoid the "poaching" of the land by the horses' feet or the passage of implements over them, and to leave the surface comparatively rough.

Where wheat follows roots, the great difficulty is to get the roots off the ground in time to admit of the preparation of the soil. It is here, we may remark in passing, that the aid of steam is so valuable to the farmer. The great advantage of having a root crop is the facility which it affords for "hoeing" and "weeding" being done for a large part of the period during which the crop occupies the ground; the soil then, on the crop being taken up, is generally comparatively free from weeds, and the preparation of the land is just so much the easier. A single ploughing will therefore often be all that is necessary; it will happen, however, that where care has not been exercised in the culture of the root crop, or from some other cause, the soil will be so hard and crusted that two ploughings will be required. An essential requisite for the successful growth of wheat in a soil is, that it possesses firmness. In the lighter class of clays, or in turnip soils, this firmness is often secured by "feeding" the green crop, as turnips, with sheep. The treading of the soil by these gives it a firmness which is rarely obtained by any other means. In other cases the press-wheel or the roller is used with advantage. It is in the firmness which the soil possesses after clover is ploughed in, that as a crop preceding the wheat its great advantage lies.

The land being prepared, the next points to be considered are the "preparation of the seed" and the "mode of sowing it." Wheat is liable to certain diseases, of which the "smut" is one of the most common, as it is one which should be avoided if possible. All authorities agree that the most effectual preventive of this disease is the "steeping" or washing of the seed before sowing it. A number of "steeps" have been introduced and used with varying success. One frequently used is stale urine. The seed wheat is put into this, all the seeds which float being rejected, and after the others are allowed to remain in the liquid for ten minutes or so, they are taken out, spread on the floor, and dried. Some sprinkle lime on the seeds as they are spread on the floor. "Down's Farmer's Friend" is a steep for wheat which has a considerable reputation. Nitrate of soda when used as a steep has this advantage, that it secures, or is likely to secure, a vigorous "braird," or early growth of the plants. Solutions of nitrate of soda, of vitriol, and of chloride of lime are also used.

There are three modes of sowing wheat in use—the "broadcasting," "drilling," and "dibbling." In the first, the seed is scattered at will over the land; in the second, it is sown in parallel lines, in a continuous stream; and in the third, it is deposited in holes made in the ground at certain intervals. Much of what can be said on the merits of the three methods has been well said by Professor Wilson, in his "Farm Crops," which, for the benefit of our readers, we reproduce here:—

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

This generally amounts to considerably more than the entire cost of machine sowing.

"*Drilling* offers the great advantage to the farmer of being able to regulate the exact quantity of seed to be sown; to sow it equally all over the field; to deposit it at a given regular depth in the soil, to ensure its being properly covered. A saving of seed, to the extent of one-third to one-half as compared with broadcasting, is effected, and by being deposited in the ground in straight parallel lines, great facilities are afforded for keeping the surface free from weeds, either by hoeing or hand pulling. The produce also per acre is—under equal conditions of soil, climate, &c.—shown to exceed that of broadcasting. The only charge that can be advanced against drilling is, that perhaps it offers some assistance to the wire-worm in its destructive attacks on the young plants, by forming a furrow of loosened soil, along which the wire-worm takes its course without any difficulty, destroying each plant in succession. This, however, on soils subject to it, may easily be checked by running a ribbed roller—either Cambridge or Crosskill—across the line of drills, by which the continuosity of the furrowed course is stopped at each indentation of the roller. The wire-worm then, owing to its small powers of forcing itself through the soil, can only move from plant to plant by coming up to the surface; this materially checks it progress, while its presence there is being constantly sought for by insectivorous birds.

"*Dibbling* is to be recommended chiefly for the more perfect manner in which the seed is deposited in the soil, both as regards the equality of its distribution and as regards the proportion of area allotted to each plant. The amount of seed saved by this method is an item of consideration—drilling requiring twice, and broadcasting four times the quantity. The seed, too, by being deposited in separate unconnected holes, is not so liable to be destroyed by the wire-worm as when sown in drills, while the parallelism of its lines of plants offers even greater facilities for cleaning than in ordinary drilling. Some care, however, is necessary that the dibbling machine should only be made use of when the soil is suitable and in a suitable condition. If it be too light, or too dry, the sides of the holes are apt to fall in with the seed, or before it is quite deposited, and then the depth is irregular—often too little. If the soil is heavy or too wet, the dibble forms a hole or cup with compressed sides and bottom, in which the water collects, checks the germination of the seed, and materially injures or destroys the vitality of the young plant."

We have grown wheat in all the three methods, and so far as produce, both of straw and grain, is concerned, that of dibbling we have found to be the best. But not only is increase of produce a marked feature of the dibbling method; the strength of the straw is another. And this is of the greatest importance, especially in districts where heavy rains and strong winds are frequently sustained; for the dibbled grain is rarely laid, or, at all events, it will resist "laying" influences to a much greater extent than "broadcasted" or "drilled" grain. While we write we have some grain which was sown "drill" fashion lying prostrate on the ground, while some which was dibbled is standing beautifully erect. Not only is this of immense importance in preserving the quality of the grain, but it facilitates, to an amazing degree, the operations of reaping, more especially where that is carried out by machine.

One of the disputed points in the practice of farming is the amount of seed to be sown. Some advocate "thick," others "thin" sowing; and on a review of all that has been brought forward in support of the two views, we are inclined to think that the weight of evidence is in favour of thin sowing. On this point of thin as opposed to thick sowing, it is necessary to state that much depends upon soil and climate. In localities where the climate is comparatively congenial, thin sowing will not produce such good results as thick sowing, and where the soil is poor or wet the same remark will generally hold good. It is also right to state that in some cases thin sown or dibbled wheat is badly attacked with "rust." We have seen thickly sown broadcasted wheat present a very favourable contrast to thin dibbled wheat in this respect; and yet we have also observed in similar circumstances of soil and locality the very reverse. So varying are the results of agricultural practice, and so closely does the farmer require to look at his peculiar circumstances, and so difficult is it to put down a rule applicable to all cases. The following extracts, from recent experience on the "thick" and "thin" sowing question, will be useful:—

"It is now nearly thirty years," says Mr. Hewitt Davies, in a recent note to the *Agricultural Gazette*, "since I first drew attention 'to the injury and waste of corn from too thickly sowing.' I proved by my practice of many years upon 2,000 acres of land that, with good cultivation, heavier and finer crops of wheat were to be grown from a bushel of seed per acre than from a greater quantity; and farmers in their thick sowing were worse than throwing away an amount of corn (equal in many cases to half the rent of their land) productive of a loss to the nation of millions per annum.

And I supported my practice by showing that a bushel of wheat per acre generated in the first instance many more plants than the space of ground would admit to reach maturity, and that if more seed were sown than the space afforded room for the plants to continue to grow and develop up to harvest, disease after a time must be the consequence, very prejudicial to the yield and quality of the grain at harvest, a fact well understood by gardeners, and carefully met in their practice by their hoeings, prunings, and thinnings in the infant stages of growth. Mr. Mechi has only repeated what may more fully be found in my 'Farming Essays,' and I may say has adopted the *comparatively* small proportions of seed that I recommended twenty years ago, namely, a bushel of wheat, six pecks of barley, and eight of oats per acre—quantities that I have since seen reduced with advantage, although they were little more than a third of what was then customary to sow. And with respect to the improved quality of grain to be gained from thin seeding, I may say that there is much to be done, and I am not surprised to find that Mr. Hallett is exhibiting his fine ears of wheat from thin seeding."

On the other side of the question, a practical authority, writing from Mid-Lothian, says, in the same journal, "that although the soil was in excellent condition for carrying produce, universally the thinnest crops are those most damaged with rust, yellow gum, or mildew." And referring to a case where one peck of seed per acre was used—one-tenth of the quantity used in the Lothians—he says, "because in a soil, and with a climate suitable, in such small quantities of seed for producing full crops, it is too much . . . to expect that in all climates such results, if the cultivation is suitable, will follow." (See also a paper on the "Advantages of Thick Sowing," in the "Journal of the Royal Agricultural Society of England," vol. vi.) The following is an extract of a note from Mr. Mechi—a well-known advocate of thin sowing—addressed to the *Mark Lane Express,* in which there are many points worthy of notice:—

"It must never be forgotten that thin sowing is the parent or first cause of large and vigorous ears to select from; on this point there can be no mistake, seeing that thick sowing has an exactly reverse effect, diminishing and crippling the growth of the ear, until, with extreme quantities, there is scarcely a good kernel or good ear. Therefore in order to get good ears to select from, we must sow moderately. It would be a very dangerous experiment to sow generally so small a quantity of seed as one peck per acre. In highly cultivated warm mellow soils, free from weeds, and in good heart, where harvest is ready by the 1st of August, or earlier, such small quantities may be sown, provided the sowing is done early; but we must ask ourselves how much, or rather how little, of the land of this kingdom is in the state I have described. One kernel in a hole, at intervals of nine inches by four, would, under favourable circumstances, be ample, and produce much more than if four times that number were sown; but, then, we have rooks, French partridges, birds, mice, and wire-worm to contend with.

"The latter may easily be got rid of by sowing or ploughing in rape-cake, with or without salt, the latter to be commended. Light-land men would be astonished to see our cold, tenacious, birdlime-like seed-beds in a wet seed-time, even where well drained and deeply cultivated. The seeding of friable, manageable soils cannot be compared with such a state of things. Besides, the time of harvesting depends upon the quantity of seed sown, and the period at which it is sown.

"It is all very well to talk of sowing in September, but in many districts this year all hands were then employed in harvesting, and in late districts seed-time will probably be November and December. On my own farm, experience has taught me the danger of so small a quantity as one peck per acre, and I know of some cases this year where one peck of Mr. Hallett's wheat on one acre has been found to produce only three quarters of inferior quality per acre on land which generally produces five or six quarters. Parties who have been thus unsuccessful, should, equally with those who are successful, communicate their results for the information and guidance of their brother farmers.

"Absurd quantities of seed continue to be sown as a general practice; but I would advise my brother agriculturists to feel their way down to a proper minimum quantity, suited to their soil and climate, by small experiments in their fields. I see so many farms where weeds are allowed to luxuriate and perfect their seeds almost undisturbed, in competition with the cereal crops, that in these it would be the height of folly to attempt thin sowing. There they must sow thick, to pre-occupy the ground and smother the weeds, as they will not clean-hoe. Thin sowing, to be successful, demands, like a thinned turnip crop, a frequent use of the hand and horse-hoe, to which much of the land of this kingdom is still a stranger."

Where very thin sowing is carried out, as in the case of dibbling *one* grain in a hole, it is essential that the grain should be sown very early—say the end of August, but not later than the middle of September. We sowed some wheat last year on the 4th of September, one grain in the hole, and each hole nine inches apart, and the plants in early spring were peculiarly fine, and were ready for cutting fully three weeks before the wheat sown in the middle of October broadcasted. One remarkable feature of dibbled thin-sown wheat is the amazing way in which it "tillers" or sends up stalks, the length of the straw—its thickness, and the unusual breadth and freshness of colour of the leaves. The plants resemble, in point of fact, little trees more than the comparatively weak and thin plants we are accustomed to see in wheat fields. Of a variety of white wheat, which we dibbled as stated above, we had plants or shoots which averaged thirty-five ears; the same produce we had from Hallett's Pedigree wheat, some of which we grew this year (1862). The grain of both varieties was of a very fine quality. In Fig. 1, C is a drawing of one of the ears of our own variety, one-half full size, which gives a size of ear much above the average of crops. It is this necessity for the early sowing of dibbled wheat which militates very much against its general introduction. The difficulty, however, may be overcome by sowing the seed in a "seed-bed," and transplanting as soon as the land can be got ready after getting the root crop off or the clover "ley" ploughed up. This method of transplanting is so new, and to the minds of many so odd, that its mere mention will create a smile. But the truth is, there is nothing in practice or in theory which goes against the plan. We have tried the system; and if there was any difference between the transplanted wheat and that sown in the usual method, the transplanted was the best, and this even where the transplanting was carried out very late in the season. The following extract from the

Agricultural Gazette, bearing on the point, will repay perusal :—

"A few years ago an experiment was tried at the model farm at Glasnevin, near Dublin (suggested by the one recorded by the celebrated gardener, Miller), of transplanting wheat in the spring, parting the roots so as to make each plant into *ten or more*. The crop was as good as from a field sown in the usual way. It may be worth considering whether this plan might not be advantageously tried if we are to have another wet season; for the very weather which is utterly unfit for sowing, is the best for planting; according to the well-known proverbial maxim, 'Set wet and sow dry.' Some persons, not well acquainted with country affairs, might suppose the process to be much more tedious and more costly than it is. They will perhaps be surprised to hear of the payment made by many nursery gardeners in England to the women and children employed in transplanting small forest trees (about a finger long) from the seed-bed. They pay 2*d.* a thousand; and many women and children are glad to earn in this way from 4*d.* to 6*d.* a day. It is even found to answer in some parts of England to sow wheat in the way that is called 'setting' or 'dibbling,' dropping the grains by hand into holes made for the purpose; as, indeed, is always done with beans. It would not take much more time and labour to lay the little offsets of the wheat in a shallow furrow, and then slightly cover them over. And as some set-off against the expense of labour, is to be reckoned the saving of the seed wheat. But, however, the alternative is not between sowing or planting a field of wheat (the former being in such a season as this impossible), but between the planting and the leaving of the field absolutely waste for a whole season."

Where drilling is carried out, the distance between the lines is, we think, generally too narrow, this being from six to nine inches. From experiments which we have instituted, we are inclined to place the maximum at twelve inches. This distance will enable weeding to be carried on, and hoeing between the rows, till a pretty advanced stage of the plants' growth, and will allow the beneficial influences of light and air to be better exercised. On this point the following, from the pen of a well-known authority, Mr. C. Lawrence, of Cirencester (in the "Journal of the Royal Agricultural Society of England"), will be useful :—

"I had observed some years ago, that practically the question of width lay between seven and nine inches, and the quantity of seed varied between two and three bushels per acre. Desirous of arriving at some conclusion on these points for my governance on my own farm, which comprises heavy and light land, I have, during the last five years, sown several half-acre plots in the same field, varying in width from eight to twelve inches between the rows, and with from four to eight pecks of seed per acre. Any one who has tried such experiments will have found, on comparing those of one year with those of another, in different fields very perplexing discrepancies arising from the variety of land sometimes occurring in the same field, and other disturbing causes. It is therefore only by repeated experiments year by year, in different fields, that a reliable impression can be arrived at. The result of the experiments on my farm has been in favour of twelve-inch intervals and six pecks of seed. The largest produce I had in any year was from four pecks of seed with twelve-inch intervals. I may add,—these experiments have been made in-differently on light stonebrush and tenacious soils on stiff clay. During seasons in which mildew has been prevalent, I have observed that it has to a somewhat greater extent attacked the straw of the twelve-inch than that with eight or nine-inch intervals, a result I should not have anticipated *à priori*.""

The quantity of seed varies, or should vary, according to the season of sowing. Sown early in autumn, less is taken than when sown late—say five to six pecks per acre for the early, and from seven to ten for the later sowings. The months of October and November are the usual wheat sowing months; but it should not, as a general rule, be later than the middle of November. Spring sowing is usually in the months of February and March, and should not be later than the second week of the latter month. The depth to which the seed is sown is usually two inches. The preparation of the land for spring wheat is very much similar in character to that adopted for winter sowing, only that the consolidation or firming of the soil is not so essential, as there is little chance of frost raising or lifting the wheat plant up out of the soil, which is often the case in winter where the plants have not a firm hold. In the preparation of land for wheat, advanced practice is to keep it as flat as possible. The condition of soil most favourable for the sowing of the seed is moist, but not having any superfluous wet. Much depends upon the nature of the soil; on heavy clay lands the seed is perhaps sown when the soil is thoroughly dry, lighter soils doing with more moisture than heavy.

As a rule, the soil for the wheat crop is rarely manured directly for it; it usually follows a crop which has been heavily manured, such as potatoes, mangolds, or Swedes. Artificial manures we have used with great advantage. The following gives an outline of modern practice in the use of artificial manures for the wheat crop:—In *sandy soils,* if applied in autumn, 2 cwt. of rape-cake broken or crushed to a powder, with 2 cwt. of superphosphate per acre; for spring sown wheat, 1 cwt. of nitrate of soda, 1 cwt. of Peruvian guano, 2 cwt. of common salt, or 2 cwt. of sulphate of ammonia, and 2 cwt. of salt. In *calcareous soils,* 2 cwt. of salt, 2 cwt. of nitrate of soda; this for spring sown wheat. In *clay soils:* Where wheat after turnips is taken and sown in the autumn, no artificial manure is recommended; but in spring a dressing may be applied of from 2 to 3 cwt. of Peruvian guano, with 2 cwt. of salt, per acre. Where the wheat is sown in spring, this should be applied in two portions—half at sowing and half at a later period, when the plant is well "branded" or up. In light *vegetable moulds,* a dressing of 2 cwt. of salt, and 3 cwt. of superphosphate per acre, sown broadcast, in March, will be beneficial. As in these soils an excess of vegetable matter is present, lime will be essential after draining is effected.

In concluding our remarks on the wheat crop—the most important of all the cereals—it will be advisable to notice briefly two of the most striking methods of growing wheat now attracting the attention of practical men. The first is the Lois-Weedon system, introduced by the Rev. Mr. Smith; the second, the system of "Selection," which owes its introduction to Mr. Hallett, of Brighton. The feature of the Lois-Weedon system is, wheat is grown year after year upon the same land and without manure. The following is from the Rev. Mr. Smith's pamphlet.*

* "A Word in Season, or How to Grow Wheat Profitably." Ridgway, Piccadilly, London. 1*s*.

"'At the outset of my farming, fifteen years ago, the field before us was in grass, which I pared and took off the land; then ploughed it the full depth of the five-inch staple for a crop of oats, followed by vetches. After this came the first triple-rowed wheat crop, with its wide intervals, which I dug one spit deep, bringing only a very few inches of yellow clay subsoil to the surface. The second year these well-stirred intervals bore the wheat crop, and the stubble was dug in; and thus, year after year, alternately, the same acre of land has had a fallow and a wheat crop too. In the third and fourth years the spade went down a few inches deeper; and so, gradually and regularly, for four years more, till a depth of sixteen or eighteen inches was reached, when I stayed my hand; and after that, was satisfied for the four following years with a single spit. Last year, however, I returned to the double spit and a fresh inch of clay; and this brings me to this year's operations, which we are come out to view. The digging, as you see, is two spits deep; and after the pan was a little stirred, the staple and the stubble were turned upon it, the clods shattered, and the second spit, with its sprinkling of yellow clay, was gently laid uppermost, in such a form that the frost might be felt through the whole. Look, you can almost see down to the subsoil.'

"'And what follows next?'

"'These high-ridged intervals will lie thus during winter, higher than the tender wheat, and so protect it, and checking the drifting snow. The winter fallow over, I shall stir and level the ridges with the horse-hoe, well clean the rows and the intervals, keeping the surface of the latter constantly open till the wheat is about to flower. Then will come a process peculiar to the plan, and which meets a difficulty in our uncertain climate of no ordinary importance. The rotation farmer has a heavy crop of wheat; but, heigh-ho! the wind and the rain! he is utterly helpless against these; his wheat comes down; 'the rain it raineth every day,' and his hopes are blighted. I owe my general immunity from this disaster to the broad space of my fallow intervals, which enable me to take a turn with the plough up and down; and so—the soil being well pulverised, mind that—*to earth up my wheat with the mould-board.* Immediately after this operation follows another of singular efficacy in swelling the grain; I subsoil—with Sigma's subsoiler—as deeply as I can with two horses, in the centre of each furrow just made by the plough; and this closes the work till harvest.

"'The crop being carried, I make preparations at once for sowing. I first lightly horse-hoe and clean the furrows; then plough close to each stubble, casting the earth back again into the centre. There are thus two furrows in each interval, and these I subsoil, which leaves the whole of the land intended for the crop in a hollow, pulverised condition. But though wheat loves a mellow bed, it loathes a soft one. I therefore consolidate the soil with the double clod crusher, which takes two beds at once, the horse walking on the stubble in the centre. This being done, I wait till near the middle of September for the rains, if it may be, to perfect the culture.

"I should be glad to have your close attention while I now describe the sowing; because, upon the accuracy of this process depends not only the goodness and fulness of the crop, but the great pleasure of, perhaps, a daily inspection of true lines and even vegetation of this beautiful plant for ten months in the year. All machinery for sowing, besides the single hand-dibble, I have long discarded. I reject even Sigma's admirable planter, which I hear is so effective, believing all to be comparatively unsafe and inefficient; for with the hand-dibble—with the right hand dibbling, and the left dropping the grain—*I can see the seed deposited;* I know it is there, in its right place and at the right depth. I am satisfied, too, with the rapidity with which the practised workman does his work. It is true his work is marked out for him more accurately and quickly than he could do it himself. Another hand stretches a line—nearly, but not quite, in the centre—from one end of the interval to the other.

"'With a light hand-implement, invented by Sigma, which holds three small mould-boards, set at the required distance apart, he now, guiding the middle mould-board by the line, draws with almost mathematical truth three minute furrows, in which the dibbler deposits the seed. And, when the whole piece is completed, if the surface be dry enough, I cover over the seed and close up the channels with the crusher. At spring, the crusher is again employed in compressing the wheat plant; after which the hand, and the hand-hoe—another of Sigma's capital inventions—are busy between the rows as long as it is safe; and then comes the last scene of all—the sickle and the harvest-home.

"'Sum up then the average annual outlay for these wheat crops, from first to last, always keeping in mind the digging process just described—how it begun with one shallow spit the two first years, increasing by degrees to two good spits of pulverised soil, two or three inches only of solid clay being added, and for four years not even that:—

	£	s.	d.
Digging and cleaning the moiety of each acre .	1	14	0
Horse-hoeing ditto three times 6s., ploughing 4s.	0	10	0
Hoeing and hand-weeding	0	5	0
Rolling with crusher at seed-time and at spring, 1s.	0	3	0
Two pecks of seed, 2s. 6d. ; dibbling, 5s. . .	0	7	6
Bird keeping	0	4	0
Earthing up wheat	0	3	0
Reaping, &c., to threshing and marketing . . .	1	13	0
Rent, £2 ; rates and taxes, 4s. 3d.	2	4	3
Total outlay . .	£7	3	9

Such has been the process—such the outlay. The wheat is now threshed; what is the yield?

"'From the moiety of each acre on the clay, the yield this year (1858) was upwards of forty bushels of fine red wheat, with an estimate of two tons of straw. I call it the moiety of each acre, for so it literally and actually is. The very slight change—so slight as to be unnoticed in the foregoing narrative—of twelve inches into ten between each space of the triple row, with a corresponding increased width of interval, removes, as I intended, every shade of doubt upon this point. For a full acre of wheat in ten-inch rows contains, we will say, a hundred and twenty rows. Take away, then, every alternate three rows, and you have Lois-Weedon with only sixty rows, being the actual moiety of the acre of wheat. Last year (1857) the produce in bushels was thirty-six; the year before, thirty-seven; and of the prior years, beginning with 1847, the average yield may be safely given at thirty-four.

"'It is a low average of the amount of straw produced from this same moiety of each acre, *and not returned to it,* to put it to a ton and a half; and not a high one when I value the ton at forty shillings; for whether I sell or not, such is its value to me.

		£	s.	d.
34 bushels of wheat at 5s.	. .	8	10	0
1½ ton of straw at 40s.	. . .	3	10	0
		12	0	0
Deduct outlay	.	7	3	9
Net profit	. . .	£4	16	3

There was the same average profit on the four-acre gravel piece of wheat, detailed in former editions; but as that is not wheat land, I omit, as unnecessary, any further report of the proceedings there.'"

The following diagram will illustrate the method of sowing the wheat on the Lois-Weedon system, as compared with the ordinary one of drilling. Thus the

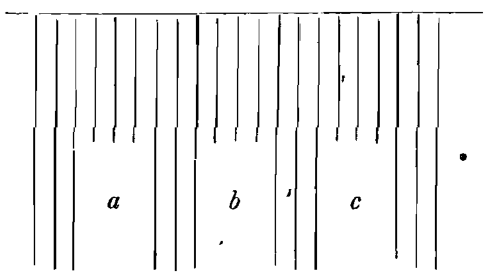


Fig. 3.

spaces *a, b, c* represent those which are left unoccupied one season, but are sown that succeeding.

