A MANUAL
OF THE
GRASSES & FORAGE-PLANTS
USEFUL TO
NEW ZEALAND.
PART I.

T. MACKAY.

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BY

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INTRODUCTION.

The object of this Manual is to place before the practical farmer, in a manner as simple and as free from technical terms as possible, a copious digest of the fullest information available regarding the various grasses and forage-plants best suited for New Zealand.

It is proposed to divide the work into three Parts.

Part I. will treat of those species which have been or should be introduced from Britain and other countries; Part II., of those kinds that are indigenous to New Zealand; and Part III. will give the particulars of any special experiments of a practical nature which have been made concerning the cultivation as well as respective values of both imported and native kinds for pasture or fodder.

As each Part will be distinct in itself, it will in the first place be published separately as soon as it is got ready for the printer.

ERRATA.

In Figure XVIII., instead of *Aliske* read *Alsike*.
In Figure XXIX., instead of *Heliantus Tuberones* read *Helianthus Tuberosus*.
In page 69, first line, instead of *rapus* read *napus*.
In page 83, tenth line, instead of *1876* read *1786*.

PREFACE.

It has been long apparent to many practical and progressive agriculturists in New Zealand that a good deal of ignorance generally prevails regarding the proper selection and cultivation of the natural and artificial grasses best suited for permanent pasture, as well as of other forage-plants, on which cattle and sheep—notably two of the principal productions of the colony—can be reared and fattened to the best advantage; and, consequently, there is a much-felt want for a manual on the subject that can be "understanded of the people." To supply, therefore, in such a shape the needful information the writer was commissioned in 1884 by the Hon. W. Rolleston, then Minister of Lands, and which was subsequently confirmed by the Hon. J. Ballance, the present Minister of the Department, to undertake the present work.

Its prosecution, however, has been subject to many interruptions from more pressing duties coming in the way, as well as delays occasioned by the difficulty at times of procuring the works of the most recent authorities for necessary information on, and collation of, subjects cognate to its purpose.

A work of the kind, no matter what degree of practical knowledge its author may possess of the subject in hand, must necessarily, from its varied character, be composed of many compilations, and consequently considerable care had to be exercised in the selection, adaptation, and assimilation of the several materials most applicable to the object in view, as well as to render them into less scientific or technical language than is generally employed in treating such subjects, so as to adapt them to the comprehension of the majority of the readers for whom the present work is more particularly intended.

The illustrations of the different kinds of grasses and forage-plants, drawn as they have been with great care and accuracy by Mr. A. Koch, of Wellington, will serve to facilitate the identification and study of the specimens they represent, as well as to distinguish several of the grasses from others not dissimilar in appearance, but different as regards their worth as food for sheep or cattle.

In conclusion, the writer has to acknowledge that he has drawn largely on the various and valuable information contained in the undermentioned works and publications, which he has not hesitated to make free use of, by transferring to these pages, with more or less modification, many particulars which appeared suitable for the purpose, and which were expressed in more apt and comprehensive language than he could have pretended to use. They are as follow:—

Hortus Gramineus Woburnensis. By George Sinclair, F.L.S., F.H.S.

Grasses and Forage-plants. By Charles L. Flint (Boston, U.S.A.).

Pasture Grasses and Forage-plants. By Samuel T. Preston (London, 1887).

Chambers's Encyclopædia.

Journals of the Royal Agricultural Society of England.

Journals of the Highland and Agricultural Society of Scotland.

Philosophical Transactions of the Royal Society of London.

The New Zealand Farmer (Auckland).

New Zealand Country Journal (Christchurch).

Newspapers: *Field, Australasian, Auckland Weekly News, New Zealand Mail, Canterbury Times, Canterbury Press, Otago Witness.*

THOMAS MACKAY.

Wellington, September, 1887.

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A MANUAL

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NEW ZEALAND.

PART I.

CHAPTER I.

THE FOREIGN GRASSES AND FORAGE PLANTS WHICH HAVE BEEN, OR SHOULD BE, CULTIVATED IN NEW ZEALAND.

In the cultivation of imported grasses in this colony, it has hitherto been almost the universal practice to either surface-sow, or lay down, pasture-land with only one or two kinds, such as cocksfoot and perennial rye-grass; with, perhaps, in some instances where the land has been ploughed, a mixture of timothy and white clover, and, but rarely, some cow-grass. The effect of this is that, while in the spring and beginning of summer there is an abundance of feed, after midsummer the grasses in such pastures present a very dried-up appearance, particularly the rye-grass, which has run up into brown and wiry seed-stalks that stock will not touch; and even after the late autumnal rains have freshened up the parched pastures, there is not much nutritive matter in the second growth, which must not, besides, be fed too close, or there would not be much left for winter feed. Now, on the other hand, if permanent pasture-land were brought by the plough and harrow to a proper tilth, and sown with a selection of grasses and clovers of various habits of growth that would be in equilibrium with each other, and so associated as to severally attain their times of blossoming at different periods,

and thus afford a succession of succulent herbage from early spring to the end of autumn, it would—having regard to being allowed due rest at times by the shifting of the stock to other paddocks similarly cultivated, and the absence also of overstocking—carry more stock relatively, and fatten them more quickly, than the meagre pastures first described. To indicate how this can be effected will be the main object of this Part of the Manual.

The imported grasses and forage-plants which have been acclimatized in this colony have been introduced principally from England. There are about two hundred known kinds of such grasses and plants grown in Britain, of which, however, there are comparatively a small number worth cultivating for their feeding properties. These only, together with those from other countries, will be dealt with; and, although they may be considered, at first sight, to be but few, it will be found that none of any real practical value, in an agricultural sense, have been omitted.

In addition, however, to describing the suitable natural and artificial grasses for permanent pasture, there are, besides, other valuable forage-plants—of which descriptions will be given—that may be the means of inducing more extended cultivation thereof than exists at present.

The following is the order in which both grasses and plants will be grouped and described:—

I. Natural, or the true grasses, such as cocksfoot, the fescues, and timothy.

II. Artificial, or the leguminous, such as the clovers, lucerne, and sainfoin.

III. Forage-plants of special value, such as Indian-corn, sunflower, and also roots of various kinds.

I. NATURAL GRASSES.

These may be divided into two classes, coarse and fine.

Class 1. Coarse Grasses.

Cocksfoot, *Dactylis glomerata.*
Meadow fescue, *Festuca pratensis.*
Tall fescue, *Festuca elatior.*
Meadow foxtail, *Alopecurus pratensis.*
Timothy or cat's-tail, *Phleum pratense.*
Prairie-grass, *Bromus uniolides.*

Perennial rye-grass, *Lolium perenne.*
Italian rye-grass, *Lolium italicum.*

Class 2. Fine Grasses.

Crested dog's-tail, *Cynosurus cristatus.*
Hard fescue, *Festuca duriuscula.*
Sheep's fescue, *Festuca ovina.*
Rough-stalked meadow-grass, *Poa trivialis.*
Tall oat-grass, *Arrhenatherum avenaceum.*
Golden oat-grass, *Avena flavescens.*
Fiorin, *Agrostis stolonifera.*

II. ARTIFICIAL GRASSES.

White clover, *Trifolium repens.*
Alsike clover, *Trifolium hybridum.*
Perennial red clover or cow-grass, *Trifolium pratense perenne.*
Red or broad clover, *Trifolium pratense.*
Lucerne or alfalfa, *Medicago sativa.*
Sainfoin, *Onobrychis sativa.*
Vetch or tares, *Vicia.*
Yarrow, *Achillea millefolium.*

III. FORAGE-PLANTS OF SPECIAL VALUE.

Indian-corn or maize, *Zea mays.*
Common millet, *Panicum miliaceum.*
Chinese sugarcane or sorgho, *Sorghum nigrum* or *Sorghum saccharatum.*
Sunflower, *Helianthus annuus.*
Rape, *Brassica napus.*
Thousand-headed kale.
Cabbage, *Brassica oleracea.*
Turnip, *Brassica rapa.*
Mustard, *Sinapis.*
Mangold-wurzel.
Carrot, *Daucus carota.*
Parsnip, *Pastinaca sativa.*
Field pea, *Pisum arvense.*
Bean, *Faba.*

CHAPTER II.

NATURAL GRASSES.

Class 1. Coarse Grasses.

Cocksfoot (*Dactylis glomerata*).

Fig. 1.

This is one of the most valuable and widely known of all the pasture-grasses. It is common to a large portion of Europe, to the North of Africa, and to Asia, as well as America. It was introduced in 1764 by the Society of Arts into England from Virginia, where it had been cultivated some years previously. Soon after its introduction it became an object of special agricultural interest among cattle-graziers, having been found to be exceedingly palatable to stock of all kinds. Its rapidity of growth, the luxuriance of its aftermath, and its power of enduring the cropping of cattle, commend it highly to the farmer's care, especially as a pasture-grass.

As it blossoms earlier than timothy, and about the time of red clover, it makes an admirable mixture with the latter plant, to cut in the blossom and cure for hay. As a pasture-grass it should be fed close, both to prevent its forming thick tufts and to prevent running to seed; for the herbage of this grass, when suffered to grow rank or old, from want of sufficient stock to eat it close, or of being cut for hay, contains nearly one-half less nourishment than that which is of recent growth. The produce does not increase if left standing after the time of flowering, but rather decreases in the weight of root-leaves; and, by reason of the rapid growth of the aftermath which succeeds an early cutting, the loss sustained in nutriment by letting a hay crop of the grass stand for seed will be found considerable. This circumstance shows the necessity of keeping this grass closely eaten down with sheep or cattle, to reap the full benefit of its superior merits as a pasture-grass. Oxen, horses, and sheep eat

it readily; cattle, particularly, have been observed to eat the culm or stalk and flowering heads till the time the seed is perfected. This grass is less exhausting to the soil than rye-grass or timothy. It will endure considerable shade. Its roots are fibrous, and penetrate to a considerable depth in the ground where the subsoil is porous: under such circumstances the plant flourishes, is productive in an extraordinary degree, withstands severe drought, and remains permanent.

The Culture of Cocksfoot for Seed.

As a rule, cocksfoot, as well as all other grasses which are specially cultivated for the production of seed, should not be allowed to mature a seed-crop until the plants are at least from two to three years old, and they should not in the meantime be even mown for hay, but eaten down by sheep and young cattle. Subsequently they should only be shut up for a crop every second year, which could be easily managed by either setting aside or subdividing paddocks in due rotation for the purpose. The reason for this is obvious: All permanent grasses require time to send their roots deep enough into the soil before they can attain a sufficiently vigorous growth, so as to produce a good quality of seed; but, unfortunately, it is too often the practice of growers of grass-seed—particularly cocksfoot—in this colony to "kill the goose for the golden egg," by even taking a seed-crop off one-year-old plants, and yearly afterwards, the result being that a large percentage of non-germinating and inferior seeds are produced from immature plants, and the plants themselves weakened and rendered almost valueless as food for stock by such a drain on their vitality.

The Harvesting of Cocksfoot Seed in New Zealand.

This industry is carried on principally in the bush clearings of the Maoris, and on the farms of settlers on the west coast of Taranaki and Wellington, and on similar lands in Banks Peninsula, Canterbury, in which district it is extensively pursued. When sufficiently ripe the seed-stems are cut from one to two feet long with either a reaping-hook or scythe, and laid on the grass—the same as a grain-crop before reaping-machines were invented; from whence it is gathered, tied, and stooked by a man who follows the cutter. When quite dry and mature the bundles are generally threshed out with a flail, although the Maoris in Taranaki fre-

quently perform that operation in a more primitive manner by treading out the seed with horses, which they ride in a circle over the bundles on a suitable piece of ground for gathering up the seed and sacking it. Where cocksfoot, however, is cultivated on a large scale for seed, a stripper, similar to the grain-stripper of South Australia, is now generally used, by which time and labour are largely saved. The seed, which is light, averages about 12lb. per bushel. After it is threshed or stripped, as the case may be, the great desideratum is to clean it properly from other seeds, particularly Yorkshire fog, or soft meadow-grass (*Holcus lanatus*), which is very difficult to separate from it. There are several kinds of machines for this purpose. Some are suited for the small producers, being adaptations of the common portable winnowing-machine; and others, particularly those manufactured by Drummond, of Cumnock, Ayrshire, Scotland, which are of various sizes and most effective, are suited for the merchants who purchase from the producers, and are principally to be seen in use in the wholesale seed-stores in Canterbury and Otago.

Commercial Importance of the Industry.

So far as it can be ascertained the average produce of seed per acre is about 350lb., for which the grower gets, if a good sample, 4d. per pound. This leaves about 2d. net after paying all expenses—nearly £3 an acre. To do this the paddocks set apart for seed must be shut up for about five months, from October to February inclusive, but after the seed-stems are cut or stripped the land can be grazed with occasional rest during the other seven months. In Banks Peninsula alone the proceeds from this industry have averaged for some years £40,000 yearly; in 1886 they reached £60,000; and, though it is difficult to get an estimate for other parts of the colony, yet it may be set down at £20,000, of which Taranaki will have the largest share. A very large quantity of the seed is exported to England and Australia.

Fig. 1.

Cocksfoot.
DACTYLIS GLOMERATA.

Meadow Fescue (*Festuca pratensis*).

Fig. 2.

This species of the fescues is common in moist meadows and pastures of rich soil in Britain, throughout Europe, in Northern Asia, and in some parts of North America, and is, perhaps, not excelled by any pasture or meadow grass whatever. It is suitable both for alternate husbandry and permanent pasture. It forms a very considerable portion of the turf of old pastures, and is more extensively propagated and diffused by the fact that it ripens its seed before most other grasses are cut, and sheds them, to spring up and cover the ground. Its long and slender leaves are much relished by cattle. It stands drought well. According to Sinclair it is of greater value at the time of flowering than when the seed is ripe. It is said to lose a little over 50 per cent. of its weight in drying for hay. In point of early produce in the spring this grass stands next to the meadow foxtail (*Alopecurus pratensis*), and is superior in this respect to the cocksfoot. It is eaten by horses, oxen, and sheep: its merits will be more clearly seen by comparing it with the cocksfoot and meadow foxtail. As it is often three weeks later in flowering than the foxtail grass, the latter-math produce must be left out for the truth of comparison as regards its value for hay; and, as it is much slower in growth after being cropped than cocksfoot, it is likewise necessary to omit the latter-math in a comparison of their produce.

The meadow fescue constitutes a very considerable portion of the herbage of all rich natural pastures and irrigated meadows; it makes excellent hay, and, though a large plant, the leaves or herbage are succulent and tender, and apparently much liked by cattle, as they never form rank tufts, which is the case with the larger grasses. It is an essential grass for permanent pasture, but does not appear to arrive at its full productive powers from seed so soon as either the cocksfoot or meadow foxtail grasses.

Fig. 2.

MEADOW FESCUE.
FESTUCA PRATENSIS.

Tall Fescue (*Festuca elatior*).

Fig. 3.

This grass, which is closely allied to the meadow fescue, grows from four to five feet high, and chiefly in moist low ground. It is most useful in permanent pastures, being an early as well as a nutritive and productive grass. Its growth is stronger than cocksfoot, and its roots are deeper. It is suited to dry weather in light soils, and holds the soil in windy localities. It grows too coarse in good land for any stock except cattle. In hill pastures sheep like it, and it keeps green when other grasses are parched.

The Culture of Tall Fescue for Seed.

It has been grown successfully for this purpose in Hawke's Bay, particularly by Mr. J. D. Ormond, on his property near Hastings. The practice is as follows: Choose rich heavy soil, and sow it with 30lb. of seed to the acre. When the crop is ripe it should be cut at once, the seed being liable to shed with the first wind. It should be threshed also at once on the ground with a flail on sheets, as half the seed would be lost if carted to be threshed in a granary. The average produce of seed on the best land is twenty-five to thirty bushels, averaging 17lb. to the bushel.

During the last two years a thousand bags of it, averaging 80lb. each, have been shipped from Napier to London at 9d. per pound f.o.b.

Fig. 3.

Tall Fescue.
FESTUCA ELATIOR.

Meadow Foxtail (*Alopecurus pratensis*).

Fig. 4.

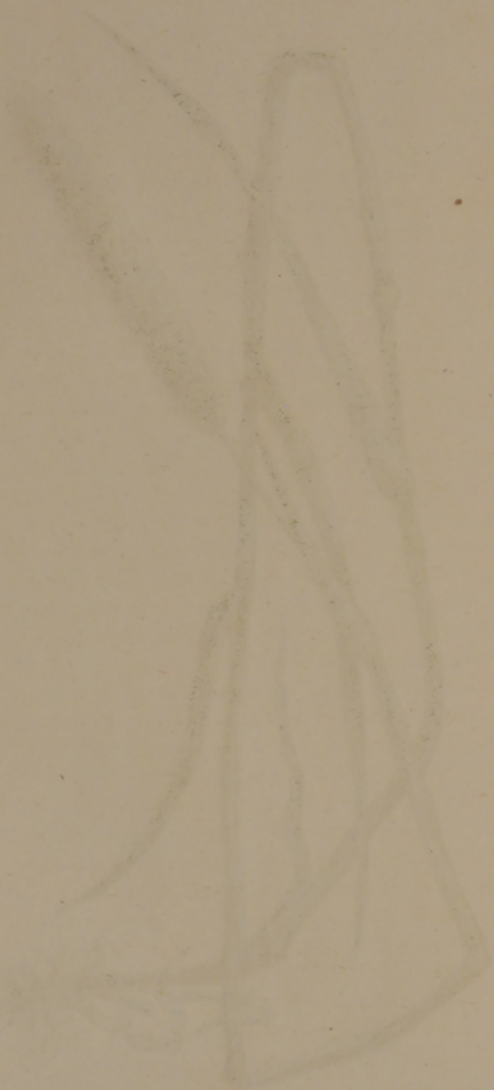
This grass closely resembles timothy; but the spike or head of meadow foxtail is soft, while that of timothy is rough. It flowers earlier than timothy, and thrives on all soils except the driest sands and gravels. It is a valuable pasture-grass on account of its early and rapid growth, and of its being greatly relished by stock of all kinds. The stems and leaves are too few and light to make it so desirable as a hay crop. It thrives best in a rich, moist, strong soil, and shoots up its flowering stalks so much earlier than timothy that it need not be mistaken for that grass, though at first sight it considerably resembles it. It is superior to timothy as a permanent pasture-grass, enduring the cropping of sheep and cattle better, and sending up a far more luxuriant aftermath. It is justly regarded therefore as one of the most valuable pasture-grasses of England, forming there a very considerable portion of the sward, and enduring a great amount of forcing and irrigation. Though forming a close and permanent sod when fully set, it does not acquire its full perfection and hold of the soil until three or four years after being sown.

The nutritive qualities of meadow foxtail are most abundant at the time of flowering. It is said to lose upwards of 70 per cent. of its weight in drying if cut in the blossom.

The seed of meadow foxtail is covered with the soft and woolly husks of the flower, while the larger glume, or scale of the calyx, is furnished with an awn. The seed is very light: there are five pounds of seed in a bushel, and seventy-six thousand seeds in an ounce. An insect attacks the seed while it is forming, and it is also subject to blight; and hence good seed is somewhat difficult to procure, and is held at a high price.

Fig. 4.

MEADOW FOXTAIL.
ALOPECURUS PRATENSIS.



Timothy Grass, or Meadow Cat's-tail (*Phleum pratense*).

Fig. 5.

The name of timothy, by which it is more generally known, was derived from Timothy Hanson, an American, who is said to have cultivated it extensively and to have taken the seed from New York to Carolina. Its culture was introduced into England from Virginia by Peter Wyncke in 1763.

Timothy is a perennial plant, which renews itself by an annual formation of "bulbs," or, perhaps, more correctly speaking, tubers, in which the vitality of the plant is concentrated during the winter. These form in whatever locality the plant is grown, without reference to dryness or moisture. From these proceed the stalks which support the leaves and head, and from the same source spread out the numerous fibres forming the true roots.

It thrives best in moist, peaty, or loamy soils, of medium tenacity, and is not suited to sandy or light gravelly lands; for though on such soils, by great care, it can be made to grow and produce fair crops, some other grasses are better suited to them, and more profitable. It grows very readily and yields very large crops on favourable soils. It is cultivated with ease, and yields a large quantity of seed to the acre, varying from ten to thirty bushels according to qualities of soils.

In Sinclair's "Hortus Gramineus Woburnensis" it is stated, in reference to this grass, as the result of experiments conducted sixty years ago at Woburn Abbey under the auspices of the then Duke of Bedford, that the crop when ripe exceeds in nutritive value the crop at the time of flowering. This conclusion is sustained by the more recent investigation of the late Professor Way, chemist of the Royal Agricultural Society of England, whose elaborate analyses of grasses will be found in the Journal of that Society, Vol. XIV., 1853. This might be inferred from the size and weight of the mealy seeds when the grass is ripe, as many as thirty bushels of which having been known to be produced on a single acre.

As a crop to cut for hay it is probably unsurpassed by any other grass now cultivated. Though somewhat coarse and hard, especially if allowed to ripen its seed, yet if cut in the blossom, or directly after, it is greatly relished by all kinds of stock, and especially so by horses, whilst it possesses a large percentage of

nutritive matter in comparison with other agricultural grasses. It is often sown with clover, but the best practical farmers are beginning to discontinue this custom, on account of the different times of blossoming of the two crops. Timothy being invariably later than clover, the former must often be cut too green, before blossoming, when the loss is great by shrinkage, and when the nutritive matter is considerably less than at a little later period; or the clover must stand too long, whereby there is an equally serious loss of nutritious matter and of palatable qualities.

Whether in growing timothy for hay or seed, or as a pasture-grass, it requires peculiar treatment to preserve it from destruction. From the description already given of the tuberous nature of its root, and the illustration of the plant in Fig. 5, it will be understood that its vitality depends upon the preservation of the tubers in question from injury. Care, therefore, should be taken that, when the plant is mown for hay or a seed-crop, it should not be cut lower than four inches from the ground; neither should it be eaten closer by cattle, horses, or sheep, nor should swine be ever allowed to graze where it is grown, as either is destructive of the tubers from which depend the roots, and the result would be the death of the plant.

The Culture of Timothy for Seed.

In the cultivation of timothy for seed the same treatment should be practised as in the case of cocksfoot (see page 5). The principal locality of this industry in the colony is Southland, and the following particulars, which have been kindly furnished by Mr. Robert Cleave, seedsman, Invercargill, through the Commissioner of Crown Lands, Southland, will be found of interest:—

1. Timothy for seed should be grown in rich deep soil.
2. When sufficiently ripe it should be cut with reaper-and-binder.
3. Manner of threshing it: If the weather is dry, it is better to be threshed out in the stook; if not, it must be put in stack, and not be threshed until it has been in stack for at least four months.
4. Cost of harvesting and threshing, per acre: For cutting, 5s.; for threshing out of stook, 13s.; if stacked and thatched, 19s.—so that the total cost in the former would be 18s., and in the latter £1 4s. per acre.
5. Approximate quantity of seed produced per acre: 2½cwt.
6. Price per lb. received by grower: 2½d. to 3½d. per lb. (equal to £3 per acre, leaving net £2 2s. if threshed out of stook, or £1 16s. if stacked and thatched).
7. Approximate quantity sold in the locality: In 1886 about 60 tons (equal to £1,930, at 3d. per lb.).
8. Approximate quantity exported, and price f.o.b.: Nil.

Fig. 5.

TIMOTHY GRASS.
PHLEUM PRATENSE.