The question, however, remains—is this system of culture applicable to farms on the large scale? It is but right to state that the answer generally given by scientific authorities, and of practical men who have devoted their attention to it, is not in the affirmative. Take, for instance, the opinion of Professor Anderson on the scientific bearings of the question; the result of the elaborate experiments of Messrs. Lawes and

Gilbert, of Rothamstead, on the soil of which the system "proved a total failure;" and the opinion of Mr. Fisher Hobbs, a well-known practical agriculturist. The following are the opinions of Professor Anderson and Mr. Hobbs:—

"In this method of cultivation," says Professor Anderson, "we see reproduced the principles which guided old Jethro Tull in his agricultural improvements, and it is peculiarly interesting as a means of impressing on the mind the importance of careful and complete tillage. By the frequent stirring of the soil, and admission of air, the valuable materials it contains are enabled to undergo decomposition more rapidly, and are prevented from falling into that inert condition into which they are apt to pass by its exclusion. No one, now-a-days, questions the effect thus produced; although, perhaps, much more reliance is placed upon manure than on tillage; and the value of Mr. Smith's system lies in its bringing distinctly before us the importance of the latter. I do not consider that the method he advocates is likely to come into general use, nor do I think it possible that it can be carried out without, in the long run, impoverishing the land. Conceal it as we may, frequent tillage is only a means of bringing the valuable constituents of the soil rapidly into an available condition; and sooner or later the supply contained in it must be diminished or exhausted. Mr. Smith seems to think that something is absorbed from the air—probably ammonia and nitric acid; but even this would not suffice to counterbalance the loss continually going on. The whole quantity of nitrogen deposited annually by the rain on an acre in these forms amounts, as has been stated to 20 lbs.; but a crop of wheat removes from 50 to 60 lbs. of that element.

The whole matter comes to be simply this: There are two methods of increasing the produce of land—tillage and manuring; and that system cannot be a good one which relies upon the one to the exclusion of the other. Both must be employed simultaneously; and in their judicious combination we may expect to find the conditions of the greatest amount of general success. When a manure is applied to the land, part of it acts rapidly, and part passes into an inert state; and the consequence is, that when tillage is deficient, there is a gradual accumulation of these inert matters, from which the valuable constituents of plants may be set free by a change in system. In such cases this matter may be considered as so much capital laid up in a useless state, which may at any time, by proper working of the land, be brought into a useful condition. It is my belief that Mr. Smith is now spending the dormant capital of his land, and that sooner or later he will find it requisite to apply manure. The true system of cultivation is surely to make use of manure, and by proper cultivation to prevent as far as possible its passing into a dormant state."

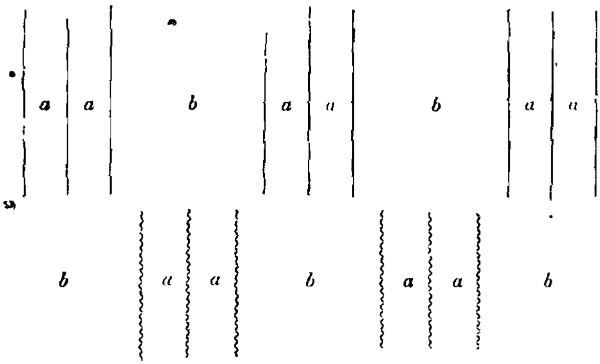
The following is the opinion of Mr. Fisher Hobbs as to the practical bearing of the system as applicable to farm practice on the extended scale. This opinion was delivered at a meeting of the London Central Farmers' Club, on May 7th, 1860, at which a paper was read on "Wheat-growing on the Lois-Weedon system," by Mr. Algernon Clarke, and which elicited a very important discussion, of which Mr. Hobbs's statement, as now given, formed a portion :—

"According to what they had heard so lucidly described by Mr. Howard that evening, and all they had previously learned respecting the Lois-Weedon system struck him that one fine field of wheat, which was excessively green, appeared to be too thickly planted. This was in the month of April. He inquired how much seed had been sown there, and was told three bushels per acre. It looked to him as if it would be all down in the straw, and turn out to bo a very inferior yield; and he observed that if they drilled it a foot apart, with one-half the quantity of seed, the crop would be much better. They said they anticipated that that would be his remark; but they had tried the experiment with English drills, and found that at the period of the year when the wheat came on to blossom, if the ground were not covered, the roots suffered so much from the drought that the wheat was not worth grinding. The year previously he had what appeared to be a good crop of wheat upon very light land. It was drilled from north to south, and the yield greatly disappointed him. This practice was now avoided upon light lands, and they drilled from east to west, by which means the sun did not reach the soil in which the plant was growing. He thought, therefore, that the same principle which the Frenchman had carried out would be most beneficial on light lands, and that wide intervals between the rows of wheat would be deci-dedly injurious, especially upon farms in the south of England."

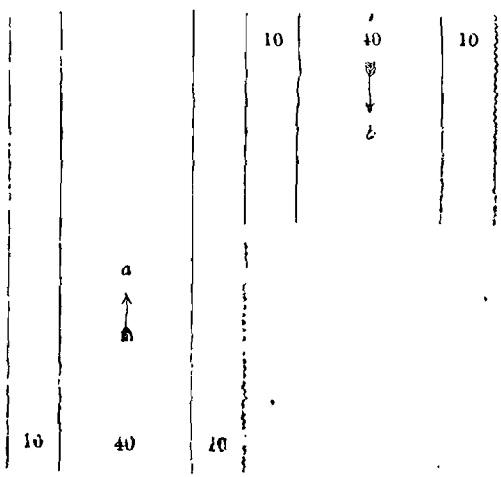
of cultivation, he should say that there could be no advantage in it to the practical farmer. He recollected visiting, some fifteen or twenty years ago, a friend, who called his attention to a similar system which had been carried out in his neighbourhood for upwards of fifty years, but with no very beneficial results; for it had not caught the attention of the neighbours, and no one else seemed to have followed it out. Even now the system was being pursued by an amateur, with no very great advantage. So far as Mr. Smith, of Lois-Weedon, was concerned, it appeared that he amused himself on his few acres of glebe land, and employed his poorer neighbours around him, and in this way he was doing good; but to lay his system before this Club as one of general application was altogether absurd. He was quite aware that Mr. Smith was acting with the very best intentions; but he felt persuaded that no one could adopt the system on an extensive scale, inasmuch as there was an inadequate supply of labour in the country, whilst if there was a fault in the existing practice, it was that they grew too much wheat already, and wheat had not been a paying crop of late years, and certainly it was an exhausting one. The proposition, therefore, to raise wheat alternately year by year was one which he did not think the farmers of England would be inclined to entertain. It was nothing new. They had all read of it in Jethro Tull. One of its advantages was that it promoted the aeration of the soil; but even that they were doing as effectively by other means, and with a good rotation of cropping secured good root crops. A few years since, when in France, he was shown a farm of about 800 acres, upon which the crops were exceedingly fine. He was invited to point out all the faults that he could discover, and it struck him that one fine field of wheat, which was excessively green, appeared *to be too thickly planted.* This was in the month of April. He inquired how much seed had been sown there, and was told three bushels per acre. *It looked to him as if it would be all* down in the straw, and turn out to bo a very inferior yield; and he observed that if they drilled it a foot apart, with one-half the quantity of seed, the crop would be much better. They said they anticipated that that would be his remark; but they had tried the experiment with English drills, and found that at the period of the year when the wheat came on to blossom, if the ground were not covered, the roots suffered so much from the drought that the wheat was not worth grinding. The year previously he had what appeared to be a good crop of wheat upon very light land. It was drilled from north to south, and the yield greatly disappointed him. This practice was now avoided upon light lands, and they drilled from east to west, by which means the sun did not reach the soil in which the plant was growing. He thought, therefore, that the same principle which the Frenchman had carried out would be most beneficial on light lands, and that wide intervals between the rows of wheat would be decidedly injurious, especially upon farms in the south of England."

Mr. Clarke, referred to above, and who is a well-known authority on practical agriculture, is an advocate for the Lois-Weedon system on the extended scale. The paper referred to is an able statement of his views, and of the methods by which he proposes to carry them out.

"The wheat," says Mr. Clarke, "is drilled in triple rows, the 'spaces' (*a a a a*) being 10 inches each, and the 'intervals' (*b b*) 40 inches, so that from the middle of one stripe to the middle of the next is 5 feet. Next year's crop is of course sown upon the fallowed intervals (*b b*), and the stubble stripes (*a a*) fallowed in turn, as indicated by the waved lines :—



So that though the crop is taken from the whole field the rows do not fallow upon the same identical places; and, indeed, instead of being a system of 'wheat after wheat,' it is in reality an alternate course of 'dead fallow and wheat.' Hence some people say—why not sow five acres with wheat in the ordinary way, and fallow the other half of the field alternately? The answer is, that by interspersing the stripes of fallow between the stripes of corn, the tillage operations of the fallow stimulate and support the growth of the corn. So that my five acres of wheat stripes (measuring these by themselves), with fallow stripes between, produced in 1858 no less than seven and a half quarters per acre; whereas, had all the wheat been by itself, and the fallow portion by itself, no such amazing yield could have been looked for. Whatever may be the explanation, at any rate here is proof that tillage in close proximity to the growing plants, and the admission of air and light amongst the green and flaggy stems, do wonderfully promote the increase of the crop, at the same time strengthening the straw and saving the grain from the damage always inflicted by lodging and mildew. For while over heavy crops, sown on the ordinary plan, come up a mass of flaccid stems, too weak at bottom to spring up against the weight of rains and violent winds, the stalks of a Lois-Weedon crop are stout, green, and strong, and bear aloft the ears to ripen and grow plump and heavy in the sunlight. The details of management are abundantly simple. After harvest, fork out couch from the closely-mown stubbles; broadshare or scarify the fallow intervals, to keep down the weeds; shortly before seed-time, again scarify and harrow; prepare a suitable mould by harrowing, taking care to set the harrows widely apart, in order to miss the stubble rows. The drilling I manage as follows:—



The drill is arranged with four coulters, two towards each end of the coulter-bar, with the distances already mentioned; and the horses walk along the middle of the interval. Going in the direction of the arrow (*a*) the outside coulter has its seed shut off, and acts only as a 'marker;' in returning in the direction of the arrow (*b*) this coulter runs again in the same track, depositing seed, while the other outside coulter is used as a marker. Sow three pecks per acre, that is, using the same drill-wheel that would sow six pecks an acre, if the rows had been ten inches apart all over the ground instead of averaging twenty inches as they do; and be sure to get the wheat in early, because of this thin sowing and the effects of the after tillage. When the wheat is well up, take a plough (with two horses in length) once along each interval, the coulter running within six inches of the wheat on the near side, and the furrow-slice covering up the old stubble. The furrow may be five inches deep, without the upturned earth falling upon the wheat on the other side the interval; and a subsoiler, drawn by any three horses in length, breaks up the furrow bottom to a depth of five inches more, making a total depth of ten inches. . . . In spring, say in February, or as soon as the land is dry enough after a time of frost, perform the same operation along the opposite side of the interval. . . . In March or April hand-hoe the wheat rows. In April, when the upturned furrow-slices are in a crumbling state, tear them down by passing a narrow harrow along the intervals, and then stir deeply with a good grubber; dot about twenty-six or twenty-eight inches wide, the horses walking in length. It will be necessary to go over the field with a hand-rake, to pull off any clods that may fall upon and bury the outside rows of wheat. . . . Horse-hoe the fallow intervals deeply at least twice during the summer; and hand-weed the wheat when requisite. When the ears are fully out and in bloom, take a double mould-board or ridge-plough up the intervals, so as to partially mould up the wheat on each side; this will prevent many stalks being blown down by winds, or borne down by heavy rains. A subsoil plough should break up the bottom of the furrow left open in the middle of each interval. . . . The crop may be mown or bagged close to the ground; and bear in mind not to obliterate the lines of stubble by harrowing or otherwise, because these form the 'guide ways' for the next sowing. It may be necessary to gather the soil again into the middle of the intervals, say by a 'pony plough.' You will observe that the subsoiled furrows . . . lie open to the weather for many weeks, and by the end of the year the whole interval has been exposed and pulverised to a depth of ten inches, forming an *uncommonly* fine dead fallow for a succeeding wheat crop. And as far as cleanliness is concerned, I find that the couch has decreased so as to be now little or no trouble; and a thick mass of butter-cups and thistles which pestered the field is also rapidly diminishing. Annual weeds have been annoying and expensive, owing to the access of air and light into every portion of the crop, but are becoming less troublesome every year; and according to the experience at Woolston, my non-inversion husbandry will ultimately wear them all out. In fact, after bearing six white corn crops in succession, the piece is so free from filth that I should simply have to plough, harrow, and sow, if I chose to have any other sort of crop after the present year's wheat. Now, as to experience. You cannot tell, excepting approximately, and by assuming some debatable items for granted, what a wheat crop costs in ordinary farming; but as in this experiment I use no manure and graze no stock, I have simply to reckon the outlay for tillage operations. During the experiment wages have ranged from 10*s*. up to 12*s*. per week, with an addition for harvest; and I allow 2*s*. 6*d*. a-day for a horse and implement—which should be enough, seeing it is equivalent to £37 10*s*. for 300 working days in a year. At these prices the cost per acre of the several operations has been as follows:—

		£	*s*.	*d*.
Aug.	Scarifying fallow intervals	0	1	6
Sept.	Forking out couch	0	3	0
„	Scarifying and twice harrowing intervals	0	2	0
Oct.	Drilling and harrowing	0	2	5
„	Seed (three pecks), at 5*s*. per bushel	0	3	9
Dec.	Ploughing and subsoiling	0	3	6
Feb. or March.	Ploughing and subsoiling and removing clods off wheat	0	3	7
April.	Hand-hoeing the wheat	0	1	6
„	Harrowing and scarifying the intervals	0	1	4
May.	Hand-weeding the wheat	0	0	9
„	Horse-hoeing the intervals	0	0	10
June.	Horse-hoeing the intervals second time	0	1	0
„	Moulding-up wheat	0	0	8
„	Subsoiling	0	2	0
„	Hand-weeding wheat	0	0	4
Aug.	Mowing and harvesting	1	1	0
„	Threshing and marketing	0	10	0
		2	19	2
To this must be added, for rent, 30*s*.; tithe, 8*s*.; rates and direct taxes, say 7*s*.		2	5	0
	Total expenses per acre	£5	4	2

The outlay being so low, I am able to show you a profit even from the poor yields obtained on my over-exhausted ground. Taking wheat at 40*s*. per quarter, a yield of 21 bushels just meets the expenses; and all above this quantity is surplus for profit and interest for capital. Then the straw is all clear gain besides, for none of it has been returned to the land. How is my ton and a half of straw per acre to be valued, being used as it is for cattle fodder and for bedding? Surely I shall not be too high in taking it as worth £14 2*s.*, which, deducted from the expenses, will leave £4 10*s.* as the cost of the grain, and this will be repaid by a yield of 18 bushels. My average of three unfortunate years has been 26 bushels, thus leaving 8 bushels, or £2 per acre, for interest and clear profit. The nett profit of the crop of 1858, 30 bushels per acre (or 12 bushels over and above the outlay), was therefore £3 per acre; and, as I have before said, had the land been in better order, the produce would undoubtedly have been considerably more than this."

We now give Mr. Hallett's own description of his plan of "selection," as given in the "Journal of the Royal Agricultural Society of England," vol. xxii. Pt. 2.

"A grain produces a 'stool,' consisting of many ears. I plant the grains from these ears in such a manner that each ear occupies a row by itself, each of its grains occupying a hole in this row, the holes being twelve inches apart every way. At harvest, after the most careful study and comparison of the stools from all these grains, I select the finest *one,* which I accept as a proof that its parent grain was the best of all, under the peculiar circumstances of that season. This process is repeated annually, starting every year with the proved best grain, although the verification of this superiority is not obtained until the following harvest.

"During these investigations no single circumstance has struck me as more forcibly illustrating the necessity for repeated selection than the fact, that *of the grains in the same ear, one is found greatly to excel all the others in vital power.*

"Thus, on reference to the foregoing diagram (not given here), it will be seen that the original two ears together contained 87 grains. These were all planted singly. One of them produced ten ears, containing 688 grains; and not only could the produce of no other single grain compare with them, but the finest ten ears which could be collected from the produce of the whole of the other 86 grains, contained only 598 grains; yet supposing that this superior grain grew in the smaller of the two original ears, and that this contained but 40 grains, there must still have been 39 of these 86 grains which grew in the same ear. So far as regards contents of ears.

"Again, this year (1861) the grains from the largest ear of the finest stool of last year were planted singly, 12 inches apart, in a continuous row; one of them produced a stool consisting of 52 ears; those next to and on either side of it of 29 and 17 ears respectively; and the finest of all the other stools consisted of only 40 ears. By planting grains so as to form a plan of the position occupied by each when in the ear, I have endeavoured to ascertain whether this superior grain grows in any fixed place, but hitherto these endeavours have proved unsuccessful.

"We have thus far seen that 'pedigree' in wheat, combined with a natural mode of cultivating it, has increased the contents of the ears; let us now consider whether this combination can produce a number of ears equal to that usually grown per acre under the present system. . . . . ."

"In adopting my system upon a small experimental scale, say of a few acres, the best apportionment of seed to time will generally be as follows, the grain being dibbled singly in holes not exceeding one and a half inches deep at the distance:—

	Between the rows.	In the rows.	Quantity of seed.
In August or early in September	9 inches.	9 inches.	=1 bush. in 6 acres
In September	9 ,,	6 ,,	=1 ,, 4 ,,
In October	6 ,,	6 ,,	=1 ,, 2¾ ,,
Towards end of March .	6 ,,	4 ,,	=1 ,, 2 ,,
After October	6 ,,	3 ,,	=1 ,, 2 ,,

But in carrying out this system upon a large scale, we require some way of getting in the seed more expeditiously than can be done by dibbling.

"My principal object in dibbling is to ensure perfect singleness and regularity of plant, with uniformity of depth. The two latter may be obtained by the drill, as may the former, also, by adopting the following plan:—The seed cups ordinarily used in drilling wheat are so large that they deliver *bunches* of grains consisting of six or seven, which fall together within a very small area, from which a less produce will be obtained than if it had been occupied by a single grain. The additional grains are thus not only wasted, but they are positively injurious. By using seed cups, however, which are only sufficiently large to contain one grain at a time, *a stream of single grains* is delivered, and the desired object, viz., plants from single grains, at once attained. The intervals in the rows will not be uniform, but they may be afterwards equalised by the use of the hoe, if it be thought necessary. These intervals will of course depend upon the velocity with which the seed barrel revolves, which can be regulated at pleasure by a proper arrangement of the cog-wheels which drive it; but it will be necessary to fix upon the nave of the travelling-wheel of the drill itself, a larger cog-wheel than is in common use. I have had these nave-wheels made to shift with facility, so that the drill may be easily rendered again available for general purposes. By drilling thus we obtain the advantage of the "broadcast" system also—*equal distribution*—as we can have the rows as close together, and the grains as thin, *in* the row as we please. The crop should be hoed, as soon as practicable, with Garrett's horse-hoe. If the seed has been sown early, this should be done *in the autumn*, as it causes the plants to tiller and occupy the whole ground before the winter sets in."

It is right to state that the correctness of this "pedigree" theory is doubted by many authorities. The following, from the pen of Mr. P. Sherriff, of Haddington,—a gentleman who has devoted much time to the cultivation of the cereals, and to whose care we owe many new varieties,—will be suggestive on the point. It was communicated to the *Agricultural Gazette*:—

"While the writer in question," says Mr. Sherriff, "advocates improvement in cereals by adopting all the artificial appliances of good cultivation, I contend that cultivation has not been found to change well defined kinds, and that improvement can be best attained by selecting new and superior varieties, which nature occasionally produces, as if inviting the husbandman to stretch forth his hand and cultivate them.

"It has been my fortune to have raised, either from single seeds or ears, no less than seven varieties, which are extensively grown in many parts of Britain. Besides these, I have selected and grown in the same manner about two hundred varieties, personally planting, hoeing, administering nourishment, reaping, and performing all the other manipulations necessary to their growth and the reproduction of a succeeding race, without having observed any tendency towards improvement. I have also walked thousands of miles through waving wheat-fields in ear, enjoying the beauty and diversity which such crops not unfrequently present. Grain samples without number have come under my notice, yet I may with safety say that I have never seen grain which has either been improved or degenerated by cultivation so as to convey the change to the succeeding crop. The meaning of the word cultivation must, however, be limited to the application of substances to the soil and the ordinary acts of husbandry, but excluding the artificial impregnation of florets. Should the cereals ever become broken or inconstant, as many domesticated plants are, something may then be done in giving fixity to a property.

"While believing the improvement of the wheat plant by mere cultivation to be a dream, I admit that an attempt to investigate this subject may be praiseworthy, as it is most certainly harmless."

Mr. Hallett, in reply to many such objections, writes to the *Mark Lane Express* as follows :—

"The principle alluded to is that of the continued selection of the best parent plants (as proofs of the best grains), which selection, for the sake of brevity, I call 'Pedigree.'

"The most vigorous parents can be ascertained only when all have free play for the full development of their powers, or, in other words, when each grain has allotted to it all the space which it can possibly require. Hence the absolute necessity upon the selecting plots, and there only, of a mode of planting which some people choose to term 'thin seeding.'

"The practical value of 'pedigree' consists in its offering the only possible means of increasing the produce of the cereals, and in its universal applicability to all cereals in all countries wherever they are grown. It is this great principle which I wish to keep prominently in view, of which my wheat is only an illustration. The value of this principle is to be measured, not by even the most triumphant success of my wheat in competition with other varieties, but by its successful competition, after selection, with *itself* in its original state, and in its various stages of selection.

"Let us supply this test of what 'pedigree' has effected, both upon a small scale and a large one. First, then, upon the selecting plots, where the land, the mode of planting, the seed, and the absence of any special preparation have been the same throughout. In five years, only, the length of the ears has been doubled, their contents nearly trebled, and the tillering power of the plant increased eightfold. Here it is absolutely impossible to suggest any cause other than selection for this enormous increase.

"In 1861, when I grew the Common Nursery wheat for the last time, I had a practical proof afforded me, upon a large scale, of the value of 'pedigree.' Two fields of the Pedigree wheat—the one planted at the end of October with 1 peck of seed per acre, the other drilled November 20, 1860, with 6 pecks of seed per acre—produced respectively, 57 bushels of wheat, with 140 trusses (36 lbs.) of straw, and 54 bushels of wheat, with 112 trusses of straw; while upon no single acre of all my other Common Nursery wheat (the very same, except as regards selection) had I as much as 32 bushels."

A practical farmer writes also on the point to the journal already named, thus—

"From all I have yet read and seen, I think the position taken up by Mr. Sherriff has never been demolished, and it will require far stronger facts than those hitherto adduced to prove that it is possible so to treat seed corn that it becomes capable, like the improved Short-horn, of continuing the same valuable qualities under other circumstances than those under which it was reared. Of course, I do not consider that the most careful selection, and the most thorough cleaning, has anything to do with the new doctrine of pedigree. That is the old system, and I maintain the only system worth following. Not a few farmers I know have raised their oats and barley and wheat from a bushel or two of each picked out of many quarters; but whoever heard of any such ever attributing to grain so raised and kept up the same properties which pedigree in cattle confers. The most I ever heard said was that the seed was clean, true to kind, and of fine form and colour."

But, on the other side, Mr. Hewitt Davis asks—

"Are not show fruit, roots, and plants gained in the way? (Selection.) Having seen year after year how much finer was the produce from what was then thin seeding, I thought there was much to be done by combining careful selection with it. I had seen what had been done in this way in strawberry growing. Thirteen years ago I set two women in a wheat barn immediately after harvest, and had the top sheaves of wheat thrown to them off the bays, for them to draw out the finest corn. The grains from these selected ears I had carefully cleaned and made up, so as to leave only the finest and heaviest grains. In this way I collected a bushel of extraordinary fine seed, which I had drilled by itself in a corner of a field, a foot apart, and two pecks to the acre. In the spring it was twice hoed by Garrett's hoe, and carefully hand-weeded, and kept perfectly clean up to harvest. The ears from this seed grew higher and were larger than the remainder of the field, sown a bushel to the acre: there was more straw at harvest and the grains were finer, and I at once saw an opening for further improvement; but as I relinquished my farming that year, I have never had the opportunity of carrying out my views, although convinced that much was to be done in this way. In going round the Exhibition I have been struck with the beautiful samples of grain that are exhibited in some of the foreign stalls. What an opportunity is there offered for selecting and originating new varieties. I hope some of my friends will read my practice, and be induced to make trials of them. Let them get their land freely worked down and well consolidated, and drill twelve inches with one-half the quantities I used as early as possible, and they will come out powerfu competitors in the race now commencing in establishing Pedigree seed."

Such is the state of the question, a much disputed one, like nearly every other connected with agriculture. From a careful review of the evidence on both sides, in conjunction with experiments of our own, we are inclined to hold that it will be unsafe to maintain that the "selection" principle will hold good in all cases. The tendency of plants seems to be that they improve, under careful treatment, up to a certain point, after which improvement ceases, and degeneration frequently ensues. The maintenance of an improved quality is probably a much more difficult matter than the introduction of one. In growing seed from carefully selected ears of wheat, we have not found so direct an improvement in the succeeding crop as we were led to expect; on the contrary, the seed from very large ears did not maintain its character, but produced less and smaller ears. Some maintain that the best way is to grow from inferior ears, and trust to careful culture for an improvement. It is probable that more immediate results of a satisfactory kind will be obtained by so doing than by trusting to the more elaborate yet more tedious method of "selection." We have two ears before us—one, which is one-third larger than the other, belongs to the plot which had the most advanced treatment of the day given to it—the other to that which was left to itself on the "let-alone" system, too often prevalent. One has but to look at the two to note at once the marvellous difference between them. In both cases the seed and the soil were the same.