Prairie Grass (*Bromus uniolides*).

Fig. 6.

This is a most valuable grass. It was introduced into Australia from America in 1856. It fills out, spreads well, gives a great breadth of leaf, roots deeply and consequently resists a long drought, seeds freely, stands close grazing, forms excellent hay; and, indeed, has every good quality to recommend it for the most extensive cultivation as a fodder-plant, or as a constituent of mixed pastures. Horses, cattle, and sheep feed readily on it, and its nutritious properties are of the highest. Unlike most pasture-grasses the seed is greatly relished by cattle and sheep; and, as it is rich in albuminous as well as saccharine matter, it is very fattening. The late Dr. Voelcker, Chemist to the Agricultural College, Cirencester, England, places it at the head of the natural grasses in point of nutritive value, while, as to yield, it may in fair soils be cut six or seven times a year, giving a heavy aftermath during most seasons within six weeks. It is eminently adapted for the climates of Australia, Tasmania, and New Zealand, and no pasture should be laid down or renewed without prairie-grass forming a leading constituent, as, growing continuously, it at all times gives a good bite for stock when other grasses have been injured or checked in their growth by drought or frost. It should not be allowed to mature its seed the first season, but should be mown or eaten down. This induces the individual plants to thicken and tiller out, and, by not exhausting themselves in ripening seed, to get a better hold of the soil by a deeper root-growth. Late autumn is the best time for sowing, the land of course being prepared by ploughing a month or so before, and by an occasional harrowing to disturb and destroy the germinating weed-seeds. This will not only render the land clean, but will admit of the beneficial influence of atmosphere and rain by the time the seed-time comes round. On poor soil an occasional top-dressing with superphosphate or some other portable fertilizer will be effective. In New Zealand it is at its best yield from the end of April to the end of August, and therefore very valuable as a winter fodder.

It weighs from 20lb. to 30lb. per bushel according to quality,

and the average price is 4d. per pound. If sown as a crop by itself it requires 50lb. to 60lb. per acre according to the soil, and, with other grasses or clovers, in suitable proportion to the relative quantity sown of such other plants.

Fig. 6.

PRAIRIE GRASS.
BROMUS UNIOLIDES.

Perennial Rye-grass (*Lolium perenne*).

Fig. 7.

This has had the reputation in Great Britain, for many years, of being one of the most important and valuable of the cultivated grasses. It should never be grown on a poor soil, and is better adapted to a wet and uncertain climate than to one subject annually to droughts, which often continue many weeks, parching up every green thing. There is, perhaps, no grass the characteristics of which vary so much, from the influences of soil, climate, and culture, as perennial rye-grass. Certain it is that this grass has been cultivated in England since 1677, and in the South of France from time immemorial. It is admitted to be inferior in nutritive value to cocksfoot grass when green.

Sinclair, in discussing the relative qualities of perennial rye-grass with other grasses, writes: "There has been much difference of opinion respecting the merits and comparative value of rye-grass. It produces an abundance of seed, which is easily collected, and readily vegetates on most kinds of soil under circumstances of different management; it soon arrives at perfection, and produces in its first year of growth a good supply of early herbage, which is much liked by cattle. These merits have, no doubt, upheld it till the present day in practice, and constitute it a favourite grass with many farmers. But the aftermath of rye-grass is very inconsiderable, and the plant, being shallow-rooted, impoverishes the soil in a high degree if the seed-stems, which are invariably left untouched by cattle, are not cut before the seed advances towards perfection. When this is neglected, the field after midsummer exhibits only a brown surface of withered straws." He further says: "Let the produce and nutritive powers of rye-grass be compared with those of cocksfoot grass, and it will be found inferior in the proportion nearly of 5 to 18, and also inferior to the meadow foxtail in the proportion of 5 to 12, and inferior to the meadow fescue in the proportion of 5 to 17. In these comparisons, from which the above proportions arose, it was necessary to omit the seed-crops for the truth of comparison. But as the seed of the meadow foxtail is often defective, and the plants of the meadow fescue do not arrive at perfection so soon as those of ryegrass, their superiority, as above, is somewhat lessened with respect to their value as alternate husbandry grasses: for

permanent pasture, however, the above proportional values will be true, as rye-grass is but a short-lived plant, seldom continuing more than six years in possession of the soil; but it is continued by its property of ripening an abundance of seed, which is but little molested by birds, and suffered to fall and vegetate among the root-leaves of the permanent-pasture grasses. But cocksfoot grass perfects an abundance of seed, and the plants arrive at a productive state as soon as those of rye-grass: hence its superiority, as above, is equally great for permanent pasture and the alternative husbandry; which is not so precisely the case with the meadow foxtail grass and meadow fescue."

The *Australasian* of the 13th November, 1886, under the head of "The Yeoman," in Answers to Correspondents, says: "Rye-grass is by nature an annual. Whatever amount of perennial character it has attained has been developed by a careful system of saving seed only from plants that have existed for several years—the longer the better. The practice of grazing the crop, and thereby preventing its seeding, has no doubt been the cause of the grass living longer than Nature originally provided. It is the production of seed that taxes the strength of grasses, and all other plants; if by any means this is prevented, a tendency to longevity will naturally be evoked and developed. The celebrity of Pacey's perennial rye-grass, and Pollexfen's perennial rye-grass, was gained by these famous farmers by careful selection, and the practice of saving seed only from old pastures. The oldest pastures, even where the grass has been allowed to bear only a partial crop of seed, are those on soils specially suited to the crop. The best wheat soils are the best for rye-grass. As regards size of seed, it is but natural that the grass in full vigour, as in its first year, should bear the heaviest sample. A heavy sample is always regarded with distrust by intelligent buyers."

Fig. 7.

PERENNIAL RYE-GRASS.
LOLIUM PERENNE.

Italian Rye-grass (*Lolium italicum*).

Fig. 8.

This is a native of the South of Europe, and was introduced into Britain in 1831 by Mr. Thomson, of Banchory, Aberdeenshire, and Messrs. Lawson and Son, seedsmen, Edinburgh. It is much esteemed as a forage-grass. It differs from perennial rye-grass in the florets having long slender awns. It turfs less, its stems are higher, its leaves are larger and of a lighter green; it gives an early, quick, and successive growth till late in the season. It has the credit of being equally suited to all the climates of Europe, giving more abundant crops, of a better quality, and better relished by animals, than the perennial rye-grass. It is one of the greatest gluttons of all the grasses, either cultivated or wild, and will endure any amount of forcing by irrigation or otherwise, while it is said to stand drought remarkably well.

The soils best adapted to Italian rye-grass seem to be moist, fertile, and tenacious, or of a medium consistency; and on such soils it is said to be one of the best grasses known to cut green for soiling, affording repeated, luxuriant, and nutritive crops.

Fig. 8.

ITALIAN RYE-GRASS.
LOLIUM ITALICUM.

Class II. Fine Grasses.

Crested Dog's-tail (*Cynosurus cristatus*).

Fig. 9.

This grass forms an important part of almost all good pastures, and is particularly esteemed for sheep pasture and lawns, for the improvement of which it is often sown. Its herbage is fine and close, and its deep roots secure it against droughts which cause many other grasses to wither; but the herbage is not sufficient in quantity to make it desirable for hay. It forms a close dense turf of grateful nutritive herbage, and is little affected by extremes of weather. From these facts it is evident, a sward of the best quality, particularly under circumstances where sheep are a principal object, cannot be formed without an admixture or proportion of the crested dog's-tail grass.

The stems of this grass are used for the manufacture of plat for Leghorn hats and bonnets, and have the reputation of being equal or superior to Italian straw.

Fig. 9.

CRESTED DOG'S-TAIL.
CYNOSURUS CRISTATUS.

Hard Fescue (*Festuca duriuscula*).

Fig. 10.

In Sinclair's "Hortus Gramineus Woburnensis" this grass is considered one of the best of the fine or dwarf-growing grasses which are best adapted for the food of sheep. It is most prevalent on rich light soil; but it is likewise always found in the richest natural pastures, where the soil is more retentive of moisture, and is never absent from irrigated meadows that have been properly formed. It attains to the greatest perfection when combined with the meadow fescue (*Festuca pratensis*) and rough-stalked meadow-grass (*Poa trivialis*). It springs rather early, and the produce is remarkably fine and succulent. It withstands the effects of severe dry weather in rich natural pastures better than many other grasses. This property, joined to its merits above mentioned, entitle it to a place in the composition of the best pastures, though in a smaller proportion, on account of its inferior productive powers, which are not compensated by any superiority in the nutritive qualities of the grass over those grasses that are more productive, as is the case with the rough-stalked meadow-grass and some other species. The superiority of these natural pastures over those pastures which are formed of one or two grasses only, in respect of a constant or never-failing supply of herbage throughout the season, is in one point, among many others, owing to the variety of habits which exist in a numerous assemblage of different grasses. Some species thrive best in an excess of moist weather; others in a continuance of dry weather: but the majority of grasses which compose the produce of the pastures in question thrive best in a middle state between moisture and dryness. Observation will furnish abundant proofs of the truth of this, by comparing the different states of productiveness in natural pastures, during a season of changeable weather, with those of artificial pastures under the like influence of soil and climate.

Fig. 10.

HARD FESCUE.
FESTUCA DURIUSCULA.

Sheep's Fescue (*Festuca ovina*).

Fig. 11.

A small grass, the seed-stem of which rarely exceeds 1ft. in height. It is common in all the mountainous parts of Europe, and in the Himalayas; it is also a native of North America. It is especially suited for hilly and mountainous pastures, in which it forms a principal part of the food of sheep for many months in the year. Its habit of growth is much tufted.

Fig. 11.

Sheep's Fescue.
FESTUCA OVINA.

Rough-stalked Meadow-grass (*Poa trivialis*).

Fig. 12.

The superior produce of this *Poa* over many other species, its highly-nutritive qualities, the season in which it arrives at perfection, and the marked partiality which oxen, horses, and sheep have for it, are merits which distinguish it as one of the most valuable of those grasses which affect rich soils and sheltered situations: but on dry exposed situations it is altogether inconsiderable; it yearly diminishes, and ultimately dies off, not infrequently in the space of four or five years. Its produce is always much greater when combined with other grasses than when cultivated by itself: with a proper admixture it will nearly double its produce, though on the same soil, so much it delights in shelter.

Those spots in pastures that are most closely eaten down consist for the most part of this grass.

It is highly valuable as a permanent-pasture grass on rich and sheltered soils, but unprofitable for any purpose on dry exposed situations.

Fig. 12.

ROUGH-STALKED MEADOW-GRASS.
POA TRIVIALIS.

Tall Oat-grass (*Arrhenatherum avenaceum*).

Fig. 13.

This is the *Avena elatior* of Linnæus. It grows spontaneously on deep sandy soils when once naturalized. It will also succeed on tenacious clay soils. It is highly esteemed as a permanent-pasture grass, mainly for its early, rapid, and late growth; and, besides, is much recommended for green-feeding, and also for hay, from the early supply of fodder which it furnishes. After being mown it shoots up a very thick aftermath, and, on this account, partly, is regarded as nearly equal in excellence to meadow foxtail.

Fig. 13.

TALL OAT-GRASS.
ARRHENATHERUM AVENACEUM.

Golden or Yellow Oat-grass (*Avena flavescens*).

Fig. 14.

This grass does not thrive when simply cultivated by itself; it requires to be combined with other grasses to secure its continuance in the soil, and to obtain its produce in perfection. It seems to grow best with the crested dog's-tail and sweet-scented vernal, and it is said to be the most useful for fodder of any of the oat-grasses. It affects most a calcareous soil, and that which is dry. It grows naturally, however, in almost every kind of soil, from the limestone rock to the irrigated meadow: it is always present in the richest natural pastures. Its produce is not very great, nor its nutritive qualities considerable. The nutritive matter it affords from its leaves contains proportionally more bitter extractive than what is contained in the nutritive matters of the grasses with which it is more generally combined in natural pastures. This latter circumstance is the chief claim it has to a place in the composition of the produce of rich pasture-land; but more particularly, if the land be elevated and without good shelter, this grass becomes more valuable, as it thrives better under such circumstances than most other grasses, and sheep eat it as readily as they do most others. The seed is very small and light, but it vegetates freely if sown in the autumn or not too early in the spring.

Fig. 14.

GOLDEN OR YELLOW OAT-GRASS.
AVENA FLAVESCENS.

Sweet-scented Vernal (*Anthoxanthum odoratum*).

Fig. 15.

This is one of the earliest spring grasses, as well as one of the latest in autumn, and is almost the only grass of English grasses that is fragrant. It possesses a property said to be peculiar to this species, or possessed by only a few others, known as benzoic acid; and it is said to be this which not only gives it its own aromatic odour, but imparts it to other grasses with which it is cured. The green leaves, when bruised, give out this perfume to the fingers, and the plant may thus be known. It possesses but little value of itself, its nutritive properties being slight; nor is it much relished by stock of any kind; but as a pasture grass, with a large mixture of other species, it is valuable for its early growth. The autumn growth is said to be richer in nutritive qualities than the growth of the spring.

Fig. 15.

SWEET-SCENTED VERNAL.
ANTHOXANTHUM ODORATUM.

Fiorin, Creeping Bent (*Agrostis stolonifera*).

Fig. 16.

This grass grows best in moist grounds, newly-reclaimed bogs or swamps, or land liable to inundation. It has a peculiar manner of growth, which has been compared to that of strawberries. It sends out runners or stolones which strike root at the joints. Sinclair considers that the chief advantage of this grass is its late growth. It remains in a degree inactive till other grasses have attained to perfection, and, when their productive powers become exhausted, those of fiorin and its varieties begin; and it will be found on inspection that the latest mouthful of herbage, and sometimes the earliest in those pastures, is principally afforded by this grass. There has been much prejudice existing against the different species of bent-grass in general; but let the proprietor of a rich, ancient pasture divest a part of it of this grass entirely, and the value of the plant will be demonstrated in the comparative loss of late and early herbage. In these pastures late in the autumn it has been observed that the stolones extended to a considerable length, and were left untouched by cattle. In the spring, however, they were generally eaten, and the protection they had afforded to the under-grasses was evident in the superior growth of the herbage where the stolones had most extended: after this, the creeping bent was hardly to be recognized till the other grasses had again exhausted themselves towards the end of the autumn. The plant in this combination takes but little from the soil. Care, however, should be taken that neither fiorin, nor any other grass with a creeping root—for instance, the smooth-stalked meadow-grass (*Poa pratensis*)—should be grown in any land liable to be broken up for alternate husbandry.

In comparing the produce and nutritive powers of different grasses, to arrive at a knowledge of their relative value, it is absolutely necessary, for the truth of comparison, that the produce of one whole season be taken, and not one crop singly, except in instances where the produce consists of but one crop only. Accordingly, the produce of fiorin may be compared with that of cocksfoot, meadow fescue, and the meadow foxtail, when it will appear inferior to the two former species and superior to the latter.

The fiorin taken in England in December affords of nutri-

tive matter an average of 1,405lb. per acre in one year; the cocksfoot grass, 1,728lb. per acre; the meadow fescue, 1,719lb. per acre; the meadow foxtail, 1,216lb. per acre. The cocksfoot grass is therefore superior to the fiorin in the proportion of 11 to 9. The meadow fescue is also superior to the fiorin in nearly the like proportion as cocksfoot. The meadow foxtail is inferior to fiorin in the proportion, nearly, of 6 to 7.

Fig. 16.

Fiorin, Creeping Bent.
AGROSTIS STOLONIFERA.

CHAPTER III.

ARTIFICIAL GRASSES.

White Clover (*Trifolium repens*).

Fig. 17.

This species of clover is familiar to every agriculturist. The value of it to the farmer is well known. Its chief value is as a pasture-grass, and it is present in every kind of pasture-land. From the circumstance of growing spontaneously in almost every kind of soil, few plants vary so much in size: in very dry and poor sandy soils it is often so small, and grows so flat among the lower leaves of the herbage, that it is not perceptible unless a turf is cut, and carefully examined by dividing it; hence, on breaking up and manuring such soils, or simply manuring by top-dressing, a spontaneous crop of white clover appears where it was never observed before, and without any supply of seed: this has led to strange conclusions respecting the propagation of plants. The central root of white clover penetrates to a considerable depth in the soil, and the plant is thereby better prepared to resist the bad effects of severe dry weather, particularly on sandy soils. The branches that trail on the surface send down fibrous roots from the joints, which penetrate but a little way into the ground: hence it is that the white clover maintains itself in soils of opposite natures; for, if the surface be too dry to afford nourishment to the branches, the principal root preserves it; and, when the tenacity and retentiveness of the soil in a wet winter is great enough to rot the tap-root, the fibres of the runners preserve the plant in safety. From this habit of growth, top-dressings and a frequent use of the roller encourage the growth of this plant in an extraordinary degree.

Fig. 17.

White Clover.
TRIFOLIUM REPENS

Alsike, or Swedish Clover (*Trifolium hybridum*).

Fig. 18.

This is so named from being intermediate in its appearance between the white and red clovers. The seeds originally came from Sweden. It is deservedly in repute as one of the best of perennial clovers, and well adapted for permanent pasture.

Fig. 18.

Alsike, or Swedish Clover.
TRIFOLIUM HYBRIDUM

Perennial Red Clover, or Cow-grass (*Trifolium pratense perenne*).

Fig. 19.

This is a most valuable plant in permanent pastures. It withstands the effect of dry weather better than most pasture plants. Its nutritive powers are little inferior to those of red or broad clover. It thrives, as all valuable grasses do, better in combination with other grasses than cultivated by itself, and it is almost the only clover that can be depended on to stand for any length of time on alluvial and clay soils. It differs in many respects from the common red or broad clover, but especially in the leaf, flower, and stem. The leaf of the broad clover is woolly at the edges and back of leaf, yet there is not the velvety appearance which is peculiar to the true cow-grass. The flower, too, of the broad clover is generally light-pink and round, while the cow-grass is darker and more oval in shape. The stem of broad clover is generally succulent and hollow, and inclined to be pithy, while the stem of the cow-grass is solid.

Fig. 19.

PERENNIAL RED CLOVER OR COW-GRASS.
TRIFOLIUM PRATENSE PERENNE

Red or Broad Clover (*Trifolium pratense*).

Fig. 20.

This variety is used for alternate husbandry, and other purposes where a permanent pasture is not required. It is unquestionably a valuable fodder-plant, and yields an abundance of excellent feed or hay. Sheep and cattle are always fond of depasturing it.

Fig. 20.

RED OR BROAD CLOVER.
TRIFOLIUM PRATENSE.

Lucerne, Alfalfa (*Medicago sativa*).

Fig. 21.

A species of medick, one of the most valuable of the leguminous plants cultivated for the supply of food to cattle. This particular species was brought from Media to Greece in the time of Darius, about five hundred years before Christ, and its cultivation also extended among the Romans, and through them to the South of France, where it has ever since continued to be a favourite forage-plant. It is not very largely cultivated in Britain, although in some places very successfully, chiefly in the South of England; but the climate of Scotland is not too cold for it, and the different results obtained by farmers who have tried it seem to depend chiefly on difference of soil and management. It is largely cultivated in some parts of North and South America, in Peru and Chili, and grows wild in the utmost luxuriance in the pampas of Buenos Ayres, where it is called alfalfa, which is simply the common lucerne slightly modified by climate, and may be regarded as a variety. It is grown also in Australia, particularly in Victoria and New South Wales. Its tap-roots penetrate in mellow soils to great depths, having been found in sandy soils thirteen feet in length; and in the driest and most sultry weather, when every blade of grass droops for want of moisture, lucerne holds up its stem, fresh and green as in the genial spring.

The cultivation of lucerne is somewhat more difficult than that of clover for the first year, requiring a soil thoroughly mellowed, and prepared by clean and careful tillage. It suffers and languishes in compact clay-soils, and does not flourish in light soils lying over an impermeable subsoil, which prevents the water from running off. It will never succeed well on thin soils. But in a permeable subsoil, consisting of loam, or sand, or gravel, its roots can penetrate to great depths, and imbibe their moisture and nutriment in layers of soil far below the average of other plants. In this respect it differs materially from clover.

For lucerne a suitable subsoil is of the utmost consequence. For the short-lived red clover a suitable surface-soil is more important. A want of care and deep tillage, especially a neglect to break through and loosen up the hard pan wherever it exists, will inevitably lead to failure with lucerne. But when the soil

is suitable it will produce good and very profitable crops for from five to ten or twelve years; and, notwithstanding the large quantity of succulent and nutritious forage it produces, its effect is to ameliorate and improve the soil rather than to exhaust it. This apparent anomaly is explained by the fact that all leguminous, broad-leaved plants derive a large proportion of their nutritive materials partly from the atmosphere in the shape of carbon, and partly through the medium of their long roots bringing up nitrogen near the surface from a considerable depth; and that a vast quantity of roots are left to decay in the soil when it is at last broken up, varying, of course, with the length of time the plant continues in the soil, while the luxuriant foliage serves to shade the soil, and thus to increase its fertility. Much of this rich foliage is scattered and left to decay, as is the case with all similar plants at the time of harvesting; and the growth of the aftermath is also usually very considerable. The fact that it actually increases the fertility of the soil for other plants has often been proved, and may be regarded as fully established. A soil which would bear only a medium crop of wheat at first, produced a greatly-increased quantity after being laid down to lucerne a few years, till its roots enriched the soil.

Lucerne should not follow immediately after having been grown a few years on the same soil, and then broken up; but after the land on which it has been grown has been cultivated with some other crop, or laid down to the natural grasses a length of time equal to that during which it had previously remained in lucerne, it can safely be sown again with it.

The seed of lucerne, when fresh and good, is yellow, glossy, and hairy. If the seeds are white it is an indication that they are not ripe. If they are brown it may be inferred that they have been subjected to too strong a heat to separate them from their husks. In either of these cases it is not safe to purchase or to rely on them. The same might be said of clover, and it is desirable to try them by a simple method, which will be indicated hereafter in treating of the selection of seed. As the seeds of lucerne are larger than clover-seed, and the plant tillers less, it is necessary to sow a larger quantity per acre.

Lucerne is not a winter fodder; it is a summer and autumn fodder. It should be cut as soon as it begins to flower, or even earlier. If cut much earlier it is apt to be too watery and less

nutritious, and cures with greater difficulty; if later, it becomes coarse and hard, with woody fibre, and is less relished by cattle. It may be cut and fed green, and is an exceedingly valuable plant for soiling cattle, or it may be cut and cured and used like clover hay; but in either case it must be cut before blossoming.

In cultivating lucerne in New Zealand it should be sown in September and October, in drills varying from twelve to eighteen inches apart, or broadcast, with from 10lb. to 15lb. of seed per acre, according to the manner of sowing, whether in drills or broadcast. Where the soil is suitable a mixed cultivation of lucerne and prairie-grass would produce, perhaps, one of the best economic combinations, both in quantity and quality, of cattle-fodder for green-feeding that could be grown. By a study of their respective merits as valuable forage-plants, this proposition will not be difficult to understand. In that investigation it will be observed that they are both deep-rooted and drought-resisting plants, but that lucerne is much the deeper-rooted of the two, and that therein lies the main factor of the success of such a combination. This being so, lucerne would necessarily find its nutriment in a lower and different stratification of soil than the prairie-grass. They would thus not interfere, so to speak, with each other, as they would derive their respective supplies of sustenance from separate sources, although growing side by side. To grow them successfully in this manner, however, the lucerne should have the precedence of the prairie-grass by six or seven months, the lucerne being sown in September or October, and the prairie-grass in the following March or April, according to circumstances. It would by this arrangement send its roots down much in advance of the latter, and they would therefore be free of the detrimental competition with each other for plant-food in the early stages of their growth, which would naturally arise if they were sown contemporaneously. The course, therefore, to pursue is to first sow the lucerne in spring, using 10lb. to 12lb. of seed to the acre, in drills eighteen inches apart, so as to leave room for a one-horse plough or cultivator to work between the rows of plants and keep them free from weeds; and in the following autumn the prairie-grass should be sown broadcast between the drills at the rate of 30lb. to the acre.