Barley belongs, like wheat, to the natural order of plants—the *gramineæ,* or grasses, the genus being known as *hordeum.* The varieties are, according to various writers, numerous. According to Dr. Lindley they are merely variations from the original, which he considers to be the two-rowed barley. He, however, classifies them as two—the "*two-rowed barley*" (of which an illustration is given in Fig. 4), of the variety known as the "Baugholm," and the "six-rowed barley" (of which an illustration is given in Fig. 5). To these two species, Professor Wilson deems it advisable to add a third—the Common Bere, or "four-rowed barley," this being so regularly cultivated "as to assume, at all events, the physical characters of a distinct species." The varieties of barley are very numerous, Mr. Lawson enumerating as many as twenty-five distinct ones. Of the "two-rowed" barley, the following are favourite varieties:—(1) The *Chevalier,* highly esteemed, and greatly grown for malting purposes; (2) the Annat

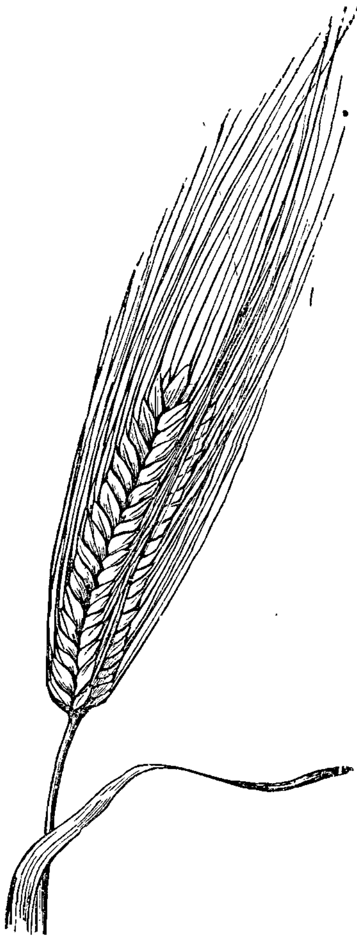


Fig. 5. SIX-ROWED BARLEY.

Fig. 4. BANGHOLM BARLEY.

(3) the Early English, or Common; (4) Nottingnam Long-eared; (5) Pomeranian, or German; (6) Norfolk Short-necked; (7) Bangholm. Of the *Bere,* or "four-rowed" barley may be named—(1) The "Common Bere, or Bigg;" (2) the "Black four-rowed;" (3) Victoria Bere; (4) Winter White; (5) Peruvian. The characteristics of all these varieties will be found in Professor Wilson's work, "Our Farm Crops."

The preparation of the soil for the barley crop does not differ in material respects from that for the wheat. The best soil for the crop is a mellow loam, and the condition in which it should be at the time of sowing is moist but not wet. The barley is distinguished in its growing capacity from the wheat by the *fibrous* bunch of roots which it sends out more laterally than vertically, wheat throwing down, under favourable circumstances, long vigorous roots which have more of a vertical than a horizontal tendency. Firmness in the soil, so much desired for wheat, is therefore not required for barley. On the contrary, it must be deeply stirred, well pulverised, porous, and of rich quality. Fortunately, the crop being almost invariably taken after turnips, the previous working of the land tends to bring about this condition of the soil. In no case, if it can be at all avoided, should barley be sown in soil wet and ill worked.

The quantity of seed per acre is usually three bushels, but in very poor soil this may be increased to four. Thin sowing has its advocates for barley as well as for wheat. Dibbling seems to be peculiarly well suited to it. We have been very successful in our dibbled barley, not only in securing a fine quality and large quantity of grain, and strong, long, and vigorous straw, but also a much earlier ripening than when drilled. Of the varieties recently introduced is the "Providence Prolific," a two-rowed barley. We have had this year (1862) a pretty large plot dibbled. Each hole was made nine inches apart from its neighbouring hole, and into each a single grain was deposited to the depth of about one and a half inches. The average produce of one grain we find to be thirty-six ears, each ear averaging thirty-six grains. As a rule, barley is more frequently broadcasted than drilled. But drilling is, so far as our own experiments induce us to believe, by far the best. Like all other cereals the growing crop is greatly improved by the light and air having abundant access to the plants. We therefore would recommend the drilling to be adopted; but in place of the distance being so narrow as six to nine inches, as is usually the case, we would increase it to twelve inches. On comparing barley sown on the narrow and the broad drill system, it is at once abundantly evident that the broad is the best. Wide distance would moreover facilitate the hoeing between the lines, and the keeping down of the weeds. These operations are not usually carried out with the barley crop, but they are as valuable to it as to the wheat crop. A disputed point in connection with the barley crop is the time of sowing; this is usually in March or April. But with this crop, as indeed with all others, early sowing is decidedly on the increase. Barley is by no means a delicate crop, and it may be sown *very much earlier* than usual. Professor Wilson suggests that the crop would stand the winter well in most parts of the south and west of England, and would tiller out in early spring so as to afford a good deal of spring-grown food for stock. We have partly adopted this suggestion, and have found the benefit of it in a comparatively large supply of green food at a time when it was most acceptable.

Artificial manures are now much used for the barley crop, in common with the other cereals. For *sandy soils,* a dressing of one hundredweight each of nitrate of soda, with common salt, applied when the plants are well up, would be beneficial. For *calcareous soils,* the same might be applied with advantage. In *loamy soils,* where the barley follows the turnip crop,—as it usually does,—artificial manures will not, in favourable circumstances of soil and climate, be required; where the crop appears poor and sickly, a top-dressing of one hundredweight of nitrate of soda and two of salt per acre will be found advantageous. The following from the pages of the *Scottish Farmer* on the cultivation of barley will be useful :—

"On soft land, farm-yard manure laid on in autumn or early winter is the best application for barley for improving or stiffening the straw. The most available form in which silicates can be presented to grain crops seems to be in the decayed straw. When early sowing is followed, farm-yard manure imparts health and strength to grain crops on all inferior and soft soils. Now here is this fact more fully observed than in peaty soils. Yet it is not an uncommon error both among practical and scientific men to recommend a different course of treating such soils.

"On clay lands deficient in vegetable matter, no light manure can be reckoned upon so certain in its effects for barley as Peruvian guano. Where clay is sound and strong, it requires a large quantity of guano to produce over-luxuriance. On other descriptions of land, however, phosphatic manures can often be applied with the best effect. In ordinary cases, these cannot be advantageously given to early-sown barley, for the simple reason that the plants grow slowly, and can pick up phosphoric acid as fast as they really require it. Men of science have been slow in recognising the important considerations that are practically bound up in this fact. Thousands of pounds are every year thrown away in giving grain crops dressings of phosphoric manures when these are of little service. We must remember that a great deal of our best lands contain abundance of phosphates to grow hundreds of crops of turnips or barley, but the roots of late-sown and quick-growing plants cannot obtain it as fast as they are capable of digesting it, when stimulated by a high temperature. The common wild mustard requires a large amount of phosphates for its growth. Wherever this weed is found flourishing in our fields in spring, it may be regarded as a good index of the soil being comparatively rich in phosphates. And hence, the practical rule may be laid down, that unless barley is sown far on in May, when its growth is very rapid, it will not be benefited by superphosphate if the soil is infested with wild mustard. A good deal of barley must now be sown late, and it is worth keeping in mind that superphosphates applied in May will push the crops rapidly forward, without inducing the gross and lusty growth that guano is apt to encourage on soft or rich soil. Superphosphate, too, will often do not a little in the way of making amends for imperfections in the pulverising processes. As the season of barley sowing advances, therefore, superphosphate of lime may gradually become a more prominent component in artificial dressings."

Oats—*Avena* is the name of the genus of this order of plants, which, like the barley and the wheat, belong to the *Gramineæ*, or grasses. The species are very numerous; but for all practical purposes these may be divided into two classes—the *Avena sativa*, or common oat; and *Avena orientalis*, or Tartarean oat. The principal characteristic of the common oat is, that the seeds grow out from the central stem on all sides, as shown in Fig. 6; in the Tartarean oat the seeds grow out from one side, as shown in Fig. 7.

The varieties of these two classes are very numerous. Of the "common oat," Professor Wilson enumerates the following:—(1) the Potato; (2) Hopetown; (3) Sandy; (4) Angus; (5) Early Angus; (6) Late Angus; (7) Grey Angus; (8) Blainslie; (9) Berlie; (10) Dun Winter Oats; (11) Dun Common Oats; (12) Friesland; (13) Barbachlan; (14) Poland. Of this variety there are two kinds, the black and the white.

The crop can be grown on a very wide range of soils. Their preparation is almost identical with that of wheat, the roots of the plant following nearly the same law as those of wheat. The quantity of seed is usually from two to six bushels per acre, according to soil and climate. Thick sowing is, upon the whole, better adapted for the crop than thin, as the plants do not "tiller" out to the same extent as barley or wheat. For this reason we have have not found "dibbling" of oats to answer; the yield, both of straw and grain, is decidedly greater, but we do not, nevertheless, think it repays the extra cost of labour required to put in the crop in this fashion. The period at which the oat crop should be sown is disputed—some advocating early, some late sowing. Our own opinion is decidedly in favour of early sowing. We have this year followed the plan already shown to have been suggested by Professor Wilson in connection

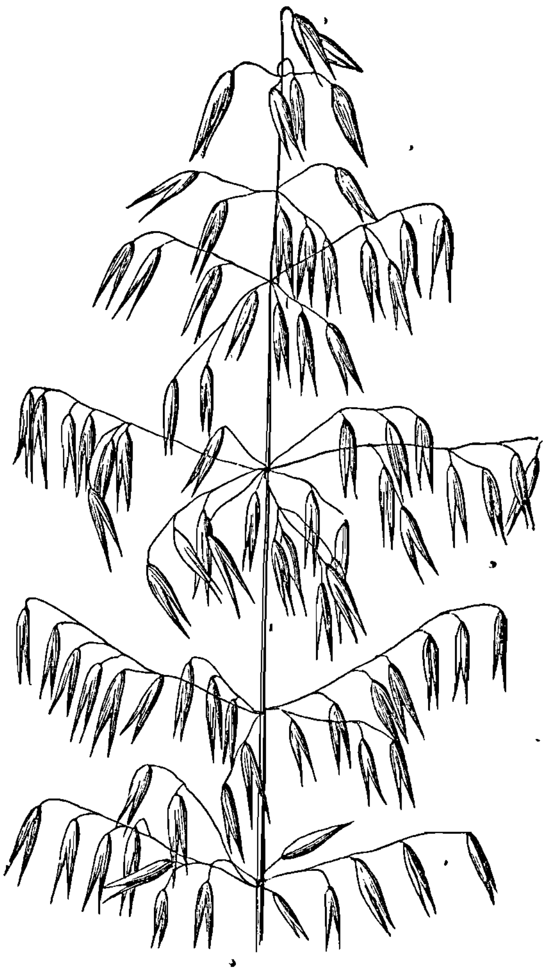


Fig. 6. COMMON OAT (POTATO).

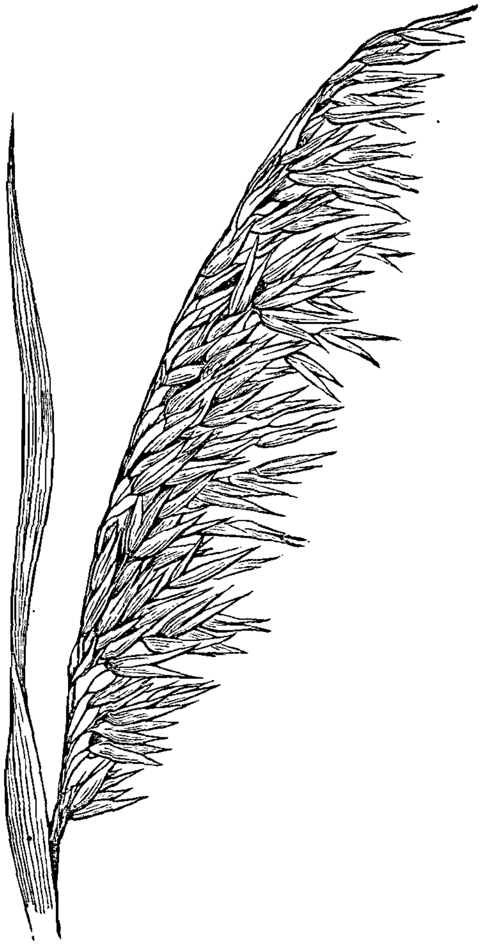


Fig. 7. TARTAREAN OAT.

with the barley crop, and have obtained this spring, at a peculiarly acceptable time, a large quantity of green food. Drilling is, perhaps, the best mode of sowing the crop, although not so general as broadcasting; drilling will afford facilities for cleaning the land between the rows and keeping down the weeds.

Oats are usually taken after the grasses; they rarely take a place in the rotation of a light land four-course farm. Where taken after "lea," that is "grass land," in *sandy soils,* artificial manure may be applied at the time of sowing with great advantage, this consisting of 2 cwt. of Peruvian guano per acre. A top-dressing will, however, be applied with benefit in addition to this, when the crop is well up, of 2 cwt. of salt, 1 cwt. of nitrate of soda, per acre. In *calcareous soils,* 1 cwt. of nitrate of soda and 1 cwt. of salt. In *clay soils,* an application of 2 cwt. of Peruvian guano at seed-time will generally wonderfully improve the crop. For *vegetable moulds,* 2 cwt. of salt with 3 cwt. of super-phosphate will be beneficial. In *loamy soils,* 2 or 2½ cwt. of Peruvian guano at seed-time; if a later dressing is required, 1½ cwt. of sulphate of ammonia, and 2 cwt. of salt. We give the following on the cultivation of the oat:—

"Early ploughing being preferable, the land is harrowed down after lying for several weeks, and then it is gone over with the small one-horse stripping plough. The furrow slices are by this means to a great measure broken. The land is rendered pliable and loose, while there is a capital bed formed for the seed, which on being broadcasted comes up into rows, and can be hoed and kept clear of weeds. By this method, too, guano and other special manures, on being sown along with the grain, come at once in contact with the roots. This particular mode, well suited for late sowing, has been coming into use of late years in many districts, and is considered to amply repay the extra labour which it involves. There are others, however, who consider that quite as good results are obtained by ribbing the land pretty early in the season. Afterwards the ribs are harrowed down, and then the land is ploughed across with a common furrow. This method leaves it broken, and the seed can either be sown with the hand or by the drill. When it is deemed advisable to sow barley after lea, this process for assisting in breaking and pulverising the soil is much in use. The roots of barley are less vigorous than those of the oat, and thus require more assistance in the way of cultivation. At the same time, however, the oat is grateful for any extra labour bestowed in securing facilities for its roots penetrating the body of the soil and gathering its food.

"On deep and good loams the oat will admit of being dressed liberally with artificial manure. On such, from 3 to 4 cwt. per acre of guano can be used with advantage; and where clay abounds in the soil, these quantities might even be increased. On light and thin land, however, guano should be used more sparingly. An allowance of 2 cwt. per acre on an average of seasons will pay better than a larger dose, as droughts will often stint and dwarf a crop, however well it may be dressed."

Rye, the last of the cereals now demanding our attention, belongs to the natural order of *Gramineæ*. There is only one species, the *Secale cereale*. The crop is now rarely cultivated in Great Britain, although greatly in vogue on the continent. The principal varieties are the spring and winter ryes. The quantity of seed is the same as for the wheat crop.

The *Harvesting* of the cereals now demands our attention. And first, as to *Wheat*. As soon as the straw immediately below the ear turns yellow, the grain is fit to be cut. All authorities nearly now agree that there is a decided gain in cutting wheat before it is dead ripe. If allowed to stand in this condition, and to be caught by rain, sprouting is pretty sure to set in, not only deteriorating the sample, but, as experiments have shown, greatly lessening the nutritive value of the grain. When the heads of *Barley* begin to droop, and the ear assumes the yellowish hue, cutting should be commenced. *Oats* should be cut before fully ripe, even although the straw should have a greenish hue. If allowed to stand till dead ripe, a very large per centage of the grain will be "shed," or knocked out, during the process of reaping and housing.

Grain is cut in three ways—by the sickle, the scythe, and by reaping machine. For some interesting details as regards the relative cost of two of these modes—the first of which is rapidly falling into disuse—see the following evidence of a practical farmer, given by Mr. J. Chalmers Morton in his valuable paper on "Recent Agricultural Experience":—

"The past season has severely tested the merits of the several reapers. In no season have the corn crops been so much laid, or so full of grass and weeds, making it very difficult for any machine to work without clogging. The reaper used by Lord Rivers this season upon one of his arable farms of 600 acres, is one of Cuthbert's one-horse reapers, an implement noted for its simplicity and strength, and upon this farm it has proved itself a very clever and efficient one, going through the whole of the past harvest without costing a fraction for repair, cutting crops which were very much laid in the most satisfactory manner. Its work is far preferable to the work of the scythe in all crops, but more especially in the barley crop when it has become dead ripe, and the ears bent, and nearly beaten into the ground. It is well known that the scythe in this case does much damage by cutting off the ears to a very serious extent, which is almost entirely avoided by the use of a reaper set to work low.

"The despatch in harvest operations in such an unpropitious season as the past, has been greatly assisted by the use of a really good reaper, and those who have had the good fortune to possess one will not readily be persuaded to do without one in future.

"My own practice during the past wet harvest has, generally speaking, been to keep on cutting oats and barley, and, when a fine day or two *did* occur, to send the reaper into the wheat (the wheat being dead ripe), and cut, bind, and cart at the same moment, stacking it in small ricks, thus making rapid progress, showing the advantage of machinery over hand-labour.

"Despatch is not its only recommendation, for it leaves a balance in money in its favour in comparison with hand-labour.

"The following figures will show the comparison between the two systems on this farm:—

By Hand-labour.

Reaping, tying, and stooking, 10*s.* to 12*s.* per acre.
Mowing, tying, raking and stooking, 7*s.* to 9*s.* per acre.

By Machine.

	s.	*d.*
2 men, at 5*s.* each per day	10	0
1 boy	1	6
Oil, say	0	4
Food for 2 horses	4	0
For 10 acres	15	10

Or, per acre for the cutting, 1*s.* 7*d.*
For tying, stooking, and raking, 3*s.* 6*d.*
Total cost per acre by machine. 5*s.* 1 .

"The foregoing prices include beer, in every instance.

"Although this reaper is called a one-horse implement, it in reality needs two horses per day, the work being too hard for one, therefore they relieve each other at intervals; this is the usual practice; but I have found it much the best plan to feed the horses highly, and work them both at the same time throughout the day. The pace is quicker, the horses are less fatigued, and fewer stoppages occur. I do not work the same pair of horses two days in succession. This reaper may possibly cut an acre or two more than I have stated in a very dry season."

The mode of setting up grain after it is cut varies very much—some districts adopting one, some another method. A very general way is to place the sheaves —each sheaf averaging eleven inches in diameter—in two rows, of five or eight each on a side; these lean against each other at the top, and the feet spread out a little; two or three inverted sheaves, or caps, cover the whole. In wet or doubtful weather the circular plan of making stooks is a good one. In this, five or eight sheaves are placed in a circle, and arranged to form a cone, the heads all meeting at the top as close as possible; the whole being covered with an inverted sheaf. This should be put carefully on, one man holding it while another opens the ears out fan-fashion, so that when placed in position they will cover the heads of the standing sheaves. The following note from the *Agricultural Gazette* will, on this point of stacking grain, be of use:—

"When bagged, *i. e.*, cut with strokes of the heavy hook, up against the standing corn, and then gathered into a sheaf, it ripens more rapidly in the sheaf, and is sooner ready to carry in dry weather. The sheaf is looser and more rapidly penetrated by the weather whatever that may be. In the south it is common to lay the sheaves together, five or six of a side, without any head sheaves. In the north, it is more common to use head sheaves, the whole stook consisting of twelve or fourteen sheaves, five or six of a side, and two over all. These two are tied near to their lower end, and the two men employed in setting up the sheaves having placed them five or six on a side, thrust the ends of these two sheaves together, and each holding his own sheaf with both hands on the under side, the two are lifted, the under side of each is half opened, and each is made to embrace the standing sheaves at either end of the stook. In Warwickshire they set up the sheaves two or three of a side, and the two head sheaves are bound together after being placed above the standing sheaves, so that the whole stook is made one piece; and when the wheat has been hand reaped and a tolerably high stubble left, the sheaves being thrust down upon it, take firm hold of the ground, and are not easily overthrown by wind. And when they are thus tied together with head sheaves, they are as impervious to the weather as it is possible to make them—drying slowly, throwing off the rain perfectly; but if ever wetted through, being very difficult to dry again."

In wet weather the best mode of setting up the corn is a matter of the greatest importance. The extremely unfavourable weather of 1860 brought out many communications on this point, from which the following selections will be useful:—

"First set two sheaves well up in the furrow, then two crosswise, pitched on the edge of each land or stetch; these will protect the other two. There will be, thus far, four small, loosely-tied sheaves, with a foot to each of the four points of the compass. Now for the fifth sheaf: I think this should be a little bigger; tied up rather further from the ears; open it for a hood-sheaf, and drop it over the other four, ears downwards. This seems very simple in theory, and I hope practice will prove that there is a germ of something good in it. Or four sheaves set up in the usual way might be so protected; then there would be none in the furrows."

"Every tub must stand on its own bottom. In compliance with this, the bottom of each sheaf must be made to cover a sufficient area of ground, and the two sheaves opposite each other not be set too far asunder. The two sheaves, one in each hand, then get a gentle pressure down, to make them sit, as it were, sure on their seats. Their tops are next spread together, where they meet, like the thatch on the top of a stack thatched after the English fashion, in order to make them defend a shower. The simple but important art of setting a stook, depends upon each couple of sheaves being thus seated firm upon the ground together, at proper distances from each other both ways. All this, too, is but the work of a moment to an efficient stooker; and nothing can be more unpardonable on the part of farmers, especially in a wet season, than to tolerate the slovenly performance of a work upon which so much depends.

"Where wheat is reaped with the hook or sickle, and the stooks hooded, the difference of detail requiring notice is the putting on of the hood sheaves. In this, the same artistic attention is required to bring the sheaves to an acute angle at the top, as if no hoods were to be used. When the crop is too ripe, the ears large and hanging, the task is often next to impossible, especially when the straw is short, and the top, or ear-end of the sheaf is thicker than the butt. The work, however, is more easily done with the small sheaves of a wet season than the ordinary size of a dry one; and whenever the top of the stook is too broad or flat, lay on a small sheaf along the top, then over this put the hood sheaves, taking care that the whole are standing right."

"A number of sheaves are placed upright on the ground, forming a circular base, with a diameter of four yards, and on these are built successive courses, gradually forming a top, the 'butts' of one course reaching to the 'bonds' of that below. In this manner, taking care to keep the middle filled up, from one to two waggon-loads of sheaves are speedily secured, and are safe from injury by rain, as each course of sheaves runs the water from off those below it. I adopted this plan in the beginning of this harvest, and with six to eight men followed the work of nine scythes, and each day secured the wheat that was cut, taking care only to have it cut while straw-dry."

"For the convenience," says Mr. P. Love—in a paper in the last part of vol. xxiii. of the Royal Agricultural Society's Journal, "On Harvesting Corn," in which will be found much valuable information—"of autumn cultivation, all crops should be cut low and shocked up in straight parallel rows, pretty wide apart, so as to allow cultivation to proceed, even though the weather should retard the cutting of the crop. It is well known that bagged, mown, and machine-cut corn does not bind so closely in the sheaf as when reaped, therefore the wind and air more rapidly extract the moisture out of the grain and straw of the former than the latter; consequently all those crops that are bagged, mown, or machine-cut, are sooner fit for carting than reaped ones.

"The best situation for stacks is an exposed one, open to both sun and air; and they should not be set too close together, that wind and sun may the more freely operate upon them; also that in case of a fire it may not spread from one to the other, also that the engine and thresher may be set down on the lee side while threshing out the grain. The best position for stacks is by the side of a good hard road; and if they are long stacks or ricks, the ends ought to stand north and south, that the sun may shine equally on both sides. We do not believe that the system of setting stacks in the fields where they grow is the most economical; they should be placed on the most convenient spot as near the homestead as three carts, when carrying the crop, can deliver them; on the threshing day, the earings, chaff, and grain will then be within a moderate distance for carting to the straw barn and granary, and the straw must be stacked till wanted, when it may be carted home by teams when returning from field work.

"The working of the portable engine and threshing machine has shown how inexpedient it is to waste a fine day, fit for threshing out of doors, in carting crops into the barn to be there threshed; in fact, barns to hold crops in the straw are no longer required, and should be converted into places for preparing food for cattle, or stalls for feeding, with a good plaster-floored granary above. When new buildings are erected, all that is required as stowage for corn is a granary, which should be erected over a good cart and implement shed.

Instead of barns, what is now most required are places for cutting chaff, pulping roots, grinding corn, and breaking oil-cake; in fact a food factory, where the straw, roots, &c., can be manipulated into food containing all the elements found in the richest feeding pasture, which develops both fat and flesh with economy and despatch. Thus we may produce a harvest of beef and mutton equal to the requirement of our fast increasing population."

DIVISION FOURTH.

THE LEGUMINOUS CROPS, CULTIVATED FOR THEIR SEEDS: BEANS—PEAS.

THE leguminous plants cultivated for their seeds, as beans and peas, serve important purposes in the farm economy connected with the feeding of stock. Beans belong to the natural order of *Leguminosæ,* and the genus is named *Faba vulgaris.* There is in reality only one species; but the usual method is to classify two, namely, that usually grown in gardens termed *Faba vulgaris hortensis,* and that grown on farms *Faba vulgaris arvensis;* to these two a third is sometimes added, which is adapted for either garden or field culture, and is therefore known as *Faba vulgaris hortensis vel arvensis.* There are several varieties of the Field bean. (See Fig. 8.) Professor Wilson enumerates the following:—(1) Scotch, or Horse-bean; (2) Tick; (3) Winter bean; (4) Heligoland; (5) Mazagan; (6) Amfield; (7) Pigeon.

The bean requires and thrives best in strong, calcareous soils, of which the condition is deeply cultivated, to enable the roots to descend freely, and firm as for

Fig. 8. FIELD BEANS.

wheat, and free from all superfluous moisture. The usual place in a rotation is after corn. The stubble is cleaned immediately after harvest, and the manure is then spread and ploughed in, and the soil left in a rough condition to be acted upon by the atmospheric influences. In place of thus ploughing the manure in at autumn for the spring crop, it may be ploughed in at spring. If cultivated, as in good farming it ought to be, as a fallow crop, the great service done by it is to serve in cleansing the land. To aid in this the beans should be drilled, *not broadcasted; the seed is usually dibbled; the* quantity of seed per acre is, on an average, four bushels for spring, and one and a half to two bushels for winter beans. The time of sowing the spring crop is in the months of February and March. The winter crop should be got in not later than the middle of October. The distances between the drills and dibbled stools vary from nine to thirty-six inches. We have grown beans at a very wide range of distances apart from each other in the drills, and at different distances between the drills; and the result of our experiments go to convince us that the width between the plants should be given in the drills, but the plants in the drills should be thick set. Give, in fact, plenty of light and air between the drills, but sow thick *in* the drills. On this point of distance, and on the use of the bean crop as a fallow crop, a writer in the *Farmer's Magazine* has the following suggestive remarks:—

"When the ground is pretty clean, and horse-hoeing is not required, the rows may be twelve or fifteen inches apart; but a very common cause of deficiency of produce is drilling too closely: the beans will flower from top to bottom, if we only give them space for the admittance of light and air—and it is flowers and pods, not straw, that we want. We have frequently grown crops of beans having stalks six to eight feet long, and with a small yield of corn; and we believe it is as much the truth of beans as of other grain crops—if you practise thin-seeding, take care that you have plenty of seed *in each row*, but let the saving of seed be in having the rows widely apart. You thus secure regularity and sufficiency of plants, while great space is provided for their full development. One of the most valuable uses of the bean crop is for enabling land to be cleaned or foulness kept in check by horse-hoeing, while at the same time a profitable yield of grain is obtained. In single rows two feet apart, or in double rows one or less than one foot apart, with two-feet intervals between, beans are horse-hoed or skeleton-ploughed, and, when in full flower, moulded-up by the double-winged plough as potatoes are, to prevent lodging and loss of corn. . . . The drilling of beans at very broad distances, and pursuing a system of tillage between, is not nearly so generally adopted as it might be with very great success. We have seen winter beans *in single rows five feet apart* yielding fifty imperial bushels per acre; the manuring, of course, being very high, the tillage exceedingly deep, and the hoeing followed up with frequency." The depth to which beans should be sown is not less than two, or more than three, inches. Lime is especially useful to the bean crop, and should form an essential part of every soil in which it is cultivated. Dressings of gypsum, with sulphate of potash, 2 cwt. of each to the acre, will be found beneficial in sandy soils. In loamy soils a top-dressing worked in by the hoe of 2 cwt. Peruvian guano, or 2 cwt. of superphosphate, and ½ cwt. of sulphate of ammonia, will be beneficial. In clay soils a stimulating manure, say of from 2 to 3 cwt. of Peruvian guano, applied as a top-dressing in April, will increase the yield.

The following, from an able authority, will be useful in the cultivation of beans:—They "are occasionally sown after the year's clover lea, and we know that some growers are well satisfied with the results of this system; but the usual place in the rotation is after a corn crop. In this case it is advisable, if the weather is favourable, to scarify or light plough the land during autumn, afterwards harrowing it, and picking off all loose weeds. This will be of great service in the after-culture of the crop, by keeping the land in a cleaner state than it would otherwise be, because, owing to the early period of the year when beans are sown, and the often uncertain state of the weather, it is not usually possible to do much towards cleaning at sowing time. The land being scarified, &c., dung may be carted out and spread over the field, at the rate of twelve to fifteen tons per statute acre, and then ploughed down with a strong furrow. When the land is well drained and moderately level, this furrow is sometimes given across the usual line of ridges. Previous to sowing, the land is harrowed, and, if necessary, grubbed, so as to break down the surface, and then drilled, the drills being twenty-seven inches apart, in order to allow the after-culture, by horse-hoeing, to be properly carried on. Four bushels of seed per statute acre are drilled by a machine constructed for the purpose, the drills being afterwards closed by the plough. When autumn cleaning cannot be effected, the dung is spread on the stubble and ploughed down; and it is of importance that the winter ploughing is got over as early as possible, so as to expose the soil to the action of the weather. Some leave the dunging of the bean crop until the time when the seed is sown, when the dung is put into the drills, the seed being sometimes drilled under the dung, that is, previous to the latter being spread in the drills; and at other times above the dung, both dung and seed being covered by the plough splitting the drills. When it possibly can be done, we consider dunging previous to the winter ploughing the most advisable system, because by this means the work is got out of hand, thereby occasioning less labour at a busy season, when it is of consequence to take advantage of every dry hour, and besides, it is easier to dung on the stubble than on the ploughed land, and there is less damage done by carting on the land during autumn than at a time when it is not, perhaps, in a very dry state. At the same time, it is not advisable to work the land and sow the seed when the former is wet.

"Beans are sometimes sown without forming drills specially for the purpose of receiving the seed. This is done in the following manner:—The winter furrow is harrowed down, and three ploughs are set to work to plough the field in the ordinary manner; the seed is sown in each third furrow, so that the plants come up in rows about twenty-seven inches apart. The broadcast mode is also occasionally adopted, the seed being merely harrowed in; but as broadcast sowing does not admit of any after-culture, we do not think it generally advisable. It may do on clean land in good condition; but as a general rule, the drill system is the best. Broadcast sowing also requires more seed than drill sowing. Dibbling is also practised, especially in some parts of England, the holes being made two and a half or three inches deep, and from three to five inches apart, according as they are dibbled in each alternate furrow, or in every furrow. The seed is also dibbled in double rows, six or eight inches apart, a space of twenty-four to twenty-seven inches being left between each double row. In all cases of dibbling, the seed is covered by a light turn of the harrow. Beans are sometimes grown in Ireland in beds, the seed being covered by shovelling the intervening furrows, the earth obtained in this manner being cast right and left over the adjacent beds. The crops grown by this mode are never so equal as those which are grown in drills, and the bed system does not admit of that semi-fallowing which is of so much importance, both to the beans and the crop of wheat which follows. The bed system, in any case, is only a make-shift to compensate for want of drainage and for bad ploughing, the deepened intervening furrows acting to some extent in place of the former, whilst the earth obtained by sinking those furrows supplies the want of cover for the seed consequent on defective tillage.

"Peas are sometimes sown along with beans, the object of this being to secure a supply of pea-straw, with which to bind the sheaves of beans. The proportion of peas may be a fifth of the entire quantity of seed, when sheaf bands merely are the object, and the peas are easily riddled out from among the beans.

"In a fortnight or three weeks after the beans have been sown, a favourable opportunity must be taken to harrow the land; and in the case of raised drills, this will be best effected by the curved drill-harrow, a pair of which is drawn by one horse. The plants come up more regularly than they would otherwise do, in consequence of this harrowing, and it helps to prepare the way for the after-culture. The roller is also run over the land before the plants appear, and in some parts of England the rolling is not given until the plants are up, rolling at that stage being intended to prevent the beans running too much straw before blossoming.

"The after-culture consists in repeated horse-hoeing, or grubbing, and hand-hoeing the ground, until the plants have become so far advanced that the horses cannot travel among them without doing injury. Those beans which are grown in raised drills must have the earth laid up to them by the double mould-board plough, when the spaces between them have been sufficiently grubbed, &c. The effect of this mode of culture is not only to keep down the growth of weeds, but also, by the stirring of the soil, to bring beans under the class of fallow crops, which is not the case when the seed is either sown broadcast or drilled at such narrow intervals that horse-hoeing can only be carried on to a limited extent."

Peas.—The pea is termed by botanists *Pisum sativum.* There are several varieties of the Field pea, of which Professor Wilson enumerates the following:—(1) Common Gray; (2) Hastings Gray; (3) Warwick Gray; (4) Rounceval Gray, Giant or Dutch pea; (5) Partridge, Gray Maple or Marlborough; (6) Purple Podded, or Australian; (7) Winter.

The most suitable soil for the pea is a "light loamy, or marly character," and the mechanical conditions are freedom from superfluous moisture, the presence of lime, depth, and good manurial condition. Peas do not usually form part of a rotation, but they may be substituted for beans, which generally follow a grain crop. The quantity of seed per acre is from two to three bushels per acre in drills, four to six when broadcasted. The period of sowing the winter variety is the middle of October. The spring may be sown from February up to the middle of April. Following a stubble or grain crop, the land should be freed from weeds as early in the autumn as possible, ploughed and left in a rough state till spring, when the seed is got in. The farm-yard manure may either be applied in autumn or spring, and if lime is used in conjunction with it, the crop will benefit by the application. Peas may be sown in one of three ways, broadcast, drilled, or dibbled. Drilling, say at a distance of two feet will enable the spaces between the rows to be hoed in the early stages of the plants,—as they progress, they will spread over the soil, and keep down the weeds pretty effectually.

DIVISION FIFTH.

ROOT CROPS: TURNIPS—KOHL RABI—MANGOLD WURZEL—CARROTS—PARSNIPS—POTATOES—JERUSALEM ARTICHOKE.

Turnips.—Of all the root crops cultivated on the farm none yield in importance to the turnip. It is the main-stay of the farmer in feeding his cattle in winter, and in producing, through them, abundance of manure for his spring and autumn crops. Its culture necessitates careful preparation of the soil, and constant watchfulness during the various periods of its growth to keep down the weeds, which tend to lessen, and to keep the soil in that state which, on the contrary, is best fitted to increase its produce.

The turnip, *Common* and *Swede,* belongs to the natural order of *Cruciferæ,* the genus being termed *Brassica.* The species known as the *Brassica rapa* includes the Common turnip and the rough-leaved summer rape; that known as *Brassica campestris* includes the Swede and the smooth-leaved summer rape. Of the Swede turnip there are several varieties. Professor Wilson enumerates the following:—(1) Common Purple Top, or Lothian; (2) Skirving's Purple Top; (3) Matson's Purple Top; (4) Common Green Top, (see Fig. 9); (5) Fettercairn Globe; (6) Laing's improved Purple Top. The Swedish turnip is readily distinguished from the Common by the smoothness of its leaves, resembling those of cabbage, the leaves of the Common turnip being rough. The Common turnip is usually divided into two classes—the yellow and the white. Professor Wilson enumerates the following as good varieties:—(1) Common, or Purple Top Aberdeen; (2) Berwickshire Improved Purple Top; (3) Skirving's ditto; (4) Aberdeen "Green Top" Yellow; (5) Yellow Globe. The white varieties are numerous. Professor Wilson gives the following as good:—(1) The Common White Globe; (2) White Norfolk; (3) Stone Globe; (4) Stubble, or Autumn; (5) Tankard; (6) Norfolk Bell Tankard. Of the hybrid turnips, which possess in some degree the peculiarities of both Swede and Common turnip, that known as Dale's Hybrid is perhaps the best.

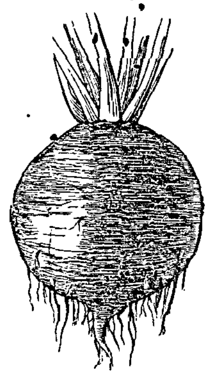


Fig. 9. SWEDE.

The quality of soil best suited for the turnip crop is a loamy one, easily worked into a fine tilth; deep, free from superfluous moisture, yet capable of retaining such a degree of moisture as best assists the plant to a quick and vigorous growth. Between the sandy and clays, which may be said to be the extremes, a variety of soils are met with which are more or less capable of producing good crops of turnips. For a long period turnips were seldom or never grown in clay soils; but now, in consequence of the beneficial effects of thorough drainage, and improved modes of working the soil, through the agency of superior implements, many of these soils are being rapidly, and have, in fact, been brought extensively into use as turnip soils.

In preparing the land for the crop, it is essential as soon as the crop—a grain crop—which precedes it is taken off, to thoroughly clean the land and rid it of all weeds; these being led off the land, and burned or added to the compost heap, the manure may then be carted and spread on the land, and the whole ploughed in, leaving the land with a good deep furrow. In spring time it is usually the case to cross plough the land thus left in autumn; but the disadvantage of this plan is, that it brings unmellowed soil to the surface, burying that which has been mellowed by the winter's influence. In improved farming it is now the practice to run a grubber through the winter-left surface—this being generally sufficient to prepare the seed-bed. If the turnips are to be cultivated on the "flat," this is all that has to be done; but if in the "ridge," the following is a usual mode of proceeding. The land is thrown up into ridges, by means of the double mould-board plough, and between these the farm-yard manure is thrown from the cart, and spread evenly out by means of dung-forks. The ridges are then split up by a plough, which covers the dung and forms a new set of ridges, which contain in their heart the manure. The sowing may then be proceeded with. The distance between the drills on the "flat," or the ridges, on the "ridge" system, is a disputed point in agriculture; usually they vary from twenty-four to twenty-seven inches. On this point, the following from a recent article in the *Journal of Agriculture*, No. 76, March, 1862, may be useful:—

"Narrow drilling in the present state of agricultural mechanics, and on an extensive scale, is not therefore practicable, even assuming that in point of acreable yield, it had some advantage over the system in ordinary use. It is well, however, to keep constantly before the mind of the farmer that science and practice alike coincide in showing that wide drilling is objectionable on light lands, and that on such lands the drills should not be wider than is absolutely necessary to enable the farmer to till his land properly, as the narrowest drills that will enable him to effect this object will give ample room for the bulbing of his roots. But this will not hold good in the better classes of land. If we attempt to grow green crops in sixteen or eighteen-inch drills on a rich or even a good piece of ground, we shall find the spaces completely filled up by the foliage before the crop is half grown; the circulation of air is impeded, and the plants will not develop as healthily as they would do otherwise. On the other hand, if, like some of our exhibition friends, we make our drills three and a half feet apart, and space our plants in the drills at intervals to correspond, and force on the roots by extra tillage and extra manuring, they will become so watery and spongey as to be comparatively worthless for feeding purposes. We had a clear illustration of this very recently, in a specimen of mangold which obtained first prize at one of our national agricultural exhibitions, and which we caused to be examined. It weighed upwards of a stone and a half, but it contained only 8½ per cent. of solid matter; while mangolds grown under ordinary circumstances contain 14 or 15 per cent. of it. These prize roots were raised on drills about forty inches apart, and thinned to about two feet asunder in the drills. In other words, each plant occupied a superficial area of six and two-thirds square feet, which is a waste of ground, manure, seed, and labour. We have made a good many experiments on a good deep, loamy clay in a first-rate climate for mangolds, and have generally found the greatest acreable yield when the drills were twenty-eight inches apart, and the plants thinned from ten to twelve asunder in these drills. But as we elsewhere stated, we do not advocate so small an interval as a general rule; a space of two and a half feet between the rows, and fifteen inches between the plants, will probably be more generally profitable. If, however, instead of making our drills twenty-eight inches wide, we extend the width to three feet, and thus lose two drills out of every nine, we would lose a very large number of roots per acre; and, bearing Mr. Sullivan's researches in mind, the loss of nutriment to our stock would probably be considerable."

The final preparation of the soil should be made some time between the middle of May and early in that of June. The quantity of seed varies from two to six or seven pounds per acre. It is deposited in a continuous line on the top of the ridge by a turnip-barrow, on the flat by a turnip-drill or by the barrow. It is always advisable to sow thickly; this secures in the first stages of vegetation a quick and vigorous growth, which helps to push the plant past the dreaded period when the "fly"—that farmer's scourge—attacks it. This happens when the plant has pushed out its cotyledonous leaves. Once in the rough leaf, the plant is safe from the attacks of this fly. To get it into this condition, every care should be taken to secure its rapid growth by having the soil in a finely pulverised condition, and the fertilising matter in that state in which it can be readily assimilated by the plant. In view of the losses often incurred by the farmer through the ravages of the "fly"—acres of promising plants being devoured by the scourge in a marvellously short space of time—all sorts of schemes have been devised to prevent its attacks. Professor Skilling puts forward his mode of sowing turnips as a likely means of lessening, if not altogether preventing, the ravages of this insect. The following is a description of it, which we have given in the *Mark Lane Express*, in an article on turnip culture:—

"After the preceding crop has been removed from the ground, the whole is *forked* over to a depth of at least fifteen inches, if the soil will permit, breaking it up, thoroughly pulverising it, and exposing all weeds, loose stones, &c. These are to be removed during frost or other convenient period. The soil should be left untrampled upon, perfectly free and open, to admit of the action of the winter's frost. In extensive farms, horse-implements will, of course, have to do this preparatory work; but according to Professor Skilling, 'no implement yet invented will come up to the fork or spade, particularly the former, for the purpose. In spring, the farm-yard manure is spread over the land, and forked in to a medium depth, all weeds being carefully removed. This may be done during dry weather in winter or spring, up to the time of sowing. A few days previous to the sowing, the land is set out into beds six feet wide, with furrows two feet wide between them, the earth taken from these being laid equally over the surface of the beds. A hand-dibble is required to make the holes, in which the seed and the stimulating manure are put. The *spacing* of the crop is done as follows: The operator stands upon the ridge (or bed), and, commencing at either side, six inches from the brow or furrow, sinks the dibble straight down about five or six inches, making a rather wide, deep, and clean hole for the stimulating manure; . . . . going on straight across the ridge, making a similar hole at every twelve inches, until he comes to within six inches of the opposite furrow: he will thus have made six holes across, each twelve inches apart. He will next step back, and, commencing eighteen inches from the former row, go straight across, making another six holes, each twelve inches apart, and will thus proceed over all the ridge until the whole ground is thus spaced and perforated.' Into the holes thus made, the stimulating manure, which we have already described, is dropped, a moderate handful in quantity, so as almost to fill it, leaving a slight hollow for the seed. This is dropped or shaken out of a bottle, or a 'tin teapot, the spout straight, twelve inches long, and slightly tapering towards the point, which is about one-half inch in diameter.' A cover is placed on the spout, perforated with four or five holes, through which the seed is shaken on to the top of the stimulating manure, the whole being finished off with a slight covering of earth. Professor Skilling, in his pamphlet, descriptive of his method of culture, enters into many interesting particulars; but the following summary of its advantages, as compared with the ordinary mode of culture, will for the present close our notice of it. The manure is concentrated into small spaces, at regular intervals of twelve or fifteen inches; it is immediately under and in contact with the seed, and about one-third of the usual quantity of seed, one pound to the acre, will be abundance. The warmth and moisture of the manure causes the seed to vegetate surely and quickly, generally from four to six days, and rush into rough leaf, to grow on continuously and vigorously until the roots reach the manure below and their proper length. The consequences are an early formation of bulbs, a steady growth and swelling, and ultimately a heavy crop."

Decoy crops—as they may be called—are sometimes sown along with the turnip seed, to prevent, or rather to invite, the attacks of the fly; thus some sow, between the ridges in which the turnip is sown, lines of mustard seed. The mustard comes up quicker than the turnip, and the fly, busy at work on the *leaves* of the mustard, gives those of the turnip time to get into that stage where they are safe. Wherever we have known this plan to be carried out, we have invariably found it successful. Another plan somewhat akin to this is to have the turnips sown near plants which are known to be decidedly obnoxious to the "fly;" the potato is of this class. Mr. Gray, of Dilston, in Northumberland, was the first to introduce—at least the first to publish—this plan of planting Swedes and potatoes in alternate rows—a plan which he found quite successful, and it has since been tried by Earl Grey, who also found it successful. The great point known is to secure a rapid and vigorous growth in the first stages of the plant, and to sow the maximum of seed rather than the minimum. The late Rev. J. Duncan paid much attention to the subject of the "turnip fly." The result of his investigation was published in a prize essay of the Highland Agricultural Society of Scotland, from which we extract the following summary, so far as the proposed remedies for the scourge are concerned. Those of our readers who may be desirous to become acquainted with the natural history details may consult the essay itself, in No. 71 of the "Journal of Agriculture and Transactions of the Highland Society," for 1861. Mr. Duncan, with painstaking accuracy, tried a number of remedies chemical and mechanical, with varied success. On these he remarks—

"These experiments, it is to be hoped, will have the effect of saving time, labour, and expense, in attempting remedies which, though often recommended, are likely to fail at the very time when the exigency is greatest. They show that a preventive must be sought for in some other direction. It may possibly be found in strewing the young turnip plants with coarse dust, or particles of some hard and gritty substance, against which the insects' jaws, trenchant enough when employed on the soft pulp, are altogether powerless. And if this be made to adhere to the cotyledon and young rough leaves by some viscid substance, it will probably be difficult for the insects to make any impression. It is on this principle, it appears to me, that we must explain the effect of road dust, which is said to have proved remedial on the continent. And it is on the same account that I should be disposed to prefer the following composition, proposed by Mr. Fisher Hobbs, of Boxted Lodge, in Essex—namely, 14 lbs. of sulphur, 1 bushel of fresh lime, and 2 bushels of road scrapings per acre—to that which he has been in the habit of using, and by which he affirms that he has saved his turnip crops from the Haltica for a considerable series of years. The latter consists of gas-lime, fresh shell-lime, sulphur, and soot. A somewhat similar composition (with the exception of the gas-lime, which is not easily procurable in rural districts) failed in my lands. The sulphur used alone is evidently powerless, but the presence of lime may excite it to more energetic action.

"It is perhaps also worth considering whether some active poisonous substance might not be employed with advantage. It is well known to insect collectors that prussic acid and some other poisons speedily kill the largest and strongest moths; and chloroform acts upon all insects much in the same way as upon the higher animals. But, generally speaking, we are not well acquainted with the effects of poisons on these creatures. It seems, however, in no way improbable that a slight sprinkling of some such substance, while it would not deter the insects from eating a little of the plant, would lead to their own destruction.*

"Although the increase of the Haltica† has of late years been very great, especially in certain parts of the country, it will seldom happen in ordinary seasons, and still less in damp and cloudy ones, that it will cause an entire failure of the crop. The farmer need not be too hasty in taking alarm. Good cultivation, and especially abundant manuring and a plentiful supply of seed, will enable the crop to withstand and outgrow very formidable attacks. Even when the seed leaves are entirely consumed, and nothing but a naked stump remains, it does not necessarily follow that the plant will die. If the centre of the stem remains uninjured, the rough leaves will expand and the plant spring, although for a time with retarded growth. This I ascertained by repeated trials. The proportion of plants necessary to form a full crop is very small, compared to the number of seeds committed to the soil. Still it is highly desirable that some means

* A square of paper, covered with some chemical composition of a poisonous nature, is now in frequent use for destroying the common house-fly; and it answers the end most completely, as I can testify from my own experience of it.

† *Altica*, or *Haltica nemorum*, the name of the insect in scientific nomenclature; the genus is so named Altica from a Greek word signifying a "leaper."

of *general applicability* could be devised for securing our turnip crops against this pest, and there is no reason to despair of doing so. For myself, I am gratified that I entered upon the examination of the subject, for I have been enabled to throw some new light on the natural history of the insect; and if I have not succeeded, notwithstanding considerable effort and some expense, in detecting any effectual remedy, I have at least shown where it is not likely to be found, and that certain approved applications, as well as some others of fairer promise, are inadequate to the object in view. I have thus at least narrowed the field of inquiry, and facilitated, I hope, the researches of others who may follow me in the same track."

Mr. Fisher Hobbs, to whom allusion has been made in the above extract, and who has paid no small attention to the cultivation of the turnip, lays great stress on the importance of the preparation of the land. On this the following remarks will be useful; they apply more particularly to the preparation of the land for Swedes, and it is assumed that the land has been thoroughly under-drained:—

"1st. I consider that autumnal cultivation is essentially necessary; first, by broad-sharing for the destruction of weeds and insects, as well as for the aeration of the soil. 2nd. That deep ploughing should follow, and subsoiling if required; and it is frequently my practice, during the early part of winter, to carry on to the land intended for a root crop the unfermented manure direct from the yards or sheds, and at once plough it in, and not a particle must be suffered to be seen on the surface; this I believe to be important, for if not attended to, the undecayed portion of the manure becomes a receptacle, and subsequently a nursery, for insects.