Except in New South Wales very little lucerne seed is harvested in Australia. Most of the seed sold in Australia is

grown in Holland, some is grown in France, and Spain could spare a good quantity. The yield in Holland is said to range from five to eight bushels per acre. The threshing is usually done by flail. It can be done by machine just as clover is sometimes threshed in England, although the flail is still preferred by some growers of the crop.

Fig. 21.

LUCERNE.
MEDICAGO SATIVA.

Sainfoin (*Onobrychis sativa*).

Fig. 22.

Sainfoin is a native of the Continent of Europe and of the South of England, and is much cultivated as a fodder-plant in dry and particularly in calcareous soils, to which it is admirably adapted. Its cultivation was introduced into England in 1651; and before the introduction of turnip-husbandry the sheep-farmers of the chalk districts depended almost entirely on it, and still do to such a degree that in many leases there is a stipulation for the tenant's leaving a certain extent of land in sainfoin. It is, however, a very local crop, being scarcely cultivated in any but the most calcareous soils, where nothing else is nearly equal to it, although it has been found to succeed well on any soil sufficiently dry.

There is no more nutritious fodder than sainfoin, whether for sheep, cattle, or horses. Even the dry stems of a crop which has produced seed are readily consumed by cattle if cut into small pieces. In the South of France, where it flourishes best, it is considered an indispensable forage-plant, improving the quality and increasing the quantity of milk when fed to milch cows, to which it may be given without producing the "hoove" or "hoven," to which they are subjected when allowed to feed freely on green clover and lucerne. Its stalks do not become ligneous if allowed to stand till blossoming, as those of lucerne do. The amount of fodder obtained from it is less than that from clover or lucerne, but its quality, where it can be successfully grown, is better. Its seeds are said to be more nutritious than oats. They are eagerly sought by fowls, and are said to cause them to lay. Sainfoin when green and young will not stand a severe winter, but after the second or third year will endure a considerable degree of cold. It will succeed in very dry soils, sands, and gravels, owing to its long descending tap-root, which has been found sixteen feet in length.

Sainfoin will endure in the soil, when once fixed there, for eight or ten years, but it requires from three to four years to attain its perfect growth. In pasture culture the grasses are apt to choke it out by their close and firm turf.

Sainfoin is best grown by being sown with barley after the latter is sown thin and harrowed, in the same manner as clover, and afterwards lightly rolled. From three to five bushels of

seed are generally used, four being the most common quantity, there being an enormous number of seeds in one bushel; but it is very precarious, and it is necessary to sow a sufficient quantity to guard against contingencies.

Fig. 22.

SAINFOIN.
ONOBRYCHIS SATIVA.

Vetch or Tare (*Vicia*).

Fig. 23.

The kinds ordinarily cultivated are the spring and winter vetches, the names of which owe their distinctiveness to the fact of being more or less hardy, and their time of ripening.

The chief application of the vetch is for soiling purposes, for, although it makes capital hay, there is some little difficulty in getting it into stack, while it is most serviceable to all kinds of stock. Sheep do better upon vetches than upon any other kind of herbage, and the plant is therefore held in high esteem by pedigree-ram breeders. Horses improve upon it more rapidly than upon any other of the artificial grasses. Cows, it is said, yield more butter when fed upon it, while pigs eat it greedily when in its green state, and thrive upon it without farinaceous food.

Spring vetches can be sown in New Zealand from September up to the end of December. The method of preparing the land for the seed is to plough it four to five inches in depth, and then harrow it fine, and sow the seed in drills. On the South Downs in Sussex they sow two bushels and a half of vetches and half a gallon of rape to the acre. Spring vetches produce rather a lighter crop than winter tares. The time for sowing winter vetches in this country is from the beginning of April to the end of May. They will stand very severe weather, and when they once commence to grow in the spring they make rapid progress, and come in very early for use.

Fig. 23.

VETCH OR TARE.
VICIA.

Yarrow, or Milfoil (*Achillea millefolium*).

Fig. 24.

The yarrow is highly astringent, and reckoned a grateful food for sheep when mixed with the common pasture-grasses; but it is more as a condiment that it is to be considered than as affording direct nutritive matter. It is therefore generally sown in mixtures with such seeds as are reckoned best adapted for permanent sheep-pasture, and in soils where it is found naturally to thrive. This plant may with advantage be sown on the poorest and driest pasture, and is capable of withstanding the most excessive drought, but it should not be grown on any land liable to be broken up for alternate husbandry.

Fig. 24.

YARROW.

ACHILLEA MILLEFOLIUM

CHAPTER IV.

FORAGE PLANTS OF SPECIAL VALUE.

Indian-corn (*Zea mays*).

Fig. 25.

Indian-corn, or maize, is the only cultivated grain of American origin; it was in cultivation before the discovery of America by Europeans, by whom, however, its value was soon recognized, and it has now become an important crop in climates suitable for it in all quarters of the world. Its generic name, *Zea*, was derived from a Greek work signifying *to live*, and was applied to this plant on account of the farinaceous or mealy nature of the seeds.

Indian-corn is extensively used as human food, and for feeding and fattening domestic animals, and holds the highest rank among the cereals, whether its nutritive qualities, or the produce and return for the seed sown, or its range of climate, be regarded.

According to some analyses, Indian-corn furnishes in its composition 88·43 per cent. of fat-forming principles, gum, &c.; 1·26 per cent. of flesh-forming principles, 9 per cent. of water, and 1·31 per cent. of salts. Its chemical composition shows it to be among the most fattening of the cereals, and this is also the result of experience. For our domestic animals, therefore, and as a means of raising and fattening them, Indian-corn may justly be regarded as a superior fodder-plant.

No part of the plant is necessarily lost or thrown aside as worthless: even the cob is ground, and for some purposes of feeding to stock it is very valuable; while, if it were necessary, the plant would supply us with a large amount and a very good quality of sugar.

The culture of Indian-corn for a cereal crop is simple, and easily understood. It requires a deep, rich, and mellow soil, thoroughly tilled. After ploughing, the land is carefully marked

off in rows from three to four feet apart each way, according as the variety is large or small, when four or five kernels are dropped in a hill, either by hand or machine, and covered to the depth of from one to two inches. After the corn is up it is cultivated with the horse-hoe or plough, to keep it free from weeds. It is sometimes hilled at the last hoeing; at others the ground is left level, which is thought to be the best.

When it is planted as a fodder crop, or to be cut and fed out green, it should be sown in drills from two and a half to three feet apart, making the drills from six to ten inches wide with the plough, dropping the corn about two inches apart, and covering with the hoe. In this mode of culture the cultivator may be used between the rows when the corn is from six to twelve inches high, and, unless the ground is very weedy, no other after-culture is generally needed. It is desirable to have the drills run north and south, so that the sun and air may supply the crop with the largest amount of nutriment. For green feed it should be cut at early flowering, and for this use it is one of the most valuable and important plants that can be grown. It is a familiar crop in the North Island of New Zealand, where it is largely grown by the Maoris as a corn crop; but it can be cultivated in parts of Nelson and Marlborough, in the Middle Island, also as a corn crop, but farther south only as a green crop for cattle or pigs.

It can be sown up to November, but not after that month, owing to the fact that it must be used before the frosts which occur in April and May.

Fig. 25

Female or Fertile Flowers.

Male or Sterile Flowers.

INDIAN-CORN OR MAIZE.

ZEA MAYS.

Common Millet (*Panicum miliaceum*).

Fig. 26.

This is a native of Turkey, and has been much cultivated in America. It is one of the best crops for cutting and feeding green for soiling purposes, as its yield is large, its luxuriant leaves juicy and tender, and much relished by milch cows and other stock. The seed is rich in nutritive qualities, but it is very seldom used for flour, though it is said to exceed all other kinds of meal and flour in nutritive elements. When the plant is cut in the blossom, as it should be, for feeding to cattle, the seed is comparatively useless. If allowed to ripen its seed, the stalk is no more nutritious than oat-straw.

Fig. 26.

Common Millet.
PANICUM MILIACEUM.

Chinese Sugarcane, Sorgo (*Sorghum nigrum. Sorghum saccharatum*).

Fig. 27.

This is a plant well known throughout the United States, and it has been experimentally grown in several parts of New Zealand, particularly in the North Island, and in the neighbourhood of Nelson in the Middle Island. It grows with a stem from six to fifteen feet high, according to the soil in which it is planted, erect, smooth; leaves linear, flexuous, gracefully curving down at the ends, resembling Indian-corn in its early growth, and broom-corn, to which it is nearly allied, at maturity. Flowers in a panicle at the top, at first green, changing through the shades of violet to purple, when more advanced.

This plant has lately been produced and used for forage, and successful experiments have been made with it for the manufacture of molasses or syrup and sugar by Judge Gillies, of Auckland. It is rich in saccharine matter, and a large amount of nutritive fodder can be obtained from it. It grows best on a dry soil and under a hot sun, and is usually planted the same as Indian-corn, both as to the preparation of ground and the time for planting; generally in hills when it is intended to ripen its seed, and in drills or broadcast at the rate of one to one and a half bushels per acre when it is wanted to be cut up green for soiling purposes, or to cure and feed out in winter as a forage-crop.

"Sorghum, in the Illawarra district (New South Wales), is the principal fodder-crop. It is nearly equalled by maize. It is the most famed fodder-crop of the dairy farmers. At Illawarra sowing commences in October, and can be continued up to January, and the crop comes in for use late in the autumn, and lasts well through the winter, its immunity from the effects of frost rendering it good after the maize has been destroyed. The seed is sown thick, and the close growth of canes about as thick as a man's fingers and ten feet high produces yields of from twenty to forty tons per acre. Stock may be injured by eating the sorghum while it is young and sour, but after the plant is in bloom it is good for food. The cows and other stock eat it with relish, and it produces a good flow of milk. The crop is cut as required, and it is not stored for the winter, but allowed to stand in the field till wanted. No doubt better results could

be obtained by cutting the sorghum and storing it in silos, but such a course has not yet been attempted. For fodder from 40lb. to 50lb. of seed per acre is sown broad-cast, and for seed about 20lb. an acre is put in with the drill" (*Australasian*, 29th May, 1886).

Fig. 27.

CHINESE SUGAR-CANE.
SORGHUM SACCHARATUM.

Sunflower (*Helianthus annuus*).

Fig. 28.

The sunflower is a common garden plant. It has been so long in cultivation and in so many parts of the world that its origin is somewhat uncertain, but it is supposed to be a native of Mexico and Peru. The industrial importance of the plant is evidenced by the rapidity with which it has become a regular crop among two of the greatest nations of the world—Russia and Germany—while in England, France, Portugal, Holland, Jamaica, and elsewhere it is more or less in cultivation for some or other of its many uses.

The uses to which the plant is put are numerous, but those of the seed are the most important. This, in its whole state, is unrivalled as a fattening feed for pigs, sheep, and poultry. Fed to fowls it makes them lay better, and to pheasants it makes the birds plumper and improves their plumage. The fixed oil obtainable from the seeds by expression is little if at all inferior to olive oil, and is used for all the purposes to which that oil is adapted. The yield of oil is 40 per cent., and the oilcake, fed to cattle, is wholesome and fattening, being considered superior to that of linseed.