3rd. That at the commencement of spring it is most desirable, as soon as the state of the land will permit, to apply the harrows and roll, especially the former. Afterwards scarify, harrow, and roll until the land is in a pulverised state; and for a fortnight or three weeks before the time for drilling, let the land remain like a seed-bed so as to attract moisture, to allow vegetation for the seeds of weeds and for insects to deposit their larvæ; this is frequently termed "purging" the land. I need not refer to the common mode of applying the fermented or partly rotted farm-yard manure for the turnip crop, except to state that it ought at once to be ploughed in, and the seed deposited immediately. 4th. That at the time of drilling the seed, it is best for the land to be ploughed (but some prefer scarifying only), and the seed *to be immediately deposited.* This is so important, that I have frequently known total failures from the neglect of so doing. There is another point which I would *strongly recommend,* that is, in dry and sunny weather to plough and to sow early in the morning and late in the afternoon, but never during the heat of the day. I know an instance where the most signal success has for several years attended this mode of operation, and where the manager has never failed to secure a plant, although he is one of the old school, and still sows the seed broadcast with his own hand. 5th. That at the time of depositing the seed, it is my invariable practice to use some description of artificial manure, generally superphosphate of lime, and I likewise add about thirty bushels of ashes per acre, made from hedge trimmings, weeds, &c., collected upon the land at different periods throughout the year. The roller may now be used with great advantage before and sometimes after, the drilling. In dry weather I strongly recommend the application of the liquid-manure drill. 6th. That before or immediately the young plants appear, the horse-hoe should be resorted to for the purpose of destroying the ova or larvæ of the insects, to prevent their coming to maturity. When once the plant is well up, the roller may sometimes be applied with much benefit, as it tends still further to disturb the insect tribe, as well as to retain moisture for the young plant, and to consolidate the farm-yard manure where lately applied. At this period the plant requires frequent watching throughout the day, and if the enemy shows itself in any force, set to work as quickly as possible to accomplish its annihilation."

The condition in which the soil should be, for depositing the seed, is a matter of importance; while some maintain that it is better to be moist, others hold that it should be as dry as possible. Opinion, however, may be said to be more generally in favour of a moist than a dry soil. Indeed, the most advanced practice of the day is to use the "liquid-manure drill," which, along with the seed, deposits a certain amount of manure in a state of solution. The adoption of this method is found to secure a rapid and vigorous growth. Those desirous to become acquainted with the detail of this plan of proceeding, may consult with advantage Mr. Ruston's essay on the use of the "Water Drill," in the "Journal of the Royal Agricultural Society of England."

When the plants are fairly in rough leaf, it is a usual plan to set the horse-hoe at work between the rows to clear the spaces of weeds and open up the soil. The rows are then gone over with six or nine-inch hoes, these being used to push out at intervals the growing plants, leaving spaces clear of them, alternating with spaces occupied by the original plants, thus:—

plants.	space.	plants.	space.	plants.	space.	plants.

This "bunching" out enables the light and air to gain access to the plants allowed to remain on the land, and pushes them on to a vigorous growth. The space between the plants left is generally nine inches, the length of the space left occupied by the plants being usually three inches. After some eight or ten days of growth in this cultivation, "singling" is gone through. This is usually done by hand, and consists in taking out all the plants with the exception of *one,* which is left to grow. The plant left in is, or should be, the strongest, and the greatest care should be taken to see that only *one* is left; if two or more are left, diseased growth is sure to result. The distance between the plants finally left varies according to the practice of different localities; a foot may be taken as the average. Some authorities do not recommend the early bunching and thinning of the plants; on the contrary, they maintain that it makes the plants which are left to grow lengthy; that the best plan is to allow them all to grow for some time till a certain vigour of growth is ensured. In districts where spring forage would be useful, and labour not very difficult to be had, it is possibly the best way not to single out the plants at first to the distances which are meant to be final; but to thin them out in the first instance to distances only of four inches apart, leaving those left in to grow for some time, when a second thinning is gone through. If the plants go on then very vigorously, a third thinning may be taken. These thinnings will be found to have plenty of leaves and no inconsiderable roots, and

will be found to be greatly relished by the stock. We have found this supply of green food not the only advantage obtained by this plan, for it enables the most of the weeds to be got rid of, and the pulling out of the plants loosens the soil and seems to give a fresh impetus to the growth of those plants which are left in to form the final crop.

The "fly" is not the only scourge to which the turnip crop is liable. In its later stages it is subject to two, the ravages of which frequently destroy the hopes of the husbandman. The most destructive of these, and unfortunately the best known, are "the finger and toe" and the "anbury." Where "the

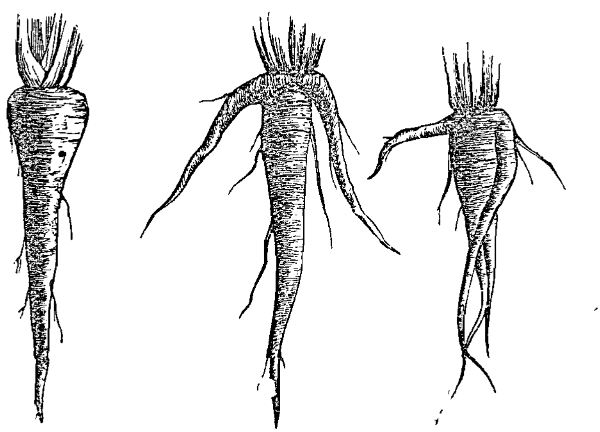


Fig. 10.

finger and toe" affects the turnip, in place of having the normal form, as in Fig. 9, with a uniform shape, long finger-like appendages project from its surface, as shown in Fig. 10, which represents two forms of diseased parsnips. Where "anbury" affects the turnip, its surface is covered more or less with wart-like excrescences, as in Fig. 11. An immense amount of matter has been given by the various *Agricultural Journals* as to the causes and proposed remedies for these diseases. The whole matter is yet, however, one of the vexed questions about which nothing has been definitely decided. The opinion that *lime* is the best application to the land seems to receive the greatest number of supporters. A paper by Mr. Barclay, in the number of the *Journal of Agriculture* for July, 1862, has attracted considerable attention in connection with the diseases of the turnip crop now under consideration. We extract the following conclusions which the author arrives at:—

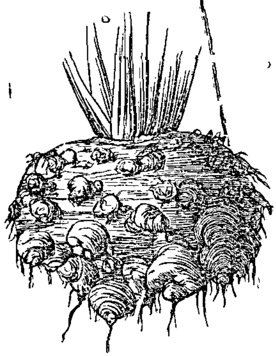


Fig. 11.

"The phenomena of the disease which have come under my notice, and appear to me well established, are—

"1st. That white globe turnips are more liable to the disease than any other variety. As this variety of turnip grows faster than any other, and as we have seen that a quick growth is the chief predisposing cause of the disease, it follows that, if the theory is correct, white globes should be the most liable.

"2nd. Light gravelly soils are more subject to the disease than any other, because they are poorest in minerals; whilst in heavy clays the supply is almost inexhaustible, although *weathering*, or lime, is necessary to make the minerals available.

"3rd. From what has been said regarding atmospheric influences, it will be seen that treading of land, by cartage or otherwise, especially when wet, will induce the disease, and that puddled end-rigs will be the part of the field most liable to its attacks.

"4th. It is also evident that the frequent repetition of turnip crops will not produce disease, if the soil remain sufficiently rich in mineral constituents, and that, from their deficiency, the first crop of turnips on poor soil may be attacked.

"5th. If a field once shows traces of the disease, it naturally follows from the theory that, until the minerals deficient are supplied, future crops will continue to be diseased.

"6th. The disease prevails more extensively on farms worked on the fifth than on the sixth shift, whether there be in the sixth shift three corn crops or only two. In the case where there are only two grain crops in the rotation, I account for the absence of disease by the longer period (three years in grass instead of two) during which the soil has to prepare mineral food by disintegration; but in the case where there are two successive grain crops, the reason appears to be, that the cereals have exhausted the ammonia in the soil, these plants having little power of extracting it from the atmosphere. The soil after two grain crops is much poorer in ammonia than after one, and there is thus a less chance of that rapid growth which is the chief indirect cause of the disease; the combustible and mineral constituents are nearer the relative proportion for producing a healthy growth, although perhaps no great crop.

"7th. Lime applied to clay soils one or two years before the turnip crop, has been found to prevent the disease. The effect of an application of lime is similar to that of *weathering*. The lime renders the minerals in the soil available for plants, and by its means a farmer may take from his land, in three or four years, as large a quantity of mineral constituents as, without it, he could do in twice the time. This would be all very well if the supply of minerals in the soil were almost inexhaustible, as they are in some clays; but the more important minerals are naturally so very deficient in our light Aberdeenshire soils, that time will have little effect after the first application is exhausted,—it cannot make available what is not there in any form. As lime requires some time to produce a material effect on the soil, it should evidently be applied a year or two before the turnip crop.

"8th. A very intelligent farmer lately informed me that he had frequently observed that well rotted farm-yard manure is, as compared with unrotted, more apt to produce 'finger and toe' disease. This is evidently due to the larger amount of ammonia in well rotted dung, and the rapid growth of the young plant caused by it; whilst fresh manure does not begin to take effect till the plant has passed the most critical period of its existence."

While on the subject of turnip disease, it may be well to note a very suggestive statement of Mr. Dixon, to the effect that he knew a farmer who never used for the turnip crop, the manure obtained from *turnip-fed* cattle. On one occasion he manured his crop with manure obtained from dairy cows, fed on an unusual quantity of turnips; the crop turned out a complete failure, being hopelessly diseased with "finger and toe."

Although last sown, the crop of white turnips is really first ready for consumption; the yellow and the Swedes nearly coming at the same time. The whites do not keep, and must therefore be used at once, the yellows and the Swedes being alone fit for storing; the yellows should, however, be used before the Swedes. Swedes are often allowed to remain in the ground, being eaten off with sheep; they are more generally, however, taken up in the autumn and stored. This storing may be under cover in an out-house, the turnips being covered over with straw; or they may be made up in heaps or clumps in the field, or near the steading. These clumps resemble in form the "potato heaps." The usual breadth of the heap at bottom is seven feet, the turnips being built up till they gradually narrow at the top. The whole heap is then covered with straw. Some care in selecting the roots to be stored should be exercised, those diseased being laid aside. In "topping" and "tailing" the roots in the field, care also should be taken not to wound or cut into the body of the roots, as this is almost sure to bring on speedy decay. The leaves and rootlets should be left evenly distributed on the ground, so that they can be turned in by the plough in preparing the land for the white crop. In some cases the leaves while fresh are given to stock, by whom they are greatly relished.

Manures for the Turnip Crop.—"The important part," says a writer in the *North British Agriculturist*, "which manures exercise in the growth of the turnip is now generally recognised; but farmers do not always bestow enough of attention in the selection of manures, and in the application of these in proportionate mixtures to suit the requirements of the soils and of the varieties of turnip grown." In cultivating Swedes, a portion of nitrogen should be present in the manure, a less quantity in cultivating yellows, and in cultivating whites nitrogen may be wholly dispensed with, except on soils of a heavy argillaceous character, or of moorish soils in low manurial condition. The following directions are applicable to soils in ordinary condition. Those following the directions should vary the proportion of manures to the soil and situation.

Swedes.—For land manured in autumn, with farmyard or other manure, apply as a mixture—2 cwt. of rape or cottonseed-cake dust, 2 cwt. of superphosphate, and 2 bushels of bone dust. A cheap guano, such as Kooria Mooria, may be substituted for the bone dust, and in part for the superphosphate. Peruvian guano can be substituted for the cake dust—2 cwt. of the guano representing 3 cwt. of cake dust; nitro-phosphates may also be substituted for cake dust. For land not manured in autumn, increase the proportion of each manure by, say, one-third; or, in other words, substitute 3 cwt. for 2 cwt. of each manurial substance. The manures should be mixed together some days previous to application to the land. If coal ashes or other ashes can be procured cheaply, a portion may be added to the mixture.

Yellow Turnips.—For land manured in autumn, 1 cwt. of rape or cottonseed-cake dust, 2 cwt. of superphosphate, and 2 cwt. of low-priced guano—such as Kooria Mooria. For land not manured in autumn, apply 2 cwt. of cake dust, 2 cwt. of superphosphate, 2 cwt. of low-priced guano, and 4 bushels of bone dust to the acre.

White Turnips.—For land manured in autumn, apply 1 cwt. of cake dust, 2 cwt. of superphosphate; or 1 cwt.

of low-priced guano, and 2 bushels of bone dust. For land not manured in autumn, apply 2 cwt. of cake dust, and 2 cwt. of superphosphate."

Mangold-wurzel.—This root, which is now extensively cultivated, belongs to the natural order of *Chenopodeæ*, and the species grown on farms is known as the *Beta vulgaris*, the garden beet being the *Beta hortensis*. Its origin is in all probability the sea-margin plant known to botanists as the *Beta maritima*.

The varieties of the *Beta vulgaris*, or mangold, are classed according to their shape and colour:—their shape, either long, as in Fig. 12, or globular; and their colour, either red or yellow—Long Red, Long Yellow; and Red Globe, and Yellow Globe. As may be gathered from these distinctions, the long variety is best adapted for light and porous, the globe for heavy soils. The mangold is generally better adapted for strong, heavy soils than the turnip, to which, as we have seen, light loamy soils are peculiarly grateful.

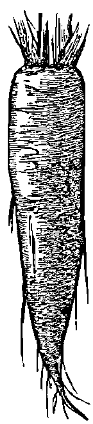


Fig. 12.
MANGOLD-WURZEL.

Mangold should follow and precede a straw crop, and should itself alternate with some other green crops, as Swedes, kohl rabi, cabbage, &c. For the mangold, deep cultivation of the soil is even more essential than it is for the turnips. Although moist at seed-time, it should be freed from all superfluous wet, and should be rich in manurial constituents. It is the general practice in this country to apply the farm-yard manure to the soil in the spring, at the time of sowing. The land should be scarified and ploughed in autumn, so as to clean it well of the weeds, and left in a rough condition till the following March. The land is then cross-ploughed, or the cultivator sent across the winter furrows; then harrowed, to remove the weeds. The manure, say 14 or 15 tons to the acre, is then put on, and a dressing of guano of 2½ cwt. and 1½ cwt. of salt to the acre. sown broadcasted. Recent experience in this country, and the extended experience of continental agriculturists, have shown the advantages of ploughing in the manure in the autumn; where this is done, the spring labour of preparing the land is reduced to a minimum—a point of very great importance, as the seed requires to be sown very early; for all that is necessary to be done is to cross the winter ploughing with the grubber or the cultivator, which will bring the soil to a fine tilth. The seed may either be sown on the flat or in ridges; the latter is perhaps the most general, as it enables horse-hoeing to be commenced and facilitated at an early period of the growth of the plant. The usual time for sowing is the month of April; it is sometimes carried forward to May; but early sowing is decidedly on the increase, and is to be recommended. The seed is generally deposited by hand-dibbling; as the seed being rough in its exterior, sowing by the drilling machine is not so easily done; the drill is, however, sometimes used. As the seed is enveloped in a very hard case, germination, especially in dry weather, is very slow and very unequal. To ensure a quick and equal germination, it is a frequent practice to steep the seed in water for twenty-four or thirty hours before sowing. Some object, however, to this, as, if the ground remains hard and dry, although germination is secured, the growth of the plant is injured from the hard dry soil in which it finds itself. We have experimented with the seed sown dry and sown steeped, and in all cases we have found the steeped seed to take the lead and *keep* it. The distance between the plants varies according to the kind grown. The "Globe" variety will obviously require wider spaces than the "Long," say 12 or 15 inches for the Globe, and 9 to 12 inches for the Long. These distances are for the soils best adapted for the crop; for less genial soils, shorter distances will be required. The width between the rows or drills is 12 to 18 inches for the Long, and 18 to 24 inches for the Globe varieties. The quantity of seed is 7 lbs. per acre.

It has long been the practice of the continental farmers to sow beet and mangold in seed-beds very early in the season, transplanting the best of the plants to the field. This is attended with the best results the crop being generally large, and the plants healthy. We have found transplanted mangolds to be superior to those grown in the ordinary way. Professor Buckman, in the *Agricultural Gazette,* has given some interesting tabular and other statements on this point, from which we extract the following. The inquiry, in connection with which these facts were elicited, was instituted by the Professor to determine the benefit or otherwise of stripping the leaves from the mangolds during the period of their growth to be used for feeding purposes—a practice so common that this supply is looked upon as one of the great advantages of growing the crop. We now present the Professor's own statement:—"The plots were 2½ yards square, and the seeds drilled in rows. In each plot twenty-four plants were ultimately left. On the 4th of September stripped half of each plot, taking from three to four outer leaves from each plant, varying the direction of the stripped plants as under, in order that no source of error should arise.

PLAN OF STRIPPING.

Stripped.	Intact.	Stripped.	Intact.
Intact.	Stripped.	Intact.	Stripped.

"The stripping was repeated on the 21st of September, and it should be observed that between the 4th and 21st very rapid leaf growth had been made; and between the latter date and the period of harvest, viz., November 12th, the leaf growth was also very vigorous, so that had there been a third stripping, the difference in the results might probably have been even more striking.

"The following is the resultant weight of the topped and tailed roots :—

WEIGHT OF TWELVE NON-TRANSPLANTED ROOTS.

Number of sorts.	Sorts of Mangold-wurzel.	Leaves intact.	Leaves stripped.
		lbs. oz.	lbs. oz.
1	Elvethan	8 10	5 4
2	Yellow Globe	9 0	5 2
3	Red Globe	8 2	6 12
4	*New Olive-shaped Red Globe* .	*11 13*	*7 6*
5	New Olive-shaped Yellow Globe	16 13	12 3
6	Sutton's New Orange Globe . .	9 5	3 12
7	Improved Long Yellow . . .	19 0	9 11
8	New Long White	15 0	7 8
9	Silver Beet	16 15	5 9
	Total . . .	114 10	63 3

"The experiment was further interesting as showing in plots, side by side, the different characters of so many *derivate forms of the sea-side beet, while the* resulting weights indicate such as succeed best in our position."

To note the effects of transplanting on so many varieties, Professor Buckman, in thinning the plots mentioned, transplanted twenty-four. The following is a tabular result of this part of the experiment :—

"These transplanted specimens grew well from the first, a result most probably rendered the more certain by the wet cool season. The bulbs, however, were not seen above the ground as in the ordinary way of cultivation; and instead of a tap root to be cut away in the operation of tailing, there was found a large bunch of delicate root fibres. The results of these experiments are as follows :—

WEIGHT OF TWELVE TRANSPLANTED ROOTS.

Number of sorts.	Sorts of Mangold-wurzel.	Leaves intact.	Leaves stripped.
		lbs. oz.	lbs. oz.
1	Elvethan	14 10	5 10
2	Yellow Globe	13 0	6 14
3	Red Globe	15 4	7 3
4	New Olive-shaped Red Globe .	12 4	5 6
5	New Olive-shaped Yellow Globe	11 14	7 10
6	Sutton's New Orange Globe . .	10 2	5 9
7	Improved Long Yellow . . .	15 10	11 1
8	New Long White	12 11	7 6
9	Silver Beet	15 13	6 11
	Total . . .	121 4	63 6

"Here, then, is a positive increase from transplantation; and though I by no means think the process would always succeed, yet it is well to know that wherever a crop be thin, there can at least be no harm in filling up with transferred plants, and I am inclined to think that in most seasons at least a paying result would follow. In fact, many of the large specimens of roots exhibited are derived from getting some early plants, perhaps by means of the greenhouse, and then transplanting them in good rich soil; they then afford striking evidence of what may be done in this way

"I consider," says Professor Buckman, in conclusion, "that the matter of whether or not it be judicious to strip mangolds of their leaves, however partially, resolves itself into a question of value. If the leaves be worth more than the consequent lessening of the roots, which I deem inevitable, there is no mischief; but to suppose that the farmer can make use of green mangold leaves, and have as good, to say nothing of an increased crop of roots, I consider contrary to both science and practice.

"Again, as regards transplantation, I consider it a valuable process, and incline to the belief that it will be found of great advantage if carefully done, and done with judgment as to time."

It is right to state, in connection with the question of stripping the leaves of mangold, that it is by no means in a settled condition. The experiments, conducted with great care at the Glasnevin model farm, show in point of fact a positive gain in weight of the roots from the practice of stripping the leaves. The following is the average result of an experiment of our own, made this autumn (1862), to determine the effect of stripping the leaves on the growth of the root:—

Name of root.	Without leaves.	With leaves.
	lbs. oz.	lbs. oz.
Long Red . . .	0 15¾	1 8
Long Yellow . .	0 15	1 3½
Globe Yellow .	0 15	1 3½
Globe Red . .	1 2¼	0 15¼

The conditions of soil, manure, and culture were in every way similar; the soil, however, as may be judged from the weight of the specimens, was by no means of that quality to secure a very heavy crop. The experiment, so far as it is worth, goes to prove the correctness of Professor Buckman's statement as to the effect of stripping the leaves from the mangold; but it will be noticed that an exception in the above table is the Globe Red. Desirous to see whether this was a rule, we weighed a greater number of roots of this variety than of the others, and in all cases found the stripped roots to weigh heavier than those on which the leaves were allowed to remain. May not some varieties be better adapted for being stripped of their leaves than others? It is doubtful, however, whether experiments such as we have given are to be depended on as affording trustworthy results. Such are the uncertainties connected with the nature of the soil in which each individual root grows, and the application of manure to it, that although to all appearance the roots may be grown under precisely the same circumstances, those circumstances may in reality be very different. That this is often the case, is evident from many of these experiments; for we have found that the roots of the same variety used in the same plot are not by any means equal in weight. An element of doubt is therefore thrown into the question which it is difficult to get rid of. After all, reasoning from analogy is perhaps the safest guide in the matter; and from this it would appear that the best way is to allow the roots and leaves to grow together till finally taken up. That the leaves exercise an important influence on the growth of the root is most certain, otherwise they would not be there: Nature does not work at hap-hazards in her processes.

Great care should be taken to have the roots taken up and stored before the frost sets in, as they will not keep if frosted. In taking them up they are left lying on the rows; other workpeople follow, and with a knife cut off the leaves—taking special care to avoid wounding the root—trim off the fibrous roots, and scrape off adhering soil. After this, if the weather is good, they should be left to "sweat" in small heaps in the field, for two or three days; then taken and stored in the out-buildings, or pitted. If carefully stored they will keep till far in the following season.

In all artificial manures for the crop, salt should form an important ingredient; this holds good, indeed, of all our farm crops, the origin of which has been littoral, or sea-margin, such as the Swedes, rape, and cabbage. For *sandy* soils, 1 cwt. of salt, 1 cwt., of sulphate of ammonia, and 2 cwt. of superphosphate per acre. For *calcareous* soils, 1½ cwt. of salt, 3 cwt. of superphosphate, and 2 cwt. of Peruvian guano per acre. For *heavy* soils, 4 cwt. of guano, 2 cwt. of salt per acre, and an extra dressing of farm-yard manure. For *vegetable* moulds, 4 cwt. of superphosphate, and 2 cwt. of salt per acre. For *loamy* soils, 2 cwt. of salt, 2 cwt. of superphosphate, and 2 cwt. of Peruvian guano per acre. We have already adverted to the use of salt as a manure for the mangold.

"It strikes me," says "F.R.S." in the *Mark Lane Express*, "that the mangolds are freed also from another enemy by the use of salt. I mean insects. Slugs and wire-worm, both very destructive during certain seasons, are certainly banished by salt, if not killed. Salt appears to be one of the cheapest and safest manures we can use. No soils naturally have too much of it, excepting perhaps those directly influenced by brine springs. One of its most valuable properties is its power to attract moisture. For this reason it may be sowed when the soil is perfectly dry, a condition fatal to so many manures, and will absorb the moisture from the atmosphere, and convey it to the root of the plant. Its principal office is to keep everything in the soil in a soluble state, and consequently in a state fit for the nourishment of vegetable life. Its benefit is not alone experienced by the root crop, but by the grain crop which follows, for its presence checks a redundance of straw, and enables that straw to strengthen itself by assimilating from the soil the silica, of which, in certain combinations, it is a solvent."

Kohl Rabi.—This belongs to the order *Cruciferæ,* the genus *Brassica,* and the species is named by botanists *Brassica caulo-rapæ.* As the value of the Swede consists in its root, of the cabbage in its leaves, so that of the kohl rabi exists in its stalk, which bulges out between the root and the leaves, as shown in Fig. 13. All three are members of the *Brassica* tribe. The following is an abridged description of the plant and its cultural requirements. It was written by the author of the present treatise for the *Journal of Agriculture* (No. 69, 1862), and is reproduced here :—

Fig. 13.—KOHL RABI.

"A variety of circumstances in connection with the culture of the Swede has very recently given a prominence to the kohl rabi, which is likely to result in its extension to a larger breadth of land than it has yet enjoyed. For some years the Swedes have been gradually becoming a more risky crop. The tendency to push the plant to an extreme of productive energy has probably weakened its powers of resisting disease, or the action, perhaps, of that mysterious law which tells us that 'change' is one of the great features of the economy of creation, and ultimately punishes all persistent attempts to raise a too rapid succession of the same crop on the same soil. Whatever may be the cause, certain it is that the Swede has, year after year, shown an increasing tendency to disease,—so much so, that many first-rate farmers have determined no longer to have their patience tried, and their losses repeated, by attempts to grow the root. Opportunely, as a substitute for the Swede, which has for so long been the mainstay of the farmer in feeding his stock during the winter and spring months, comes the kohl rabi, presenting numerous advantages—such as a capability to bear transplantation, and to resist the effects of drought and the severity of winter; to these may be added its little liability to attacks of insects, and, above all, its highly nutritious properties, and the avidity with which it is consumed by all varieties of stock. Kohl rabi has been pronounced the 'bulb of dry summer,' heat and drought not being inimical to its growth, and yielding an excellent crop where white turnips and Swedes could barely exist. The report of Dr. Anderson, as to its feeding properties, proves it to be 'about twice as valuable as ordinary turnips, and naturally to surpass the best Swedes. . . . .'

"The varieties of kohl rabi cultivated for feeding purposes are the 'green' and the 'purple,' and of each of these there are two kinds, the 'round' and the 'oblong.' The purple is considered to be the hardiest of the two varieties, and the oblong the best for farm purposes. It is fitted to grow in a wide variety of soils; extremes, either of light, or sandy, or of heavy clay soils, should be a oided. The land, of whatever kind, requires to be well worked, of fine tilth, and highly manured. Farm-yard dung contains all the properties of fertilisation; but should the supply of this be deficient, artificial manures may be employed, care being taken to apply, through their means, potash and common salt to the soil in which the plants are cultivated. Where bone dust or superphosphate are used, common salt should be mixed with them, in the proportion of one-tenth to one-fourth, and of potash half the preceding proportion.

"There are two modes of cultivating kohl rabi. In the first or original method, the seed is sown in a seed-bed, previously well manured, at the rate of eight ounces of seed to every six yards square of surface, this giving plants for an acre, and being done at the end of February or beginning of March. On the plants attaining a height of six or eight inches, they are transplanted to the field, this being laid out in drills in the manner followed in the cultivation of turnips, the drills being twenty-seven inches apart, and the plants sixteen inches apart in the lines. The second plan of culture is to sow the seed at once in the drills on the flat, singling the plants out. There is a considerable saving of seed effected by raising the plants in a seed-bed,—as compared with the quantity required for drill sowing, eight ounces against two to four pounds. But the former plan involves the risk of the transplanting process failing more or less in a dry season, and extra expenditure. The weight of experience, however, is apparently in favour of the mode of raising plants in a seed-bed, and transplanting afterwards, as that which is the most economical, and affording greater certainty in securing a good crop. . . . .

"The plot of land set aside for the seed-bed should be well dug and manured in the winter, and prepared for the seed the first week of March. As before said, a plot six yards square will raise plants sufficient for an acre. The seed should be sown in drills about twelve inches apart, so as to afford room for hoeing and weeding, without which strong healthy plants need not be looked for. When six or eight inches high, transplanting should be done, care being taken to choose moist weather for this operation.

"Mr. Bennett, an authority on points connected with the cultivation of the kohl rabi, states that he has abandoned the seed-bed, and drills the seed in ridges twenty-seven inches apart, thinning the plants out to a distance of sixteen inches. The mode of cultivation pursued by Mr. Bennett is the same as for Swedish turnips—ten tons of farm-yard manure, and a fourth or a fifth of a ton of good artificial manure (as blood manure, superphosphate, rape-cake, or the like) per acre. The seed is not drilled before the middle of May, and used at the rate of two pounds to the acre. After thinning out the drills, the surplus plants are transplanted to the piece of land from which a green crop has been removed. By this one operation Mr. Bennett is able to 'provide sufficient plants for setting, and at the same time' leave, properly singled out, enough for the general crop. . . . .'

"In hoeing the kohl rabi, Messrs. Lawson recommend the operation of hoeing not to be done in wet weather, as this will give a check to the growth of the plants which they would never recover. 'In hoeing,' they say, 'it is a good practice to leave the rows in tufts with a few plants in each, clearing away a foot square between them, not forgetting to push all weeds away from tufts. A week or ten days afterwards, the rows may be gone over again, and the tufts singled out by hand, taking care to leave the strongest plants.' . . . The horse-hoe should be in continual requisition, to keep the land free from weeds during the growth of the plants. The plants will attain maturity in their twenty-fifth week, or thereabouts. The pulling and storing operations are much the same as for other root crops."

We may add to the above that our experience is decidedly in favour of the system of raising the plants in seed-beds, and transplanting them to the drills. The crop raised from transplanted plants has always, with us, been the strongest in the early, and the heaviest in the later, stages of their growth. Of the two kinds—the purple and the green—we prefer the green. With this crop, as with others, it is, however, difficult to recommend any particular variety or any peculiar mode of culture as adapted and applicable to any one soil. Circumstances of soil, locality, and climate bring into operation different causes, and produce different effects; and the student of agriculture should ever remember that successful practice in one does not ensure like success in another locality. Farming requires the exercise of perpetual observation, and a constant registration of facts and the results of experience. General rules for practice can only be given, and the farmer will have to discover what modifications, if any, are required to suit the specialities of his own case

Carrot.—This belongs to the order *Umbelliferæ*, the genus is *Daucus*, and the *Daucus carota* is the species cultivated. For long its cultivation was confined to the garden, but its many excellent qualities as a food for stock are bringing it every year more and more into repute. It is specially adapted for light sandy soils, although our improved modes of culture are rapidly bringing heavy soils into a cultivation fitted to produce pretty fair crops of it. Professor Wilson enumerates the varieties of it adapted for field growth. (1) The Altringham; (2) Large Red, or Orange Cattle; (3) Long Red, or Surrey; (4) Short Red, or Horn; (5) Large White Belgian; (6) the Yellow Belgian.

The preparation of the soil demands the utmost care of the cultivator; it must be deeply tilled and finely pulverised, and free from all stagnant moisture. The place in the rotation of the carrot is between two straw crops. As soon as the grain crop is off the ground, the land should be thoroughly cleaned from weeds. The farm-yard manure, in a well-rotted condition, should next be laid on the land, and the whole ploughed in with as deep a furrow as possible. If the land is forked by men following the plough, so much the better. The land is then left till early spring, when, if it has been well cleaned in the autumn, all that will be required will be to cross the furrows with a grubber, pulverising the soil, and well mixing with it the manure.

The period for sowing is the month of March, and the quantity of seed per acre two to four pounds. As the seed is covered with short rough hairs there is great difficulty in sowing it alone; it is therefore usual to well mix it with dampish sand. The mixture is allowed to lie for some days. The seed must not be old; indeed, it is imperative that it should be of the last year's growth.

The failure of many a crop may be traced to this cause. The seed is drilled, the width between the drills being fifteen to eighteen inches. As soon as the plants are two or three inches high, they are "bunched" out, and in a few days afterwards singled out carefully by hand, the distance between the plants being from six to nine inches. The greatest care should be taken to keep down all weeds. The roots are taken up about the end of October, but earlier if frosts are likely to set in. If the weather is fine they should be allowed to lie in the field in small heaps to get "weathered," before being stored. The storing is done in the same way as the mangolds.

Parsnips belong to the same order as the carrot, namely, the *Umbelliferæ,* its botanical name being the *Pastinaca sativa.* Four varieties are cultivated in our fields. (1) The Common Long-rooted; (2) the Long Jersey; (3) the Smooth-rooted; and (4) the Turnip-rooted. What has been said of the cultivation of the carrot applies almost equally to the parsnip; it is, however, calculated to grow in a wider variety of soils. It, like the carrot, requires a deeply-cultivated soil; if this is not given to it, it is apt to throw out "forks," or lateral roots, as in Fig. 11. Its place in a rotation is similar to the carrot. Its period for sowing is the end of February or beginning of March; the quantity of seed varies from two to four pounds per acre. The seed should be mixed with moistened sand, as, although not covered with hairs like that of the carrot, it is exceedingly light and thin, and apt to adhere together. The seed must be new. The roots may be taken up in October, although they stand the frost exceedingly well.

Potato.—The natural order of plants to which this belongs is the *Solaneæ,* the genus *Solanum,* and the cultivated species is *Solanum tuberosum.* The varieties are very numerous. Mr. Lawson enumerates, in his "Vegetable Products of Scotland," nearly two hundred of them. The same eminently practical authority divides the varieties in three classes—1st, the *Early,* of which the leaves and stems decay by the time they are ready to be lifted: of this class the tubers are ready for immediate use; 2nd, the *Large field,* of which the foliage does not decay till touched by frost, and of which the tubers require to be kept some time before being ready for use; 3rd, *Late large sorts,* adapted for cattle feeding. Of the two latter classes, adapted for field culture, Professor Wilson gives a list as follows:—Class second—(1) London Blue; (2) Pink-eyed Irish Round; (3) Scotch Black; (4) St. Helena; (5) Stafford Hall. And of class third—(1) Brown's Fancy; (2) Common Yam; (3) Connaught Cups; (4) Cups; (5) Irish Lumpers; (6) Mangold-wurzel; (7) Ox-noble; (8) Pink-eyed Dairymaid; (9) Red Yam. The characteristics of all these will be found at pages 23, 24, 25, and 26 of Vol. II., "Our Farm Crops." The potato grows in a very wide range of soils, from very sandy to heavy clay. The soil which suits it best, however, is a medium between these two, an essential quality is that it be light and porous. Considered as a fallow crop, its place in the rotation is between two grain crops. The preparation of the land is required to be carefully looked after. Autumn clearing of the stubble should commence immediately after the crop is removed from the land. When it is thoroughly cleaned from all weeds, it is deeply ploughed, and left to stand all winter. Manure is not generally applied until the spring; it is then applied heavily, as much as twenty to thirty tons to the acre. It is questionable, however, whether this heavy manuring does not induce the dreaded disease which for so many years has reduced the value of the potato crop. We shall give a note on this subject, however, presently. The land for potatoes is invariably thrown up in ridges; for the proper working of which, therefore, it is essential to have the manure applied to the land in a "short," or well-rotted condition. Guano is also applied to the crop; it is usually broadcasted over the manure, and the whole covered up by the ridging plough. The seed potatoes are generally cut up into parts, known as "sets;" but it is a disputed point with some farmers whether whole potatoes are not more likely, when planted, to produce sound potatoes. Reasoning from analogy, one would be apt to suppose that cutting the seed is not a good thing, and that other things being equal, unsound potatoes would be the result of the plan. The subject is one worthy of full investigation—an investigation which we regret to say has not yet been scientifically accorded it.

The quantity of seed per acre varies, as may be supposed, according as whole potatoes or "sets" only are used. The usual depth to which the "sets" are planted is three inches; the distance from each other in the drill, twelve to fifteen inches; and the width of drills from each other, twenty-seven inches.

The granite and the greenstone soils of Cornwall, and the red sandstone soils of Lancashire, possess all the characters of a potato soil in such perfection that they may be looked upon as model soils. The plans of culture there adopted are therefore worthy of note. The following, from the pen of Professor Tanner, gives a description of them:—

"There is a great difference in the management of these two districts. In Cornwall, the general plan is to dig the ground by hand in autumn, and plant the sets in drills as the ground is dug; thus the earth dug from one drill is cast into the former drill. The early kidney potato is the variety grown; these they plant as early as October and November. After the sets are dropped, some earth is thrown over them; and then the manure being spread in the drill upon the seed, it is ready to receive the earth dug in the preparation of the next row. The manure preferred is a compost of farm-yard dung and sea-weed, &c. Nothing more is done to the crop until the spring, when the ground is flat-hoed in March. Potatoes thus treated are dug early in April, but the general digging commences in May.

"In Lancashire, the system is different in many respects. The ground having been ploughed in the early parts of the winter, receives another ploughing in January or February, dry weather being carefully and promptly seized for this work. After this the manure is got ready for being used by being well rotted, for which an occasional turning is necessary. At the end of March, or very early in April, the manure, which is then thoroughly rotten, is cast over the ground, and the plough follows immediately. Some farmers then harrow the ground, and plough again. With this preparation the potatoes are dropped in drills made by hand labour, as already described, and covered with soil taken from the next row. The manure used is somewhat similar to that employed in Cornwall; sea-weed and sea-sand are here also mixed with farm-yard manure, and valuable indeed they are as fertilisers of the land.

"There is one point particularly worthy of notice in the Lancashire system, which is, the great care taken with the potato sets in preparing them for planting, a practice worthy of more general adoption. In January the seed is brought out and spread upon floors, where it will be warm, so as to encourage a growth of the germ or sprout."

The Rev. E. F. Manby, in the "Royal Agricultural Society's Journal," gives a description of the method to be pursued in carrying out the sprouting system:—

"In order to ensure success and command high prices the seed must be *sprouted; i.e.*, it must have made an advancement in growth at least one inch. This sprout should be strong and well-developed; its thickness about that of the stem of a common tobacco-pipe, and its top crowned with green buds, just entering into leaf; at the bottom of the sprout are emitted, or in the course of emission, small thread-like roots, which, as soon as planted, take possession of the soil. Here is the grand secret of obtaining *early* potatoes. The kind of potato used is the *lemon kidney*. The tubers thus sprouted should be placed in the soil two inches deep. The best soil is a dry sandy loam; this should be manured in February, just before the ploughing, at the rate of thirty tons per acre. The manure should be short and decomposed. When the land is ploughed down in February, it remains till the end of March or beginning of April. The potatoes are placed in the ground in the second week of April. The tubers which have more than one good sprout are generally cut lengthways, never crossways. The best plan is not to cut the root at all, but cut off the second sprout. The tubers are set out in rows, fourteen inches apart, with twelve inches apart in the rows. If guano or other artificial manure is used, it should be placed in the furrow and the potato above it, never in the guano.

As soon as the plants are visible, flat-hoeing is begun; once will do in fine, but twice or thrice in showery weather. Moulding is commenced when the land is clean, this being done early in the morning or late in the evening; for, if moulded during the heat of the day, the rootlets would be scorched, and the plants would droop. Four weeks after the moulding, the crop (Lemon kidney) will be ready for taking up. The first symptom of ripeness is the lower leaves curling up; the tuber will not increase much in weight after these turn yellow."

We have already alluded to the fact that some authorities maintain that it is to the practice of "over-manuring" that the potato disease is chiefly owing. The following is a description of the Hon. Grantley Berkeley's system of growing potatoes without manure:—

"On finding, when the disease broke out, that a four-acre field, in which for a series of years I had grown potatoes, was terribly affected by the malady, I turned my attention to the disease, in a desire either to alleviate or discover a remedy. On observing that the leaves and haulm became in the first instance yellow, parched, and dry, it occurred to me to treat the visitation as a feverish or vegetable epidemic, and that if my conjecture was correct, the most likely way to success would be to withhold entirely the manure, to keep the same seed and the same land, and exhaust, by the continuous growth of the potato (which is of itself an exhausting crop) on that particular site, the productive properties of the soil.

"This plan I at once put in force, when, after two or three seasons without manure—my crop of course gradually failing in size and quantity—the disease gave symptoms of being beaten; for though the haulms perished, every crop, as year succeeded year, became gradually more free from the devastations of the disorder, till at last there was no disease in the roots at all. By this time the yield of those four acres had fallen in quantity more than one-half. In some seasons, with manure, the crop had reached above a hundred and thirty sacks; when the disease left the field, the return was reduced to fifty sacks; but from the ravages around me, and consequent rise in price, I made more by my half crop than I made when the field was in full bearing. Further, to test the state of the land, I then put in a crop of oats, considering that, unless a great reduction had taken place in the richness of the soil, it having been free of corn for so many years, the oats ought, for a crop, to do very well. The land, however, was so exhausted, that the oats did not amount to more than half a crop, and I became satisfied that a portion of my object had been thoroughly obtained. On the season following the crop of oats, under great doubts as to what the result might be, I again planted my potatoes, having still raised seed in other places similarly dealt with, and drilled in with them about half the usual allowance of manure. I confess that it was with much anxiety that I watched the effect. The potatoes came up luxuriantly, and, as usual, the haulm died away; but when the crop was lifted, the slight tribute of manure was like a glass of wine to reduced human nature. The yield was one hundred and forty sacks of potatoes—I think, nearly ten sacks more than it had ever been in full manure, and before the disease was known; and from that time to this, at the time of raising and in keeping through the winter, my potatoes have remained free of the disease. I kept them through all last winter, and sold only at seed-time; and now that I have removed from Beacon Lodge, where I had resided for twenty years, and planted these same potatoes in a new soil, hitherto badly affected, my crop has just been lifted—Jersey Blues, Bedford Reds, Ashleaf, and other kidney potatoes—and the potatoes retain their health and value, and the disease (all but in the haulm) is gone. At one time, and while at Beacon Lodge, I offered to give, and did give, to the poor people some of my seed potatoes, on condition that they would continue them on one spot of land; but they would neither obey my directions nor keep my potatoes unmixed with other seed, so that I relinquished the effort in that direction. On removing this last season from Beacon Lodge to Winkton House, I have discovered that, to keep these healthy potatoes to one spot is not necessary, for it is the potato that is cured, and not the soil wherein the root was grown; and this fact is just now tested, not only thus in my garden at Winkton, but in the garden of one of my neighbours, by name, Boulton."

It is quite impossible to go into the subject of the potato disease in the short limits now at our disposal. The reader interested in the matter will find it fully and ably discussed in Professor Wilson's "Farm Crops," and in a paper by Professor Tanner in the *Mark Lane Express*, April 23rd, 1860, and also in a paper by Dr. Jeffrey Lang, in the "Journal of the Royal Agricultural Society of England," vol. xix., entitled "The Potato: its Culture, Production, and Disease."

DIVISION SIXTH.

CROPS CULTIVATED FOR THEIR LEAVES, AND FORAGE CROPS:—CABBAGE—RAPE—MUSTARD—VETCHES—RYE—CLOVER—LUCERNE—SAINFOIN—RYE-GRASS—GORSE.

Cabbage.—This belongs to the natural order of *Cruciferæ,* the genus *Brassica,* and the species is *Brassica oleracea.* For farm purposes there are only two varieties—the *drum-head* or *cow cabbage,* or "close-leaved," as Fig. 14; and the "open-leaved," as the *Jersey,* or *thousand-headed.*

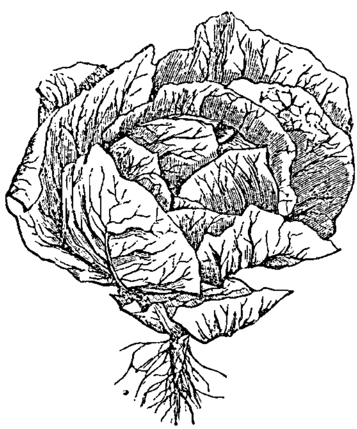


Fig. 14. DRUM-HEAD CABBAGE.

The soil best adapted for the crop is a "rich loam," or "alluvial;" it is better calculated for heavy than for light soils. Although it is sometimes the practice to sow the seed in drills or ridges, like turnips, and thin them out to the proper distances, the best plan is to sow the seed in a seed-bed, and transplant the plants. Those who have carefully tried the two methods will, we are convinced, be assured of the fact, that it is essentially a transplanting crop. The crop is greedy for manure, and it requires a deeply-cultivated and clean soil. Like all the other members of the *Brassica* tribe, salt should form an essential part of the manure applied to, it; superphosphate, say 2 cwt., salt, 1 cwt. to the acre, with 2 cwt. of guano, may be broadcasted over the land, and harrowed in just before the ridges are made up. In the after-culture of the crop, the great point is to keep down weeds and the soil as open as possible. We have found that by throwing at the roots of the plants—when about four weeks planted—a dressing of coal ashes, nitrate of soda, and salt, in equal proportions, that we have secured a very decided increase of the crop.

The seed—four ounces will rear sufficient plants for an acre—should be sown in a seed-bed, the soil of which is well manured and finely pulverised; and if in drills nine inches apart, so much the better, as the weeds may be kept down. If in a sheltered spot, the time of sowing may be as early as in the beginning of February, but March is the usual time. Better crops will be secured, however, if the seed is sown in the beginning of August, the plants "pricked out" in October at distances of six inches between the plants, and these transplanted in the spring in the place prepared to receive the final crop. This plan will of course be more troublesome than the one described above, but it will give the heaviest crop in the end. Where the seed is sown in the seed-bed early in the spring of the same year which produces the final crop, the plants are to be taken up about the beginning of May, and transplanted in the ridges of the prepared land. The distance between each plant should not be less than thirty inches. As the drum-head cabbage, and, indeed, the thousand-headed, can stand frost pretty well, cabbages need not be stored up, but cut off as required for feeding. The stalks of those cut early, if left in the ground, will have produced, by the time when the land in spring should be cleared for the crop to follow, a by no means contemptible supply of green food, and at a time when green food is doubly acceptable. But as the land is generally required for the succeeding crop, and as in some districts the frost is so severe as likely to do damage to the crop, cabbages are often cut and stored up. This should be done under cover, and the cabbages carefully built up so as to admit of free ventilation throughout the heap. Treated thus they will keep good for a length of time. The open-leaved cabbages, or thousand-headed, cannot be thus stored up, but must be eaten by the stock as required.

Rape belongs to the natural order of the *Cruciferæ*, the genus *Brassica*, and the two species are the *Brassica campestris* or smooth-leaved summer rape, or *colza*; and the *Brassica napus* or rough-leaved winter rape, or *coleseed*.

Rape can be grown on soils of a very opposite character, as on the soils, for instance, of those in the fen districts—rich in organic peaty matter; and on clay soils. For soils of the first character, the *Brassica napus*, or winter rape, is best suitable; for those of the latter, the *Brassica campestris*, or summer rape. The soil should be carefully tilled, and be rich in manurial matter, which can be easily taken up by the plants. The crop may either be sown on the flat or on the ridge, the distance between the drills or ridges being from fifteen to eighteen inches. The place in the rotation is between two grain crops. The quantity of seed varies from three to five pounds per acre, and the time of sowing for early keep in March or April. The crop, summer rape, will be ready to be ate off by August, in ample time to get the succeeding grain crop in. A succession of crops may be sown so as to keep up a supply of green food till the root crops are available. Where a supply of rape is wanted for early spring feed, the *Brassica napus,* or winter rape, may be sown in autumn. Although it may be drilled in like turnips, we are inclined to advise the adoption of the continental and Irish method of sowing the seed in a seed-bed early in August, and transplanting early in October. This transplanting brings on the plants rapidly, and they grow strong and vigorous. Even in the culture of summer rape in drills it is advisable, when the plants are about two to three inches high, to hoe out the drills or ridges, leaving clear spaces of three to six inches between the plants. This ensures a vigour of growth, which is wanting when the plants are allowed to grow just as they come up in the drill.

Mustard.—This plant, belonging to the natural order *Cruciferæ,* the genus *Sinapis,* and of which there are two species—the *Sinapis alba,* or white, and the *Sinapis nigra,* or black mustard, is now sometimes cultivated as a forage crop. Cows are exceedingly fond of it. One great advantage which its very rapid growth gives it is, that it can be taken as a stolen crop between two important crops. No matter how comparatively short may be the interval which it remains on the ground, a crop will be obtained which, in the majority of cases, will repay the labour and cost expended. It is adapted for almost any class of soils: we have grown it upon a piece of exceedingly heavy clay, with excellent results not only as regards quantity, but as valuable in bringing the land into something like tillage. The seed should be sown in drills, and the spaces freed from weeds. When grown as a decoy crop between the ridges of the turnip crop, as explained in the section on that crop, it is advisable to allow it to grow to a height of say nine to twelve or fifteen inches, and then take it up for stock feeding. When grown thus, we have begun to pull it up when about six inches high, and by the time that one supply was about finished, the last rows had obtained their maximum height. Grown in this way, it serves two useful purposes. To ensure a vigorous growth, it is advisable to thin the plants out to distances of twelve to thirteen inches in the drills; but this only when the crop is allowed to grow to a height of from four to five feet. The thinning out will not be necessary when the crop is to be eaten off at the earliest stages of its growth.

Vetches.—This plant belongs to the natural order *Leguminosæ;* the distinct genus is *Vicia,* of which there are more than a hundred species. The species most generally cultivated is the *Vicia sativa,* or common vetch, or tare; of this the two varieties are *winter* and *summer.* The vetch has been cultivated as a forage plant from a very early period, and is still highly esteemed for this purpose. It is not what is called a rotation crop, but rather takes a place in the farm as a catch, or stolen crop. The proper place is between two grain crops. The crop can be grown upon a wide variety of soils, although the strong soils are those best adapted to yield the largest produce. "On farms," says Professor Wilson, in his most useful work entitled "Our Farm Crops," "where vetches are regularly grown each year, it is generally the practice to sow out one portion in the autumn for early spring.

Keep all the other in the spring, so as to come to maturity about the time the first is consumed. In this case the order of succession in the system of cropping is somewhat interfered with. The winter vetches generally succeed a straw crop, and being consumed early in the summer, leave the land healthy for a root or fallow crop; while the spring vetches may be sown either upon the winter fallow after late turnips consumed on the land, or early rye-grass cut for soiling. These again are ready for cutting about the month of June; and allowing a month for the consumption of the crop, there is ample time to get the land ploughed up, and a crop of some quick-growing plant, as mustard or buckwheat, fed off the land before the time for sowing the grain crop arrives, for which either of those plants forms an excellent preparation." The quantity of seed to the acre is about two bushels; the seed should be sown in drills at least twelve inches apart. Vetches are often sown in conjunction with *Rye*, the grain serving as a support to the vetches, keeping them off the ground, and adding greatly to the productiveness of the plants. Rye, it may here be said, is often grown as a forage crop, to be cut green—oftener, perhaps, in this country for this purpose than to raise food for man.