The fresh leaves make a good fodder, which is eaten with avidity by cattle, and for bees the sunflower is unrivalled, large quantities of honey and wax being obtained therefrom. One of the most remarkable properties of the plant is its large power of absorbing and exhaling moisture. The actual extent of this power is differently stated by authorities, but the lowest estimate given of the exhalation of the sunflower is 1½lb. of water within twenty-four hours. Another authority states that it will lose nearly 2lb. by perspiration in twelve hours, and that taking all things into account a sunflower perspires seventeen times more than a man. On account of this property it is recommended to be planted round swamps as a barrier against malaria, and it has been used for this object with undoubted effect.

The cultivation of the sunflower is very simple, and it yields a quick crop. Under favourable conditions the ripe seeds have been reaped within ten weeks of sowing. It is not particular as to soil, but prefers it light, rich, and well drained; soils less well suited only make the difference of a smaller harvest. It is advisable to sow early so as to secure perfect maturity before

the cold season. The quantity of seed to the acre will vary from 4lb. to 6lb., according to quality and state of the soil. It should be sown in drills, the distances between the rows and in the drills also varying with the conditions: eighteen inches between the rows, and the seed dibbled in at intervals of twelve inches, make good distances, the plants being thinned out, if found necessary, to insure full exposure to the sun, a condition essential to securing good heads of seed. A sufficient interval between the plants is the more necessary from their habit of spreading their branches and heads in successive layers one over another. When twelve inches high the plants benefit by a slight earthing-up.

The only objection that appears to the cultivation arises from the inequality with which the heads ripen; but this objection is thought to be overcome by the cultivation of late years of a species producing only one large flower to each plant. A yield of fifty bushels to the acre, under favourable conditions, is not uncommon.

In the year 1873 some interesting experiments were made at Bangalore, in India, by Colonel Boddam, to test the value of the sunflower as a cultivated plant. The seed used was the Giant Russian, which is double the size of the ordinary seed. Six pounds were sown in drills three feet apart on the 29th August, 1873, and the plants were harvested in the last week of December. They were seven to eight feet high, each bearing one large head; the largest of six taken from a plot of average growth was thirty-five inches in circumference, weighed 3lb., and contained 1,875 seeds. The others ranged from twenty-nine to twenty-five inches in circumference, averaging about 1lb. in weight, and the seeds varying in number from 1,000 to 1,400. The leaves were sun-dried and pounded, and made 500lb. in dry fodder, which, mixed with meal or bran, was fed to milch cows with good effect. The dried leaves will keep for a long time. The seed, after being husked, was made into coarse meal, which was pressed for oil, about 1cwt. of the meal yielding three gallons of oil and 35lb. of oil-cake. Colonel Boddam says that the empty seed-head and stalks make good fuel; and the potash which they produced made an excellent manure for coffee and tobacco.

The sunflower will grow in almost any soil and in any climate. It will bear cold or heat, drought or rain. The seed

keeps and carries well, and presents the further advantage as a crop that it can be gathered and stored until the grower has time and opportunity to turn it into money.

The sunflower is subject to no disease or climatic disqualification. It can be tried in any odd corner of the farm, and, if successful, is as simple as maize to grow upon a larger scale next year; but the plant has many more uses than maize, and is a much more sure and unvarying source of profit.—(From "Cultural Industries of Queensland," by Lewis Adolphus Bernays, F.L.S., F.R.G.S.)

Fig. 28.

SUNFLOWER.
HELIANTHUS ANNUUS.

Jerusalem Artichoke (*Helianthus tuberosus*).

Fig. 29.

This plant occupies the same place in the botanical system as the sunflower. Its leaves are rough; stem 6ft. to 10ft. in height; root tuberous like that of the potato; and it is generally propagated by small tubers, or cuttings of tubers, the same as the potato. It is perennial, a native of Brazil, and was introduced into Europe in 1617. The term *Jerusalem* is a corruption of the Italian word *girasole*—turning to the sun—a property imputed to this genus of plants. Fowls, particularly pheasants, also pigs and cattle, are remarkably fond of its tubers. They are produced in considerable quantities, and, as they are not liable to be injured by frost, their cultivation for feeding the above-mentioned live-stock in winter has been recommended. They are also, as is well known, eaten at table, cooked in various ways. The leaves and stems contain much nitrogen, which renders them, along with their palatability, good for cattle-food.

The ash of the tubers, according to Boussingault, consists of the following ingredients:—

Potash	54·67
Soda	Traces
Lime	2·82
Magnesia	2·21
Oxide of iron, alumina, &c.	6·39
Phosphoric acid	13·27
Sulphuric acid	2·70
Chlorine	1·97
Silica	15·97
	100·00
Percentage of ash in dry state ...	6·00

Fig. 29.

Jerusalem Artichoke.
HELIANTHUS TUBEROSUS.

Rape (*Brassica rapus*).

Fig. 30.

A biennial plant, much cultivated both on account of its herbage and its oil-producing seeds. It is a native of Europe. The root of rape is slender. The stem is taller than that of the turnip, and the foliage more luxuriant. The cultivation of rape is very general in many parts of Europe, from which it seems to have been introduced into England. Large quantities of oil are made from its seeds, chiefly in the fenny and other alluvial districts of the East of England, where also it has long been extensively employed for feeding sheep. On the Continent it is not unusual to sow rape for green manuring, ploughing its herbage into the soil, a mode of enriching land much more common in some parts of Europe than in Britain. Rape delights in a rich alluvial soil, and is particularly suitable for newly-reclaimed bogs or swamps, in which the turnip does not succeed well; but it is also extensively cultivated in the chalk and limestone districts of the South of England. The mode of cultivation does not differ much from that of the turnip. In New Zealand it is often sown broadcast, with 4lb. to 5lb. of seed to the acre. To afford a regular succession of food it should be sown in this country at three different periods during November and December, and the sheep are put upon it three months after it has been sown. It will thus come in at a period when it is most wanted, when the freshness of the grass pastures is on the decline, and before the turnips are fully grown. In rich soils rape sometimes attains a height of three or four feet, so that the sheep turned in are hidden beneath the leaves, and seem to eat their way into the field. They eat the stalks even more greedily than the leaves. A too exclusive feeding on rape is, however, apt to produce diseases, which a sprinkling of salt and a supply of hay are found useful in preventing.

Fig. 30.

RAPE.
BRASSICA NAPUS.

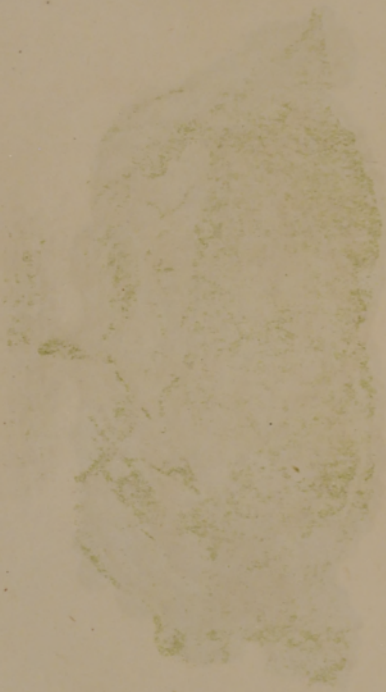
Cabbage (*Brassica oleracea*).

Fig. 31.

There is no more useful crop than cabbages—the drumhead kind is the best—for the autumnal fattening of cattle, sheep, or pigs. They are available for consumption when other green food is scarce. But the plant may be cultivated at different periods of the year. In New Zealand young cabbages planted out in April and May will yield crops available for consumption in December, January, and February.

CABBAGE.

BRASSICA OLERACEA.



Thousand-headed Kale.

Fig. 32.

This hardy and highly productive member of the cabbage-tribe was, no doubt, in the first instance, like sainfoin and lucerne, introduced into England from France. It produces a large amount of feed, and, like the cabbage, it possesses the merit of affording highly serviceable green food at very different periods of the year. It will keep well in frost, and in wet weather stock will thrive better on it than on turnips. It is a useful sheep-feed on all lands that are at all unkind to turnips. In winter it is a valuable food for milch cows. It has been grown in New Zealand, and can be sown from the beginning of September to the end of February. In this latter month it is a useful crop to sow amongst the stubbles after a corn crop. It requires 4lb. of seed to the acre, which should be sown in drills from eighteen inches to two feet apart with an ordinary turnip-drill.

Fig. 32

THOUSAND-HEADED KALE.

Turnip (*Brassica rapa*).

Fig. 33.

A biennial plant, of which there are two kinds of great value for feeding cattle—namely, the improved Swede and the green-topped Aberdeen. Although the introduction of it into general field-culture was one of the greatest improvements ever effected in the husbandry of Britain, yet it is not very nutritious, no less than 90 to 96 parts of its weight actually consisting of water. The Swedish Turnip, or Ruta Baga, was introduced into cultivation in Britain from the North of Europe more recently than the common turnip, and has proved of very great value to the farmer. It grows best in a rich free soil. The mode of culture varies with the soil. Where the soil is light and dry, a smaller amount of ploughing, harrowing, and drilling is necessary than on stiff soils. The turnip is not well suited to clay soils, although it is often grown on them. A complete pulverization of the soil is requisite before the sowing of the seed. On light soils a crop of turnips generally succeeds wheat or oats as a rotation crop. The land is generally made up in raised drills by the plough, and the seed, from 3lb. to 5lb. an acre, is sown by the drilling-machine on the top of the narrow ridges, which are about 27in. apart. The most approved method now of sowing turnip seed is by the water-drill with manure and water. The water aids the distribution of the manure, and causes rapid germination of the seed. (See lecture of Mr. W. E. Ivey, Principal of the Agricultural College, Lincoln, Canterbury, on the turnip, in the *Otago Witness* of the 12th November, 1886.) Small doses of guano, superphosphate of lime, crushed bones, or other such manures, produce great crops of turnips. They seem to act chiefly when the plant is young; and when it is further advanced it derives nutriment from the soil, and even from the subsoil, by deeply-penetrating roots, and from the atmosphere by its large leaves. The young plants are thinned out by the hand-hoe to a foot or upwards apart, and the ground is stirred and carefully kept clean by the plough or horse-hoe. The turnip crop is thus of great use in clearing the land of weeds. In many places part of the crop is eaten on the ground by sheep, which are confined to a small part of the field by means of movable fences. It is common to leave one of each three rows of turnips for this purpose, the other two rows being carried to

the farm-yard for feeding cattle, or stored. They are stored either in a house, or in conical heaps, covered with their own leaves, or with straw and earth. They are sometimes protected from frost by being earthed up in rows by the plough. Some kinds are much more easily injured by frost than others; the Swedish turnip least of all.

The introduction of the turnip as a field-crop is one of the most important events in the history of British agriculture. It has rendered possible a rotation of crops, which has been extremely advantageous, and has made the supply of butcher-meat more constant, by providing a supply of winter-food for cattle and sheep, whereas formerly all depended on the pasture. Moist weather, both in summer and autumn, is most suitable to its growth.

In New Zealand a great deal of land which has been merely surface-sown with one or two kinds of grass seeds, the produce of which has been early exhausted by the close feeding of cattle and sheep, is often ploughed and sown with turnip seed broadcast, the yield from which is also fed off with cattle and sheep, by which the soil is manured considerably, and rendered suitable for either a grain crop or laying down in permanent pasture, according to circumstances.

Fig. 33.

TURNIP.
BRASSICA RAPA.

MUSTARD (*Sinapis*). WHITE MUSTARD (*Sinapis alba*).

Fig. 34.

Mustard is often sown for feeding sheep and cattle when a turnip or rape crop has failed. It is sown broadcast, at the rate of 4lb. to 5lb. to the acre. It grows best on alluvial soil. The seed germinates more quickly than the turnip, and it is the practice of some farmers to take advantage of this to divert the turnip-fly from the turnip plants, by mixing with the turnip seed about 1lb. of mustard to 4lb. of turnip seed. The result is that the mustard plants appear sooner than the turnip ones, and the fly settles first on the former, leaving the latter almost unmolested.