Clover.—This, the most important of all our forage crops, belongs to the order of *Leguminosæ*, forming a distinct genus *Trifolium*, of which there are a great many species. The following are enumerated by Professor Wilson as the species most generally cultivated in this country:—(1) *Trifolium pratense*, Common red clover; (2) *Trifolium pratense perenne*, Native perennial red clover; (3) *Trifolium medium*, Zig-zag clover, or Marl grass; (4) *Trifolium repens*, White, or Dutch clover; (5) *Trifolium hybrid,* Hybrid, or Alsike clover; (6) *Trifolium procumbens,* Hop trefoil; (7) *Trifolium incarnatum,* Scarlet, or Italian clover. The characteristics of all these will be found in "Farm Crops," pp. 88 to 95, vol. ii. All soils in which lime is present are capable of growing one or other of the species we have enumerated. The clovers, therefore, play an important part in almost every rotation, their place being invariably between two grain crops. Unfortunately, as Professor Wilson clearly points out, clover is rarely grown alone as a separate crop of the rotation, but is sown along with grass seeds—generally "rye-grass," which, belonging to the same "order" as the grain crop which precedes and follows it, thus does away with the very principle of a rotation the basis of which is to place as wide intervals as possible between plants of the same order.

Clover is always sown with the straw crop which precedes it. With winter wheat, the clover is sown in the spring in April; with barley and oats it is advisable to allow the grain plants to be well up, and get a hold of the soil, before the clover is sown. When the straw crop is harvested, the clover crop, obtaining a more plentiful supply of light and air, acquires new vigour, and gets a good hold of the soil, to enable it to resist the winter frost. It occupies the ground all the succeeding season, and is either cut green or made into hay. If made into hay it should be allowed to grow till the flower-heads are pretty well formed. The time for cutting will depend upon the season; but in good seasons it should be cut, made into hay, and off the ground before the first week of July. Time is thus permitted for a second crop, which may either be cut as forage, or be ate off with stock. If the clover is to form one year only of the period of rotation, the "ley," as it is called, is ploughed up to be in time for the crop, say wheat; but if the clover is to remain a second year, it should receive a good top-dressing of farm-yard manure as soon as the second crop is disposed of. The usual practice is to consume the whole of the produce of the second year by stock. In connection with the clover crop what is called "clover sickness" has attracted considerable attention. The following is stated by Professor Buckman, in a recent article in the "Bath and West of England Society's Journal," as the causes of, and the remedies for, this. The causes act either separately or together:—"First. A too frequent repetition of clover, or its allied plants, by which some of the chemical elements upon which such plants feed are abstracted; and, in the case of thin soils, they too soon get charged with humus, which, though adapted for the growth of chickweed, sandworts, cudweed, &c., is unfit for clover. Second. Clovers, both in the sorts grown and in their method of growth, are yearly becoming more delicate; for as the sorts themselves are derivatives, so their permanency is difficult to maintain; and as, on the one hand, they are grown up sickly by being smothered and drawn up by the cereals, so, on the other, they are robbed of much of their food. Thirdly, and lastly, though by no means least, clover seed is too often found to be so dirty that, from this cause, added to the natural weeds of the soil, so delicate a plant as the young clover is frequently smothered in its infancy by hosts of weeds which occupy the space of the desired plant, and at the same time appropriate the food designed for it. The remedies for these evils recommended by the Professor are:—First. The desirability of procuring a new strain of the plants from well-selected wild specimens. Second. The cultivating this seed for market free from the contamination of another crop, as a means of getting it absolutely pure. Third. In the growth of a crop of clover, weeding, which would thus be practicable, should not be neglected. Fourth. If broad clover has been frequently repeated there should be a change to rye-grasses, or rye-grasses with white Dutch clover or trefoil. Fifth. Spring top-dressings after weeding on a weak plant will mostly be found to be of great use."

Lucerne.—This plant belongs to the same order as the clover, and forms a distinct genus—*Medicago,* of which there are several species, the lucerne being the most important; its botanical name is *Medicago sativa.* It is highly esteemed on the continent, as a forage plant, where it is grown extensively. It is better adapted for warmer climates than our own, although in many districts good crops are here obtained. It is a perennial, and when grown under favourable circumstances, heavy and numerous cuttings may be obtained from it. The soil best suited for it is a dry deep one. The seed is sown in April, and is best sown in drills fifteen to eighteen inches wide. If so sown, seven to ten pounds of seed per acre will suffice; if broadcasted, fourteen to twenty. Lucerne is grown as a distinct crop, and does not take part in a rotation.

Sainfoin belongs to the same order as lucerne; its botanical name is *Onobrychis sativa.* Light calcareous soils are best adapted for its growth. Its cultivation resembles that adopted for lucerne. It is valuable for bringing light chalky soils into cultivation. Sainfoin is often sown along with a straw crop, like clover; but the peculiarities of the plant are best supported when it is sown like lucerne, as a distinct crop. Like that plant, it arrives at perfection in its third year of growth. The most economical way to use it is to cut it green.

Rye-grass.—This is the only *grass* which is exclusively or singly grown as a forage plant. It belongs to the order *Gramineæ;* the genus is *Lolium,* of which there are two species valuable in the field—(1) *Lolium perenne,* or Common rye-grass; (2) *Lolium Italicum,* or Italian rye-grass. The latter is the crop to which the following remarks specially refer, as it is by far the most important and valuable as a forage crop. Italian rye-grass can suit itself to a wide variety of soils, possessed of a moderate degree of fertility; it succeeds best, however, with rich loamy soils. Its place in the rotation is generally after a grain crop; but this is wrong practice, as the plant belongs to the same order as the grain crops. Its proper place is after a manured green, or root crop. In the usual practice of the farm it is sown either as a distinct crop, or sown down with the grain crop, as wheat, oats, or barley—the last is the grain crop with which it succeeds best. In the latter case it is sown in spring, the grain crop being slightly harrowed before the seed is put in. If sown by itself in autumn, if the weather is favourable, a cutting may be obtained the same year. Remarkable crops are obtained from Italian rye-grass where liquid manure is available. Top-dressed with lavish washings of town sewage, or the liquid manure of the farm, as much as from 90 to 100 tons per acre have been obtained in one season. Where liquid manure or sewage is available in large quantities, from 2,000 to 3,000 gallons per acre should be applied during the season. Treated thus, the growth of the plant is amazingly rapid. Repeated cuttings may be obtained for forage purposes; but if it is to be made into hay, the best time to cut it is when the plant is in full flower, but before the seeds are properly formed. The quantity of seed required when grown by itself as a distinct crop is from two and a half tc four bushels per acre. When the crop is designed to occupy the land two years, it is a usual practice to mix the seed with clover seed—as, to two bushels of rye-grass, fifteen or twenty ounces of clover seed.

Gorse, Furze, or *Whin.*—By these three names is the plant known; the first being the English, the second the Irish, and the third the Scotch designation for it. It belongs to the order *Leguminosæ,* and forms a distinct genus, *Ulex,* of which three species are useful in the field:—(1) *Ulex Europæus,* or Common gorse; (2) *Ulex nanus,* or Dwarf gorse; and (3) *Ulex strictus,* or Irish gorse. It is specially adapted for poor dry soils, in the poorest of which, indeed, it seems to thrive. The seed should be sown in drills eighteen to twenty-four inches apart, at the end of March. A cutting may be obtained in the autumn of the second year. It is valuable not only because it is highly relished by cattle, but because it comes in during the winter months, when green food is peculiarly acceptable. Before it can be consumed by stock it has to be crushed by machine or by a hand mallet.

DIVISION SEVENTH.

GRASSES.—PASTURES.—MEADOWS.—HAYMAKING.

Grasses.—Some of the grasses, as described in last division, are grown specially as forage crops, as Italian rye-grass, either to be cut and used as green food for stock, or allowed to grow for a longer period, then cut and made into hay. The grasses selected for this purpose are those which grow rapidly, producing the largest produce in the shortest space. Grasses, again, are grown to form "artificial pastures," which occupy the land for two or more years, and which, alternating with other crops, form part of the regular rotation; this part of the rotation of a farm is usually designated the "seeds." The third way in which grasses are used, is "permanent pasture;" the object in this case being to imitate, as closely as possible, the grasses of fine old pastures.

The varieties of grasses are very numerous, but a few comparatively, however, are used, these being selected with a view to obtain the nutritive and aromatic properties which distinguish the grasses of our best natural pastures. As might be supposed from the different soils and climates with which the farmer has to deal, very considerable diversity exists in the kinds and quantities of the grasses used in practice. Each locality, in fact, has its own particular mixture best calculated to pay, from which it will easily be understood that this can only be decided upon after long experience and observation. There are, however, several mixtures which have been recommended; and of these, as giving the tyro some idea of the names of the grasses, and the quantities used, the following will be useful. We are indebted for the material of these tables to the exceedingly valuable work of Messrs. Lawson and Son, of Edinburgh and London, entitled "Treatise on the Cultivated Grasses, and other Herbage and Forage Plants." For full information of the grasses of Great Britain, the reader may consult with advantage Dr. Parnell's work, published by Messrs. Blackwood, Edinburgh. Mr. Sowerby's work on the Grasses may also be perused with profit.

TABLE OF MIXTURES OF GRASS SEEDS PER ACRE FOR HAY AND ARTIFICIAL PASTURE, IN ALTERNATE CROPPING.

Common and Botanical Names.	Heavy Soils.		Light & Medium Soils.	
	1 Year's hay & 1 Year's pasture.	1 Year's hay & 2 Years' pasture.	1 Year's hay & 1 Year's pasture.	1 Year's hay & 2 Years' pasture.
	lbs.	lbs.	lbs.	lbs.
1. Cocksfoot grass, common rough (*Dactylis glomerata*)	2	2	2	2
2. Italian rye-grass (*Lolium Italicum*)	9	9	9	9
3. Common perennial rye-grass (*Lolium perenne*)	15	15	15	15
4. Yellow clover (*Medicago lupulina*)	2	2	1	1
5. Catstail grass (*Phleum pratense*)	2	2	2	2
6. Clover hybrid (*Trifolium hybridum*)	2	2	2	2
7. Red clover (*Trifolium pratense*)	4	4	4	4
8. Clover perennial (*Trifolium pratense perenne*)	2	4	2	4
9. White clover (*Trifolium repens*)	4	4	4	4
	42	44	41	43

When a crop is required for one year's hay, the following are the mixtures recommended:—

Names of Grasses.	Heavy Soils.	Medium and Light Soils.
	lbs.	lbs.
1. Dactylis glomerata	—	—
2. Lolium Italicum	9	9
3. Lolium perenne	15	15
4. Medicago lupulina	1	—
5. Phleum pratense	1	1
6. *Trifolium* hybridum	1	1
7. Trifolium pratense	8	8
8. Trifolium pratense perenne	—	—
9. Trifolium repens	2	2
	37	36

Table of Mixture of Grasses per Acre for Permanent Pasture.

Common or Vulgar, and Botanical Names.	Heavy Soils.	Medium Soils.	Light Soils.
	lbs.	lbs.	lbs.
1. Smooth-stalked meadow grass (*Poa pratensis*)	—	—	1
2. Stoloniferous meadow grass (*Poa trivialis*)	3	2½	—
3. Birdsfoot trefoil (*Lotus corniculatus*) . .	—	½	½
4. Birdsfoot trefoil, greater (*Lotus major*) .	½	½	—
5. Yellow clover (*Medicago lupulina*) . .	1¼	1	1
6. Clover hybrid (*Trifolium hybridum*) . .	2½	2	2
7. Red clover (*Trifolium pratense*) . . .	1½	1¼	1
8. Clover perennial (*Trif. pratense perenne*).	3½	3½	2½
9. White clover (*Trifolium repens*) . . .	6	5	4
10. Foxtail grass (*Alopecurus pratensis*) .	2½	2	1½
11. Sweet-scented vernal grass (*Anthoxanthum odoratum*)	½	½	½
12. Yellow oat-like grass (*Avena flavescens*)	—	1	1
13. Cocksfoot grass, common rough (*Dactylis glomerata*)	5	5	4
14. Fescul grass, hard (*Festuca duriuscula*)	2½	2½	2
15. Tall meadow fescul grass (*Festuca elatior*)	2½	2	—
16. Fescul grass, various leaved (*Festuca heterophylla*)	2	2	—
17. Fescul grass, meadow (*Festuca pratensis*)	4	3½	2
18. Red fescul grass (*Festuca rubra*) . . .	—	—	2
19. Italian rye-grass (*Lolium Italicum*) . .	9	8	7
20. Common or perennial rye-grass (*Lolium perenne*)	10	10	9
21. Catstail grass (*Phleum pratense*) . . .	3	2½	2
22. Meadow grass, wood (*Poa nemoralis*) .	1½	1¼	1
23. Meadow grass, Hudson's Bay (*Poa nemoralis sempervirens*	1½	1¼	1

The foregoing table is for mixtures where the seeds are sown down without a crop. The following shows the mixtures adapted to be sown down with a crop, as barley :—

No. denoting Name in preceding Table.	Heavy Soils.	Medium Soils.	Light Soils.
	lbs.	lbs.	lbs.
1.	½	—	1
2.	2½	2	—
3.	—	½	½
4.	½	½	—
5.	1¼	1	1
6.	2½	1½	1½
7.	1½	1	1
8.	3½	3	2
9.	5	4	4
10.	2	1½	1¼
11.	½	½	½
12.	—	1	1
13.	4	4	3½
14.	2	2	2
15.	2½	2	—
16.	2	2	—
17.	3½	3	2
18.	—	—	2
19.	8	7	6
20.	9	9	8
21.	2½	2	1½
22.	1¼	1	1
23.	1¼	1	1

Improvement of Pasture Lands.—The large extent of land which is under pasture grass, both in England and Ireland, makes it a point of no small importance to ascertain the best modes of improving it, and rendering it profitable to the maximum extent. The poor condition of the herbage in too many districts, shows that much has yet to be done in improving the fields which yield them. In a very great many instances, by far the most economical way would be to plough up the old pastures, put the land under a course of cropping, and prepare it for the laying down of permanent pasture with improved grasses; but there is such a favourable notion prevalent in the minds of many landlords as to the value of old pasture lands, that it is quite impossible to prevail upon them to adopt this radical but proper mode of treatment. The improvement of old pastures is therefore all the more necessary to be attended to. Improvements consist in—(1) draining the land; (2) sowing "renovating mixtures" of grasses best suited for the soil and locality; (3) refraining from cutting the grass and making hay of it; (4) top-dressing it, with artificial manures. Draining is of essential service to pasture land, especially in heavy soils; where it is thoroughly carried out it secures that degree of porosity in the soil which is best calculated to increase its productiveness, for in wet weather all undue moisture is carried off, while in dry, the capillary attraction brings up the moisture of the soil to the upper surface, and refreshes the herbage which it bears. A natural result of neglect of drainage in pasture fields is the appearance and maintenance of poor, aquatic, unnutritious grasses. These, on the land being drained, will disappear, and will *apparently* reduce the value of the pasture; but this loss is only apparent, for it can be made up—and well made up—by sowing renovating mixtures (alluded to above) of the finer grasses. Some practical men have, however, raised the question whether drainage in certain soils is good for pasture lands. We know of one instance where the undrained portion, left purposely by the farmer, a thoroughly practical man, to test the point, gives far better results than the drained portion. It is right, however, to state that the opinions as to the value of drainage as given above are those generally held to be correct. Pastures are often reduced in value by the practice of taking crops of hay off them. The hay crop is a peculiarly exhausting one, far more so than the wheat crop: thus, while the latter takes off the land 10 lbs. of nitrogen for every 1,000 lbs. weight of its straw and grain, hay takes off 14 lbs. for the same weight of material. In addition to the loss thus sustained by depriving the land of so much of its fertilising constituents, a further loss is sustained by allowing the grasses to mature before being cut for hay. This inevitably weakens the reproductive power of the grasses, which become weak, and are ultimately supplanted by inferior grasses which spring up. The improvement of pasture lands is further effected, and, perhaps, in a more marked manner than by any of the methods above described, and this is by the use of surface applications, or top-dressings, of manures. The pasture lands of Cheshire have been enormously increased in value by the application of bones, in the form of dust or crushed. "For pasture land, especially the poorer kind, there is nothing equal to bone manure, either as regards the permanency of its effects, or the production of a sweet, luxurious herbage, of which all cattle are fond." It is right to state that the practice of bone manuring, although remarkably successful in Cheshire, has not been found so in other districts where it has been tried. Artificial manures, as guano, nitrate of soda, &c. &c., are now used with great success in improving pasture lands. The following is an extract from a prize essay in the "Highland Society's Transactions," bearing on the use and value of artificial manures as top-dressing for pastures.

"From what has been said it will be seen that my experience in top-dressing pastures may be summed up thus:—

"1. On strong soils on lands under cultivation, guano, sulphate of ammonia, nitrate of soda, and soot, are the best, and that they will prove remunerative if the weather is not too dry. The first three, even in the unfavourable season of 1859, held a high place in the experiment detailed.

"2. On light soils, in alternate husbandry, composts of earth, bone dust, cattle urine, salt, sea-weed, and fish refuse, are the most suitable.

"3. For old grass on strong soils, powdered lime is the most effectual dressing that can be applied. Although it did not stand well in this experiment, its good effects may be fully expected.

"4. For old grass on light gravelly soils, clayey compost mixed with quicklime, bone dust, and salt makes a good dressing, and peat and wood ashes produce an excellent effect. Should all these fail to make good pasturage, then certainly it ought to be ploughed up.

"We are told by Professor Johnson that the bones of the sheep contain 70 per cent. phosphate of lime, and that a milch cow carries off annually 30 lbs. of bone-dust from the land; and if this waste is to be supplied, as it certainly ought, there can be no better way of doing it than by adding bones, lime, and other phosphatic manures to the land. Let our grazing lands, then, be liberally dressed, where necessary, with those manures, and we shall have abundance of grass. When the supply of bones fails, we may have recourse to coprolites; and when the pastures in our low valleys have all been clothed in their deep green verdure, we may with propriety extend the system to the pastoral glens, and the lime and the bone earth will soon make a favourable change on the hill-sides of the country."

Where farm-yard manure is used to top-dress pastures, or meadow land, it is advisable to lay it on the land early in the season, say November. Not only has the manure time to decompose and get incorporated with the soil, but in cases where renovating mixtures of grasses are applied, the manure tends to shelter the young grasses from the frost. A very useful "compost" for top-dressing pastures is that recommended by Professor Tanner. It consists of the "scouring of ditches, road-scrapings, weeds, sods, bog earth, and, in fact, any vegetable matter not suitable for the farm-yard manure heap." These matters, or such of them as can be obtained, are to be well mixed up, together with lime fresh from the kiln, and a little water added to it. If there is much vegetable matter in the heap, one cart-load of lime should be used to three of the matter of the heap; the quantity of lime should be increased in proportion to the poverty of the heap in vegetable matter. The heap should be allowed to rest from four to six months, then turned over and well mixed before being applied to the land. The application should be made in early spring, at the rate of thirty loads to the acre, the whole being well rolled and bush-harrowed.

Meadows, for Hay.—Artificial manures are now much used for top-dressing meadows. Bones are not so valuable for meadows as for exhausted pastures. The manure generally used is farm-yard, or compost such as above described. Nitrate of soda and Peruvian guano, of all the artificial manures, seem to give the best results. We have used nitrate of soda, and have found it give a considerable addition to the crop. It not only increases the produce, but it seems to have the effect of improving the quality of the grass,—weeds and poor herbage disappear. We recommend in all cases the nitrate of soda to be mixed with coal ashes and common salt. Nitrate of soda alone we conceive to be the most expensive way in which to use this manure. Nitrate of soda, however, containing no phosphate, although rich in nitrogen, it will in many soils be advisable to use a manure in which phosphates are present. Peruvian guano possesses both nitrogen and phosphates, hence the esteem in which it is held as a top-dressing for meadows. Phospho-Peruvian guano is also said to be an excellent manure. The result, of the practice of the past few years in the top-dressing of grass lands has proved that those salts (as nitrate of soda, sulphate of ammonia, soot, and guano) which have a nitrogenous base, give the most satisfactory yield. We give below the artificial manure recommended by Messrs. Lawes and Gilbert: this is to be applied in January every year; a good top-dressing every four or five years of 10 or 12 tons per acre of good rotten dung being also given. The quantity of artificial manure per acre is 2 to 2½ cwt. The following is the manure:—"Peruvian guano, 3 parts; nitrate of soda, 1 part; sulphate of ammonia, 1 part." Soot, coal ashes, wood ashes, common salt, super-phosphate, rape-dust, muriate of ammonia, are all useful for the manuring of meadows.

The following are the artificial manures for the *gramineous* or grass crops, from Mr. Jacob Wilson's valuable paper (see division on Manures), will be useful:—

"*Sandy Soils.*—Grasses, both in permanent and artificial pastures, may receive 1 cwt. each of guano and nitrate of soda towards the end of February, and a similar quantity in April."

"*Calcareous Soils.*—Sulphate of ammonia 1 cwt. of nitrate of soda 1 cwt., with 3 cwt. salt, will be an excellent dressing; or, instead of this, 2 cwt. guano and 2 cwt. salt will produce a beneficial effect. It would be still better if this application could take place at two separate times, instead of the entire quantity at once."

"*Clay Soils.*—For artificial grasses, I would apply 3 cwt. guano, or 2 cwt. guano and 1 cwt. sulphate of ammonia, either all at once towards the end of March, or at two different times previous to and after that period, as the season permits. For permanent pasture, the general management during preceding years would in a great measure guide me. If I knew it to have been grazed by cattle for a number of years, and the produce sold off the farm in the shape of beef, or more especially as milk or butter, without an equivalent being supplied by an allowance of cake, I would, without hesitation, give it a dressing of bone-dust, as the most effectual means of restoring the loss incurred; twenty bushels per acre applied early in winter would be enough. For land regularly mowed, a compost of lime, soil, and salt, applied during the winter, is an excellent manure; or 2 cwt. guano and 1 cwt. superphosphate, given in March, would produce a luxuriant crop. Except on grass land which has been thoroughly exhausted, the effects of bones will not be so visible; but on such land they produce a marvellous effect, as the exhausted pastures of Cheshire have demonstrated."

"*Vegetable Moulds.*—Coarse grass is the natural and universal produce of such land; consequently, in an arable state, Italian rye-grass grows most luxuriantly, and often to the exclusion of clover and the finer grasses. Where required, 2 cwt. each of nitrate of soda and common salt would produce a capital bite. A bone manure, partially soluble, with a slight admixture of a saline substance, will invariably produce good effects; but perhaps the best results on permanent pasture on these soils have been obtained from a compound dressing of lime, soil, and salt, the wonderful effects of which on land recently enclosed, and usually of a peaty nature, are familiar to most of you."

"*Loamy Soils.*—For artificial grasses, 2 to 3 cwt. guano, or 2 cwt. nitrate of soda, will be enough if applied early in April. For permanent pasture, 2 cwt. superphosphate, 1 cwt. guano, and 1 cwt. nitrate of soda may be recommended."

Haymaking.—The grass of meadow lands is generally ready to be cut in the middle or towards the end of June: when the grasses are in flower is the period at which they should be cut. All the grasses do not flower at the same period, and some do not attain to their full nutrition till the seeds are nearly ripe; as, for instance, the *Dactylis glomerata*, *Holcus odoratus*, and *Phleum pratense*. Some delay cutting till these are fully developed. It is unsafe, however, to do so, as a very favourable time for haymaking may be allowed to pass away. Further, although a somewhat greater degree of nutritive properties may be obtained in certain grasses by allowing their seeds to nearly ripen, others will by this time have got too ripe, and the period of growth for the "after-math," or second crop, will be so reduced, that all advantage obtained by waiting will be lost.

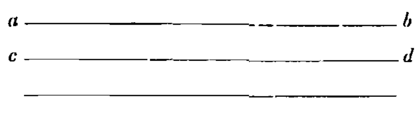
In making hay, the standard to be arrived at is to have it, when stacked, in the condition of "dried green grass," with a fine full odour and flavour. A ton of hay in this fine condition is worth three of the yellow, musty, odourless, and flavourless hay too often seen. To obtain hay in this condition, the signs of settled weather should be taken advantage of; and when once cut, and the weather favourable, no time should be lost in keeping the grass in perpetual movement, tedding and turning it over and over, exposing it to the sun and wind. The quicker the hay is made the better, and it is a tried economy to employ a superabundance of hands rather than to have too few. The following will convey to the reader an idea of the principles which should guide the farmer in haymaking. It is extracted from the valuable article on "Haymaking," in the "Cyclopædia of Agriculture," edited by Mr. J. C. Morton:—

"1st. He must remember that the chief point is to preserve the hay from dew and rain,—water washes away the soluble salts and other matters, and when in the stack will cause fermentation, and that injures the hay by destroying some of its most valuable properties; therefore, bring it into wind-rows, or make it into foot-cocks at nightfall, and never open it in the morning until the dew has evaporated.

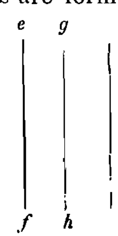
"2nd. Bear in mind that, if the weather is unfavourable, the less it is disturbed the better, and the longer will it retain its native powers. Hay has been found to preserve a great amount of its nutritive qualities for may days, nay, even weeks, when mown wet, or when saturated with the rains whilst lying in the swath; if, therefore, the weather be unfavourable, it will be better not to ted the hay at all, nor even turn over the swath. If repeatedly dried and wetted again, it soon becomes valueless; this error of meddling with hay amidst frequent showers must, if possible, be avoided, for it is far better to have it somewhat tainted in the haycock than thus exhausted of its nutriment, and spoiled by being repeatedly spread.

"3rd. Take care not to allow it to remain long under the hot beams of the sun without being turned,—this will preserve the colour and fragrance of the grass; so that, without baking it too much (thus destroying its virtues), it may be so dry that as little heating or fermentation as possible shall occur in the stack, remembering also that coarse grass does not require so much 'making' as fine succulent herbage."

The methods employed in "getting" hay differ in various districts; as a general rule the process is somewhat as follows:—The mowers should begin to mow early in the morning, say about three o'clock,—the dew being on the grass facilitates very much the mowing operation. Care should be taken to make the mowers cut as close to the ground as possible. This is necessary; not only to enable the after-grass, or second crop, to grow rapidly (long-mown grass always grows slowly), but the weight of the crop is much increased; an inch at bottom is worth several at the top. The grass cut thus early in the morning, should be allowed to lie in "swathe" till the sun is pretty well up, and has been beating on it for some time. In fine genial June weather this will be about nine or ten o'clock. The process of tedding is then begun; and this should be done carefully, so that the grass be spread as equally out as possible. No tufts or lumps of mown grass should be allowed to lie, but all opened up well. The thinner the grass is laid out the better. This tedding, or spreading, is done by means of the "hay-fork," or "pikel," as it is termed in the north of England. If the weather is fine and sunny, with a gentle breeze blowing steadily, the hay will almost "get itself," as the phrase goes, and towards afternoon it may be "wind-rowed;" that is, gathered or raked into rows, and allowed to lie for some time in this way. If the weather, as above stated, has been very good, these rows may be put into "foot-cocks"—that is, into small heaps, and thus allowed to remain all night. Next morning (second day), *as soon as the dew is dried off the ground and from the cocks,* these small heaps are to be tedded out, spreading the grass as evenly and thinly out as possible. If the weather is thoroughly settled this may be allowed to lie for several hours; thereafter "wind-rowed," lying thus for some time; then "cross-cut;" and finally raked into small "cocks," and left for the evening. The operation of "cross-cutting," here alluded to, has for its object the turning over of the wind-rows first made, which we suppose to have been made by raking the hay into rows in the direction of the lines *a b, c d,* &c.



These rows are raked up, so that new rows are formed running in the direction of the lines *e f, g h,* &c. Before putting the hay into large cocks, two or more of these wind-rows are raked together into large ones. On the morning of the third day, these are opened out, and well spread, for exposure to the sun and wind. The hay, by this time



pretty well made, is next gathered into large wind rows or rows, and finally put into large cocks in the evening. If the weather has been good the hay thus made may be led next day, or may be begun the same evening, and stacked. A very good way to test whether the hay is ready to be led, is to take a good handful and plunge the face into it, allowing it to rest for a short space; the peculiar feel of odorous dryness will, after a little experience, tell whether it is fit to be stacked or not. As soon as it is considered ready to be stacked, lose no time in getting it housed or stacked; work late on the same evening it is ready, as long as your men can see: every moment is precious in haymaking.

Such is a brief outline of the process of haymaking in fine, settled, sunny, and breezy weather; but of course it is rendered much more tedious and unsatisfactory in rainy or unsettled weather. We have had hay made in three days, and we have had it under the process of making for nearly as many weeks. When the weather is fairly unsettled, bear in mind the second of the rules as above, quoted from the "Cyclopædia of Agriculture." We can render ready testimony to the value of the rule. Where hay has been subjected to much rain during making, it is apt to become musty. In stacking it, as each layer is put on, it is considered a good plan to sprinkle salt over its surface before putting on another layer of hay.

After stacking, slight heating sets in, or "sweating," as it is graphically, if not elegantly, termed in rural districts. This process is good to bring the hay made from poor grass into good eating condition; but where the grass is rich and of good quality, the benefit done to the hay by it is, to say the least, very doubtful. Weather is, however, in many districts so capricious and unsettled, that it is difficult to get hay always housed in such good dry condition as not to "sweat" a little after it is stacked. Of course, hay should never be put in the stack or in the house so damp as to cause it to over-heat and get burnt.

Hay is stored in one of three ways:—(1) In a "stack" which is altogether exposed to the weather; (2) in a hay-house, which is provided with a roof, but has its sides and ends more or less open; (3) in a loft or barn. Where hay is stacked, a rick-cover should be used. This is an arrangement of vertical poles supporting an awning or cloth, under cover of which the stack is built up. The great advantage of this is, that as soon as the hay is fairly in the stack, it is independent of any rain which may fall after it is stacked.

As it is a good rule in the making of the hay from permanent meadow to keep perpetually turning and exposing it to the sun and air,—this, however, only in settled and continuously good weather,—so is it, on the contrary, a bad one in the case of artificial grasses and clover. When cut, the swathes should be allowed to lie till the upper part is dried, then gently turned over to expose the under side. This turning over should not be delayed till the leaves are dry and brittle, as if this is done they will break short off, leaving little but dry and unnutritious stalks.

The making of hay on the large scale is now greatly facilitated by the use of machinery, as the "mowing" machine and the "tedding" machine. The following, from a paper in the last part of the "Journal of the Royal Agricultural Society" (vol. xxiii. part 49), on "Recent Improvement in Haymaking," by Mr. Bowick, on the use of the mowing machine, will be useful:—

"*Time is everything in the matter;* and the man who makes, carries, and secures his hay in good order in the shortest time is the most successful manager. We set Wood's two-horse mower to work, which is a first-rate little implement, cutting upon an average from six to eight acres per day. The first day's work we allow to remain untouched, as left by the mower, in small cuts or swathes, unless the weather should be very forcing; for I do not think it wise to move hay about too much. Next day we use the shaker,—Howard's or some other,—with this improvement, that we introduce, instead of a pair of shafts, a pole and an extra wheel, which takes all the weight off the horses' backs, putting thereto a pair of old carriage-horses. A man is mounted on the box, and drives away famously. The grass so shaken out is very soon made into hay, which we then rake into rows with the horse-rake. After this we run up every row of hay so collected by Sir J. Tyrrell's cocking rake (invented by himself), which draws together very large heaps eight feet high. Two or three men can follow with forks and secure a large quantity in the afternoon, or on the appearance of a storm."

The following is from the same paper, on the mode of using the tedding machine, as described by one of its largest manufacturers :—

"Our mode of haymaking," he writes, "is to put the tedding machine into operation as soon as the scythes have got a fair start ahead, and to work the machine across the swathes *obliquely*—generally endeavouring to work with the wind sideways to prevent the hay being blown on the horses. If the crop is unusually heavy, so that the tines of the machine cannot get hold of it all at one turn, we recommend that the field be twice gone over, the revolvers being a little raised from the ground for the first time, and then lowered for the second bout sufficiently to complete the spreading after the grass has been allowed to lie for a few hours. The next operation should be performed with the second or backward motion. After reversing the action of the machine, the tines should be lowered till they just touch the ground; you will then turn over and lighten up the hay, without knocking it about as much as the first action does. We recommend that the use of the reverse action be continued until the hay is completely made."

DIVISION EIGHTH.

INDUSTRIAL PLANTS:—FLAX—HOPS.

Flax.—Of the crops cultivated for the special purposes of our manufactures or trades, flax is decidedly the most important. It belongs to the natural order *Lineæ*, of which the genera are three, and species ninety; of all these only one is cultivated, the *Linum usitatissimum*, or "common flax."

Flax can be cultivated in a wide variety of soils; its most genial soil is, however, a rich, deeply-cultivated, loamy soil. Sparingly cultivated in Great Britain—Ireland being the only country where its cultivation may be said to assume any importance—the crop takes no special place in our rotations; fortunately the habits of the plant are such as to enable it to follow or precede almost any of our usual crops. The land should be deeply ploughed in autumn and left rough till spring, when the cultivator should be sent across, reducing it to a fine tilth, the surface being smoothed by running a light roller over it. The period for sowing is about the end of March or beginning of April, the quantity sown being from one to two bushels per acre. The seed is usually sown in this country by the drill, the rows being eight to ten inches apart. Where a first-rate crop is wished for, hand-weeding should be carefully attended to. The flax is pulled as soon as the flowering has fairly begun, when the stem near the root begins to change colour. The flax is not cut like grass, but pulled up by the roots. The handfuls are then laid across, each allowed to dry in the sun for a few days, afterwards bound up into "stooks," and, finally, when dry, are stacked like our ordinary grain crops.

It does not form part of the plan of this treatise to go into the technical details connected with the preparation of the flax; for these we refer the reader to a small treatise on "Flax," published by Routledge; and to Professor Wilson's "Farm Crops."

The Belgians have long been famous for their skill in the cultivation of flax, that grown in the neighbourhood of Courtrai, in West Flanders, being considered especially fine. The writer of the present treatise, during a somewhat lengthened sojourn in Belgium, visited this celebrated flax-growing district, and sent a few notes on the method of cultivation there adopted to the *Agricultural Gazette*, of which the following is a brief abstract. The soil sought after by the Flemish farmer for his flax crop to come to the highest perfection, "is that which is new, easily worked, strong and fertile, neither too wet nor too dry. The finest flax is obtained in the deep soil of a clayey sand, or loam." Rotations are carefully attended to; the guiding principle by which they are arranged is to keep the interval between two crops as long as possible.

"Generally, the flax crop succeeds the clover, oats, rye, wheat, or hemp. It loves new land, as a meadow or pasturage broken up. Astonishing crops are obtained from land in the neighbourhood of towns where market-garden produce is raised, from the great quantity of manure employed, as in the case of the onion, &c.

"In West Flanders a six-years' rotation is as follows:—1st year, potatoes; 2nd, rye with carrots—these being largely watered; 3rd, flax; 4th, rye; 5th, turnips; 6th, oats. A nine-years' rotation is as follows:—1st year, oats; 2nd, flax and turnips; 3rd, wheat, manured; 4th, rye or colza alone, or with clover; 5th, clover; 6th, wheat; 7th, potatoes or beans; 8th, oats with clover, sometimes with wheat; 9th, clover.

"In the Pays de Waes (East Flanders) a seven-years' rotation is as follows:—1st year, potatoes, hemp, barley, or rye; 2nd, after potatoes or hemp, rye or wheat; 3rd, after rye or wheat, flax and clover, or flax and carrots; 4th, clover, and if carrots have been grown during the third year as above, rye; 5th, after rye oats, after the clover barley or rye; 6th, buckwheat or rye, rye after barley; 7th, rye. Where the oleaginous plants are cultivated, as rape, the following is a nine-years' rotation:—1st year, potatoes; 2nd, flax and turnips; 3rd, oats with clover; 4th, clover; 5th, wheat; 6th, rye; 7th, colza; 8th, barley; 9th, rye and turnips."

The preparation of the soil for the crop is a matter of the most anxious care with the Flemish farmer; it is deeply worked, carefully cleaned from weeds, and richly manured. As soon as the crop which it succeeds is off the ground, the soil is ploughed up, and the clods well broken by the *traineau*,* or roller. Later on in the season, the land is again worked, so as to bring it to as fine a tilth as possible, the land being left in deep ridges. In spring the land is again ploughed, and well harrowed, the manure being liberally applied at this stage. This manure is composed of human excretæ, urine, and rape or oil-cake dust. The land being thus finally prepared, the sowing is proceeded with, the period for this being generally from the end of March to the 10th of April. The seed is sown broadcast; and as soon as it is in, the land is harrowed with a light harrow. Towards the twelfth or fifteenth day the weeding of the crop is begun. This is most carefully done; indeed, it is carried to a nicety which would in this country—where weeds unfortunately are not so dreaded as in Flanders—be considered altogether unnecessary.

Hops.—The hop belongs to the order *Urticeæ*, its botanical name is *Humulus lupulus*. It is grown exclusively for use in the making of beer. The varieties principally grown are the Whitelines and the Goldings. The hop may be cultivated in a wide variety of soils; that which suits it best, however, is "a deep rich loam, or a rubbly or porous subsoil, or where a loam of sufficient depth rests upon the broken bed of the upper chalk." The hop occupying the ground for a considerable period, and being in every sense a special crop, it takes no place in a regular rotation. The soil on which it grows should be deeply tilled and well manured. The plants may be raised from seed, or from plants transplanted from a "bed," or from the cuttings or

* Those of our readers desirous to become acquainted with the peculiarities of Flemish implements, as well as of modes of cultivation, may refer to "*Notes of an Agricultural* Tour in Holland, Belgium, and on the Rhine." Longmans and Co.

shoots of the old plants. The practice of raising plants from the seed is not usually followed. An authority on the growth of the hop, states that plants which have been "bedded" out will "generally give a yield of 3 to 4 cwt. the first season after they are planted, whereas no produce can be expected the first season from a ground planted with *cuttings*." In planting "bedded sets," they should be planted early in November. "Cuttings" may be got in early seasons from the parent plant as early as February; March, however, is the usual period. The cuttings should be planted as soon as taken from the plants.

The plants are placed in the ground in small raised hills, the distances between the hills being from six to seven feet. The plants are set either in squares or triangles, the latter being that generally adopted, as it enables the cultivating implement, employed to stir the soil between the plants, to be more easily used. In forming the hills, holes are dug in the ground at the proper intervals, twenty-four inches square, and twelve to fifteen inches deep. These are filled with a compost manure or farm-yard dung, and finally covered with soil. Towards the beginning of June, sticks from four to five feet for "cuttings," and six to eight feet for "bedded" plants, are placed in each hill; to these the young shoots, as they grow, are tied. In favourable seasons, and with bedded plants, a small crop may be obtained the first year's growth. In the following spring, the plants are to be pruned and dressed, and then the hills are "poled." The dressing consists in removing the earth from the hill sufficiently deep to expose the suckers; these are cut off, forming a stock for setting out new hills. On the poling being finished, the soil between each hill is well stirred; and as the season progresses, about May, the plants are tied to the poles with rushes or Russian matting. In June, the plants are earthed up at the roots. The hops, when ripe, are picked off by hand, and taken at once to the drying-house, or kilns, where all moisture is got rid of. They are then taken out of the kiln, cooled, and packed up in "pockets," or bags. The "poles" are freed from the shoots of the vines, pulled up, and stacked. The hop arrives at its full bearing power in three years, and the period of its after productiveness depends upon the care taken of its cultivation; where well looked after, it will continue bearing for many years. Plantations have been recorded as bearing well up to a hundred and a hundred and fifty years of age.

For description of other special crops cultivated to a comparatively small extent in this country, as hemp, teasel, madder, coriander, carraway, woad, and weld, we cannot do better than refer the reader to Professor Wilson's "Farm Crops."

APPENDIX.

THE BEST MODE OF CONDUCTING EXPERIMENTS ON THE FARM.

THE success of farming being dependent—as we have shown repeatedly in the text—on the close attention of the farmer to a wide variety of circumstances, the importance cannot be over-estimated of carrying out a complete series of experiments, and of carefully recording their results, with a view to eliminate from them rules for adaptation to the peculiarities of his own soil and locality. Every experiment which is well conducted is just so much added to the stock of facts and experience valuable to the agriculturist; and he who thus devotes his time to the elucidation of one subject only, may be considered as a benefactor to the list. There is no fear of a lack of subjects for experimentalising upon. The difficulty, indeed, is that there are more waiting the patient attention and care of agriculturists than are likely to be taken up for some time.

"The experimenter may," says Professor Anderson, while writing on this subject, "make up his mind that there is no difficulty in finding matter for inquiry, and that almost anything he does will be valuable; although naturally there are some subjects of more general interest, and more universal importance, than others, and which it is above all things desirable to have clearly established. Among these may be particularly mentioned the conditions under which the more common artificial manures may be most usefully applied. Of course many experiments have been made in which these substances are compared with one another, but it is not so easy to ascertain the relations they bear to farm-yard manure. In many instances these substances, and more especially Peruvian guano, are used as substitutes for dung. Thus a farmer has resolved to give to a particular crop twenty tons of manure, but he runs short, and, desiring to use Peruvian guano to make up the deficiency, the question arises, how much of the latter is equivalent to a ton of the former? That is to say, how much ground should be used with the prospect of obtaining an amount of crop equal to that which the dung will give? There is no point in regard to which greater differences of opinion exist among practical men than this, and the reason no doubt lies in the fact that the two things are not strictly comparable, their mode of action being in many respects different.

"Dung not only acts during a whole rotation, but produces certain chemical changes on the soil, promoting those decompositions which are so necessary for bringing its various constituents into the state in which they are most suitable for the plants; while guano is limited in the time of its action, and does not promote, at least to any extent, the decomposition of the soil. Notwithstanding these obviou differences, it would be very important to have a more definite ide on this point than can be derived from the facts at present at ou disposal; and for this purpose it would be necessary to have severa series of *experiments made in different parts of the country, in suc* a manner as to be completely comparable, and continued throug several seasons, and on different descriptions of soil. Suppose 20 tons of farm-yard manure to be used as the standard, another plot might be manured with 10 tons and 3 cwt. guano, another with the same quantity of manure and 4 cwt. guano. Further, there should be spaces without dung, but with 6 and 8 cwt. of guano per acre, and also others in which 10 tons of farm-yard manure used alone are contrasted with the effect of 3 and 4 cwt. of guano alone.

"The whole experiment might be arranged somewhat after the following scheme:—

20 tons farm-yard manure.	10 tons farm-yard manure, and 3 cwt. guano.	Nothing.	3 cwt. guano.	10 tons farm-yard manure, and 4 cwt. guano.	8 cwt. guano.	10 tons farm-yard manure.	6 cwt. guano.
7 cwt. guano.	8 cwt. guano.	10 tons farm-yard manure.	6 cwt. guano.	20 tons farm-yard manure.	Nothing.	10 tons farm-yard manure, and 3 cwt. guano.	10 tons farm-yard manure, and 4 cwt. guano.

"Larger quantities of manure might be used on the same principle if it be thought necessary, and portions of the experiments might be omitted if the individual considered their number greater than he could accomplish. Various modifications would also be introduced in particular instances; indeed, it would be advisable to leave experimenters considerable latitude in their choice; but it is essential that, in all cases, the experiments should be performed in exactly the same manner by more than one experimenter."

In an able paper by Dr. Anderson, from which the above is taken, there is so much that is valuable, bearing on the mode of conducting experiments in agriculture, that we think some useful purpose may be served if we give here a *resumé*, or condensation of it.

The object of all agricultural experiments is the practical one of increasing by artificial means the products of the soil. This result may be arrived at in one of two ways,—either by the study of a particular case, or by indirectly establishing general principles. The former is that generally pursued by the farmer, as his object is a personal one,—for instance, in trying the effect of guano and superphosphate. If he finds that the former is best for his soil, he considers the experiment determined. But it may happen, and, indeed, often does happen, that his neighbour may find results of the very opposite character. Investigation may show that the soils operated upon are different in character, one very light, and the other heavy. But farther, the discrepancy between the results may be still noticed, while the discrepancy between the soils may not exist at all; on the contrary, they may be pretty uniform in character, as superficially observed or characterised. A closer investigation will very likely show, therefore, that there are minute differences in character, which bring about startling differences in results. It is obvious, then, that if experiments are instituted between say two manures, and the results are barely announced, without a full statement of characters of soils, and of all the circumstances which influence the results of the experiments, such experiments are really of no extended practical value, but are more likely to mislead than to guide. Doubtless the results in such cases may be scrupulously given, but, without all circumstances of soil being also given, the utility of the experiments is very much narrowed.

The agricultural experimenter should have a definite object in view. He may either determine, after pursuing the results of agricultural progress, to try anew a series of experiments already attempted, noting similarity or discrepancy of results, or he may set out on an inquiry not yet made. It is of importance that he should not undertake too much; one experiment faithfully carried out is worth a hundred loosely done. "It is best in every case to concentrate his energies in a limited field, and to endeavour to vary his experiments within a narrow circle, in such a manner as to give precision to his results, and to eliminate all sources of error."

The determination of the field in which the experiments are to be made, affords much scope for care and attention. Uniformity of soil should be sought after; uniformity of treatment should also be the object of the experimenter's care; inattention to these two points leads to fertile sources of error. It is not necessary to have the soil in a highly cultivated condition or manurially rich—indeed, it is better that it should not be so, as elements of disturbance will thus be introduced into the experiments. To obtain really good results, the spaces or plots on which the experiments are to be made, "should be fixed the year before, and the ordinary crop of the rotation being grown in the usual manner over the entire field, the quantities produced on each of these plots should be separately weighed, and thus the limits of the natural variation determined."

Whether the absolute uniformity of the soil has been well determined or not, it is essential to have all the plots or experiments made in duplicate, because the same treatment in every respect of the two plots will yield results startlingly different. When these are met with, they of course open up interesting questions as to the cause.

The duplicate plots should be as widely separated as possible; and where difference of soil, or exposure of the field, &c., are observable, it will be necessary to have one plot on each part.

The size of the plots in which the experiments are to be made is a matter of much importance. "It is usually maintained that the larger they are the better, and there is no question about the advantage of making experiments on a considerable scale; but I have no hesitation in stating that this may be carried too far. It is obvious that when the plots are of considerable size, the risk of errors arising from inequality in the characters of the soil is, to a certain extent, diminished; but this again is counterbalanced by the consideration that we proportionately reduce the number of experiments made; because there are many persons who might be inclined to devote an acre or two to a series of experiments, who would grudge the extra space, trouble, and expense which would be entailed if each plot were to be of that extent. The fact is, that the size of the spaces may be very moderate, provided the experimenter is careful, and the soil has been proved to be of uniform quality; and thus preliminary experiments, extending over a year or two, made with the express intention of establishing this point, may, in the long run, be the sources of material economy.

"Where the plots are small, the chief direction in which risk of error is to be encountered lies in the necessity for more careful measurement, and in the chance of the manures being mixed at the edges of the adjoining spaces, or the roots of the crop passing over and taking advantage of the manure not intended for them. These sources of error must exist in all experiments, but where the breadth of land in which they are made is considerable, they are so minute as to be quite insignificant, although where the plots are small they become of serious magnitude. They may, however, be altogether avoided, provided care be taken not to place the spaces in immediate contact with one another, but to have a narrow strip of unmanured land between each. If this precaution be observed there is no reason why very moderate sized plots should not be employed; and it is perfectly possible that the results obtained, with proper care, from a sixteenth of an acre, might greatly exceed in accuracy and value those from a whole acre in which these minute points have not been attended to. Whatever the quantity of land be given to each plot, it is of the utmost importance that the entire produce obtained from it should be weighed. It is not an uncommon practice for experimenters, after taking considerable plots, to weigh the crop obtained from a part of them only. Thus, for example, if the experiment is on turnips, many persons are content to measure off a certain length of drill in each case, and weigh the produce of it only; but it should never be forgotten that when this is done, whatever may be the breadth of land manured, the *experiment* is made only on that portion of which the crop was weighed. It is very difficult to fix definitely the size of the plots which should generally be adopted, and many circumstances must necessarily influence the experimenter in his choice. From a quarter of an acre to an acre may, however, be mentioned as convenient quantities, although there is no reason to doubt that an eighth, or even a sixteenth of an acre may be employed, provided the precautions already mentioned be attended to; but in that case the experimenter will bear in mind the necessity for the greatest possible care.

"Supposing the *size of plots to have been determined, the land is* then to be carefully measured out, and marked with large, distinct, and permanent pins, fitted in the corners of each plot, enough being measured to give two spaces for each manure, and two without any application for comparison. The latter should never be omitted, as, indeed, must be sufficiently obvious; but it is particularly necessary to refer to this, because, strange as it may seem, a considerable number of experiments, otherwise well performed, could be pointed out which are rendered almost valueless by the omission of this most important *datum*."

The preparation of the manures to be used is the next point to be attended to. In the first place the quantity to be used should be carefully mixed, broken down, and passed through a sieve, and a portion taken out for analysis.

The whole question of *soil* analysis being at present in a very unsatisfactory and unsettled condition, no great benefit will be derived from having the soil analysed, while much expense and trouble would be incurred by attending to it. A more practical benefit will result if close attention is paid to meteorological phenomena and results. The use of a rain gauge, observations on the wind, temperature, &c., &c., will, if duly and carefully attended to, be productive of much benefit. Singularly enough, although obviously bearing closely on farming matters, meteorological observations are seldom made, and little esteemed. The state of the weather has a most important influence on the action of manures.

In housing and harvesting the produce of the experimental plots, care should be taken not to adopt the ordinary plan of taking up the produce of each plot on the same day. The disadvantages of this will be obvious when it is recollected that the action of some manures is to force, or hasten on, the ripening of the produce, in some cases a full fortnight before others. Unless the crops are taken up when fully ripe, no accurate result will be obtained.

The question finally comes, is weight the test of the value of the produce? This may be answered very briefly by stating that, for commercial purposes, the value of grain may be in this way sufficiently estimated; but for feeding purposes it will not be satisfactory. And this applies with greater force to the root crops, inasmuch as two crops may weigh equally heavy, yet have different feeding virtues. Indeed, not seldom is it found that the heaviest crop is the least valuable.

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