MUSTARD.
SINAPIS.

Sugar-beet (*Beta alba*).

Fig. 35.

There are in cultivation four kinds of beet, viz. :—

(1.) The long red, or garden-beet, so much used as a salad;

(2.) The white Silesian, or sugar-beet, with its sub-variety the rose-coloured;

(3.) The sea-beet, the leaves of which are well known as an excellent substitute for spinach;

(4.) The mangold-wurzel, or field-beet.

Von Thaër, a German writer on agriculture, is of opinion that the field-beet is a hybrid betwixt the red garden-beet and the white sugar-beet. Others say that it is the original stock, and that the finer varieties have been produced from it by higher cultivation—a more likely conjecture.

Of the white sugar-beet (*Beta alba*) there are more than one species. It has a pear-shaped root and light-green top, green leaves, with lighter coloured ribs and white flesh. There is a variety of it which has a rose-coloured skin, leaves marked by purple-coloured ribs, but the flesh is white like that of the former. There is no difference in their sugar-yielding qualities.

The average temperature of the continental beet-growing countries, and of the localities in England where beets are grown to advantage, ranges from 62° to 65° Fahr.

The average composition of the root of the sugar-beet of France, Belgium, and the Rhenish provinces, is theoretically nearly as follows :—

Sugar	... ...	10½ per cent.
Gluten	... ...	3 „
Fibre	... ...	5 „
Water	... ...	81½ „
		100

Practically, the percentage of sugar extracted reaches about 8 per cent. But the proportion varies very much. Thus it is greater—

(1.) In small beets than in large. Chemical inquiry has proved that the proportion of sugar was larger and of salt less in beets not weighing more than 3lb.; 1 per cent. of salt in the sap will render 3 per cent. of the sugar uncrystallizable. The best roots weigh, on an average, from 1½lb. to 2½lb. each.

(2.) In dry climates, and especially when the climate is dry after the roots have begun to swell.

(3.) When grown in light potato or barley soils than in heavy soils. The land should be well drained, and capable of being cultivated to a depth of eighteen inches.

(4.) In the part under than above ground. The tap root is the richest in sugar.

(5.) When manure has not been directly applied to the crop, as its contact with the plants occasions unequal growth, as well as infests them with various kinds of insects. Strictly speaking, the manure should be worked into the ground some months previously to the seed being sown. Superphosphate of lime and bone-dust are the best manures for this root.

It has been proved that a crop raised by means of the direct application of manure contains more salt and gives more uncrystallizable syrup than when raised without direct manuring. At the factory where this was tested a larger price, therefore, was offered for roots grown upon land which had been manured during the previous winter; a higher still for such as were raised after a manured crop of corn; and a still higher when after the manuring two crops of corn were taken before the beet was sown.

In France and Belgium the crops gathered are from fourteen to fifteen tons an acre, while about Magdeburg, in Prussian Saxony, they do not exceed ten or twelve tons. But the latter are richer in sugar and poorer in salts in proportion.

These facts show how much practical agriculture, as well as climate, has to do with the success of this important manufacture.

Having regard therefore to the use and application of suitable manures, and the proper rotation of crops, the mechanical cultivation of the sugar-beet should be pursued as follows :—

The ground is to be prepared for it in the same manner as for mangold-wurzel, turnips, or carrots. The best seed is to be got from Magdeburg, in Prussia, or from M. Vilmorin, the celebrated seedsman in Paris. It should be sown in this country in October. Ten pounds to twelve pounds of seed is the quantity required per English acre. Sugar-beets are planted more closely than mangolds. The distance between the rows, and from plant to plant, should not be less than twelve inches nor greater than eighteen inches. If the young plants are

caught in spring by a night's frost they should be ploughed up and fresh seed sown. They should be horse- and hand-hoed. The earth should be well gathered up round each plant, in order that the head of each root may be completely covered with soil. When the roots begin to show the commencement of decay in the leaves they are ripe, and should be dug out, the mould gently shaken off, and the heads cut off together with as much of the roots as shows the presence of leaf-buds. They should then be piled in heaps on the ground to hinder the evaporation of their moisture, and covered with a layer of earth to protect them from light and frost. A beet-root of good quality should not exceed three pounds in weight, and should be firm, brittle, emitting a creaking noise not unlike a pineapple when cut, and perfectly sound within; the degree of sweetness is also a good indication.—(From "Transactions and Proceedings of the New Zealand Institute, 1872," Vol. V., pp. 485, 486, 487. Abstract of Paper "On the Cultivation of Sugar-beet in New Zealand," by T. Mackay, C.E.)

Fig. 35.

White Imperial

White Silesian

SUGAR-BEET.

BETA ALBA.

Mangold-Wurzel.

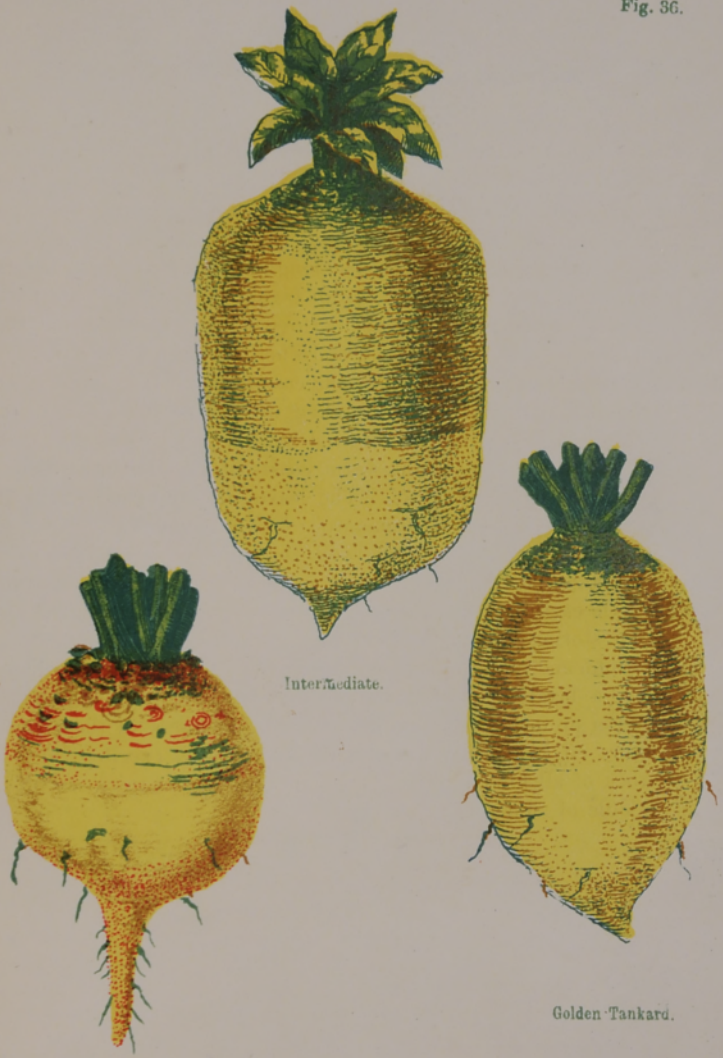
Fig. 36.

A name in general use to designate the varieties of the common beet cultivated in fields for the feeding of cattle. The field-beets differ from the garden-beets chiefly in being larger in all their parts, and coarser. They have large roots, which in some of the varieties are red, in some greenish or whitish, in some carrot-shaped, and in some nearly globular. The cultivation of mangold as a field-crop was introduced into England from Germany in 1876, but it is only of late that it has much extended. At first so little was its value known that the leaves alone were used as food for cattle. Its importance, however, was soon appreciated, and it rapidly gained favour. It is much more patient of a high temperature than the turnip, liable to fewer diseases, and vastly more productive under liberal treatment. In the Island of Jersey, and in highly-manured grounds in the vicinity of London, as much as seventy to eighty tons to the acre have been raised. Throughout the South of England it is generally admitted that it is as easy to grow thirty tons of mangold to the acre as twenty tons of Swedish turnips.

The lower temperature of Scotland, however, does not admit of the crop being raised to the same advantage. The yield is much smaller than in the South, and the plants are more liable to run to flower. This seems to be owing to the cold contracting the vessels, and in some measure acting in the same manner as a diminished supply of food in favouring the formation of seed. The increased precariousness of the turnip-crop in Britain of late years, however, has induced many to make trial of the cultivation of mangold, and with considerable success. The mode of culture there does not vary materially from that followed in raising turnips. The land receives a deep furrow in autumn, and, if quite free from weeds, it is well manured. In the spring, drills or ridges from twenty to thirty inches wide are formed by the double-mouldboard plough; and if manure has not been applied in autumn, from twenty to thirty loads per acre are spread along the furrows. In addition, from 3cwt. to 4cwt. of guano, and 4cwt. of common salt, are sown broadcast over the drills; indeed, this crop can rarely be over-manured. The manures are then covered by the plough, and the ridges are afterwards run over with a light roller to smooth them down.

Two or three seeds are then dibbled in on the top of the ridges, from twelve to eighteen inches apart. It requires about 7lb. of seed to the acre; and, as the grains are enclosed in a hard and rough coat, they may be moistened in water for two days previous to their being planted, for the purpose of promoting a quick and regular braird. The long red, the round red, and the round green-topped yellow are all favourite varieties in England. As soon as the plants are about three inches above ground they are singled out by the hand, and their cultivation is afterwards the same in all respects as in the case of Swedish turnips. The crop is usually ready to be taken up by the end of autumn; indeed, it should not be delayed beyond this period, for, being originally a native of the warm coasts of the Mediterranean, it is injured by severe frost. The leaves are wrenched off by the hand, and the earth is merely roughly taken away from the roots, as they do not keep well through the winter if cut or bruised. The roots are stored in pits, covered with straw and a little earth as a protection in severe weather. It is some time after storing before the roots can be used with advantage, for in autumn and the early part of winter their juices, being unripened, have a laxative effect on animals. Swedish turnips are at this season preferred for feeding; but the harshness of the mangold wears off by spring, and it then becomes an excellent food for stock of all kinds, and, if well kept, retains its juiciness till the middle of summer.

Fig. 36.



MANGEL WURZEL.

Carrot (*Daucus carota*).

Fig. 37.

The common carrot is a biennial plant common in Britain and most parts of Europe. The small and early kinds are cultivated for culinary use, the larger and late kinds for feeding cattle and horses. Of the latter the Altringham carrot is most generally grown. The carrot prefers a light and rather sandy soil, and often succeeds well on a peat-soil. About 10lb. of seed to the acre should be sown. As an article of food it contains a large amount of what are fat- and heat-producing compounds, with a small proportion of flesh-forming matter. It consists essentially of starch, sugar, and albumen. The following is the composition of dried carrot:—

Starch and sugar	93·71
Albumen	4·35
Red neutral substance (carotin) ...	0·34
Fixed and volatile oils	1·00
Ash	0·60
	100·00

Fig. 37.

Long White Belgian Green-top.

Improved Long Red. Altringham.

Carrot.

DAUCUS CAROTA.

Parsnip (*Pastinaca sativa*).

Fig. 38.

The common parsnip is a native of England, and is abundant in some districts, particularly in chalky or gravelly soils. It is also found in many parts of Europe, and of the North of Asia. It is a biennial, and has long been cultivated for the sake of its root, which is more nutritious than that of the carrot. The produce is also, on many soils, of large quantity; and, although the parsnip delights in a very open rich soil, it will succeed in clayey soils far too stiff for the carrot. It is not so extensively cultivated as a field-crop as it ought to be, more particularly as cattle are very fond of it; and not only is the flesh of those fed on it of excellent quality, but the butter of dairy-cows fed on parsnips in winter is far superior to that produced by almost any other kind of winter-feeding. The mode of cultivation scarcely differs from that of the carrot, and about 10lb. of seed to the acre should be sown. There are several varieties in cultivation. A very large variety, cultivated in the Channel Islands on deep sandy soils, has roots sometimes three or four feet long, but this is fully twice the ordinary length. It is improved rather than injured by frost; but is apt to become rusty if allowed to remain too long in the ground, and exhibits acrid qualities after it has begun to grow again in the spring, so it should be taken up and pitted in the same way as carrots before winter is over.

Fig. 38.

PARSNIP.
PASTINACA SATIVA

Field Pea (*Pisum arvense*).

Fig. 39.

Peas are cultivated to a considerable extent as a field-crop, but are best adapted to districts in which the climate is least moist, the seeds being very apt to grow in the pods when moist weather prevails in autumn, by which the crop is injured or destroyed. The haulm or straw of peas is used for feeding cattle; and, for its sake, field peas are often reaped before they are quite ripe, great care being taken in stacking the straw to provide for ventilation, so that it may not heat. Pea haulm is more nitrogenous and more nutritious than hay.

Land to be sown with field peas should be very clean, and, in particular, free from couch-grass; otherwise the best management cannot prevent its becoming foul whilst bearing the pea-crop. The seed—three bushels to the acre—ought always to be sown in rows twelve inches apart, or, in rich soils, eighteen or twenty inches apart, and should not be buried more than three to four inches under the surface. All possible means ought to be used to keep the land free from weeds. Peas are often sown broadcast, which renders it impossible to do anything for this purpose. In the harvesting of peas the sheaves are generally left loose till the haulm is somewhat dry. In drying it shrinks very much. Broadcast peas are often cut with the scythe, and the harvesting of them is managed much as that of hay.

Peas and beans when sown together—one and a half bushels of each—in alternate rows, produce a better crop than sown separately.

Fig. 39.

FIELD PEA.
PISUM ARVENSE.

Field Bean (*Faba*).

Fig. 40.

The bean was cultivated, to a small extent at least, in ancient times, both in Palestine and Egypt. The Roman family of the Fabii are said to have derived their name from this plant. It requires a rich or alluvial land to grow the bean in perfection, and hence it is only found entering into a regular rotation of cropping upon soils of the best class. Since the introduction of maize into the South of Europe, the land under this plant has been considerably restricted. The maize thrives better, and is far more productive, than the bean in warm climates. Indeed, the high summer temperature of the continents of Europe and America is by no means favourable to the growth of the bean. In the West of England the summers are rather too moist for its yielding its seeds in abundance. The straw and haulm are apt to be developed too much, and the blossoms do not set well. Beans are largely cultivated on all the better descriptions of clay soils in the eastern counties, such as Kent and Suffolk. The variety most generally grown there is the common tick or field bean, having much resemblance to the Scotch or horse bean.

The modes of cultivation are very various, and a large breadth is still sown broadcast. The great objection to this mode is the liability of weeds to spring up and check the growth of the crop. Beans are considered one of the fallow crops; but the soil, after it has borne a crop of beans, is little fitted for a cereal crop unless it has been hoed and kept clean in summer. To effect this end beans are usually sown in rows eighteen inches apart, using three bushels to the acre, and hoed during their early growth either by the hand or horse-hoe to keep the crop free from weeds, which is repeated as often as it is deemed advisable, until the crop covers in the land with its abundant foliage, and keeps down all weeds. The produce varies from twenty to forty bushels per acre; but in dry and warm seasons it often falls below the first-named quantity. The weight per bushel is from 60lb. to 64lb. The straw forms good fodder both for cattle and horses, as well as supplying material for the dung-heap. Beans are usually cut by the sickle or scythe, allowed to lie a few days unbound to winnow, and, when bound, put up into stooks. The field bean is considered to be specially

adapted for feeding of horses accustomed to hard work. For this purpose it is usually roughly ground, and mixed with a little bran. A mixture of ground beans and oilcake, or linseed, is much esteemed for milch cows, as well as for fattening cattle and sheep.

Fig. 40.

Bean Pods.

Bean Fly. Natural size.

Seed.

Field Bean.

FABA.

CHAPTER V.

COMPARATIVE NUTRITIVE VALUE OF THE GRASSES.

From the descriptions in the second and third chapters of the various grasses, both natural and artificial, it will be seen that they differ considerably from each other in nutritive value: that some are most nutritious when green or in flower, others when the seed is ripe and the plant mature; that some yield a plentiful aftermath, while others scarcely any at all; that, according to their nature, some flourish on low and others on elevated lands; and that there is scarcely any climate, or any kind of soil, whether rich or sterile, sandy or loamy, but that a grass may be found adapted to it.

Some species, particularly the annual and biennial kinds, which are not usually grazed, but cut for either green-feeding or for hay, generally grow best alone, or only when associated with another—for instance, Italian rye-grass and red clover; while others, which may be termed the perennial kinds, flourish best when grown together in suitable combinations according to soil, situation, and climate, as may be best adapted to the different kinds of stock intended to be grazed upon them.

In the rearing of cattle and sheep, and their preparation, commercially speaking, for market, they should be fed upon such grasses and forage-plants as combine the necessary relative proportions of nutritive substances that will most speedily effect the object in view.

To learn, therefore, the comparative nutritive value of each species worth cultivating is important. Such a study, how-

ever, is attended with difficulties, and it is only of late years that accurate researches have been made with such positive results as would be entitled to full confidence.

The first practical experiments to ascertain the comparative value of most of the grasses grown in Europe were initiated in 1824 by the then Duke of Bedford at Woburn Abbey. They were conducted by his head gardener, Mr. George Sinclair, F.L.S., under the direction of the late Sir Humphry Davy, and are detailed in a work under the title of "Hortus Gramineus Woburnensis." This was the first text-book worthy of notice on the subject, and is looked to as an authority down to the present time. Next came the later and more elaborate analyses made by Professor Way, Chemist of the Royal Agricultural Society of England, and published in the journal of that society, Vol. XIV., 1st Series, 1853. But the methods of these two pioneers in this particular field of research are now obsolete, for the more recent and exhaustive investigations of such eminent agricultural chemists as the late Dr. Augustus Voelcker, of the Agricultural College, Cirencester; his son, Dr. J. Augustus Voelcker, Sir John B. Lawes, and others in England, as well as of the professors of chemistry at the experimental stations of the United States Department of Agriculture, have proved to be the most practical, from the fresh light which, by the advanced methods of analysis of the present day, such investigations have thrown on the comparative values of the several grasses which have been experimented upon, and which comprise most of the various kinds already described in this work. A study of these investigations shows clearly that the composition of the plant varies according to difference of soil, situation, climate, time when cut, and general surroundings, so that the publication of chemical analyses is of little use unless accompanied by descriptions setting forth the above particulars. The conclusion the compiler of a report of the United States department on the subject arrives at is, to use his own words, "Species are not in themselves at all fixed in their composition, there being as large variations among specimens of the same as between specimens of different species." For instance, in the case of *timothy grass*, procured from different localities in the States, the table below will show a wide margin of difference in some of the most important constituents of the plant.

Analysis of Timothy Grass.
(Cut in full bloom.)

Locality.	Ash.	Fat.	Nitrogen Free Extract.	Crude Fibre.	Albuminoids.	Total Nitrogen.	Non-albuminoid Nitrogen.	Per cent. of Total Nitrogenous Non-albuminoid.
Garden of the Department, 1881.. ..	7·16	4·47	50·03	27·35	10·99	1·75	·51	29·1
Garden of the Department, 1880.. ..	5·66	3·58	58·93	21·93	9·90	1·58	·38	24·0
Maryland	4·93	4·22	52·83	30·43	7·69	1·23	·15	12·2
New Hampshire ..	4·57	4·20	57·16	28·28	5·79	·93	·10	10·8
Indiana	7·05	2·18	52·99	32·26	5·52	·88	..	..

Even a superficial glance at the foregoing table will also show that in the grass grown in the Department Garden in 1881 there is twice as much fat, and also twice as much albuminoids (flesh-forming elements), as in that grown in Indiana; and, again, one cannot fail to be struck with the difference in the analysis of the timothy grown in the Department Garden in 1880 as compared with 1881.

It will thus be seen that, as in New Zealand the conditions of soil, situation, and climate may differ in many ways from those of the countries in which the experiments referred to have been carried on, it would not be of much practical use to give any details of such experiments, or to pursue this subject further at present. Nevertheless, in reference to what is indicated in the Introduction to this part of the Manual respecting the subject of Part III., yet to be published, it may be here stated that a comprehensive system of experiments, both in the cultivation and in the chemical analysis of the various grasses and forage-plants already described in the preceding Chapters II., III., and IV., as well as of the useful indigenous grasses of New Zealand, which will be treated of in Part II., is now being carried on, specially for the purposes of this work, at the Agricultural College, Lincoln, Canterbury, the results of which it is expected will establish full and reliable data on these important questions for the future guidance of the agriculturists of New Zealand.

CHAPTER VI.

THE INFLUENCE OF CLIMATE AND SEASONS ON THE GRASSES.

There is no crop more dependent on the seasons than the grasses. A moist spring, with rains evenly distributed over the months of September, October, and November, in New Zealand will insure luxuriant crops of grass and hay, but a dry cold spring is fatal to their rapid and healthy development.

Sir James Hector, K.C.M.G., F.R.S., Director of the Geological Survey of New Zealand, in his "Handbook of New Zealand," states that "the climate resembles that of Great Britain, but is more equable, the extremes of daily temperature only varying throughout the year by an average of 20°, whilst London is 7° colder than the North and 4° colder than the South Island of New Zealand. The mean annual temperature of the North Island is 57°, and of the South Island 52°, that of London and New York being 51°. The mean annual temperature of the different seasons of the whole colony is—in spring, 55°; in summer, 63°; in autumn, 57°; and in winter, 48°."

Mean Annual Rainfall.

North Island.	In.	South Island.	In.
Auckland ...	45·306	Nelson	61·599
Taranaki ...	58·084	Hokitika ...	112·156
Napier	37·260	Christchurch ...	25·774
Wellington ...	50·781	Dunedin ...	32·019
		Southland ...	43·674

From these particulars it will be easily understood that, from the equable temperature on the one hand and the abundant rainfall on the other, the evaporation from the soil is more rapid, and the actual amount of moisture in the air is greater, for the evaporation is in proportion to the height of the temperature and the extent of water- or land-surface.

The differences in climate that influence and control the growth of the grasses are chiefly moisture and dryness. Moisture must exist in the soil or the atmosphere. A luxuriant crop of grass depends not so much upon the aggregate annual quantity of rain that falls as upon its distribution over the year, especially over the growing months. A frequent rain in spring, though it may come in small quantities, causes a rapid and succulent growth; but grass derives more benefit from large quantities of rain falling at longer intervals, provided it does not come in torrents to prostrate a hay or seed crop, and that the intervals are not so long as to produce droughts. The quantity in the latter case will not ordinarily be so great as in the former, but the nutritive and fattening qualities will be better. And so it is likewise with cereals of all kinds.

CHAPTER VII.

SELECTION, MIXTURE, AND SOWING OF GRASS-SEEDS FOR PERMANENT PASTURE.

It is the experience of every person who has paid any attention to the selection of grass-seeds that it is almost an impossibility to get them pure from mixture either with bad or old seeds or with other kinds than that which they purport to be. As an illustration of this, Mr. Faunce-De Laune, in his valuable article in the Journal of the Royal Agricultural Society of England—Second Series, Volume XVIII., Part 1, No. xxxv.—"On laying down Land to Permanent Grass," gives the following account of the difficulties he encountered in procuring pure mixtures of grass-seed :—

"Nine years ago circumstances led me to lay down to permanent pasture certain portions of land; and I did as most others have done — ordered the ordinary mixture for permanent pastures from one of the best seed-merchants. My first attempts were on a piece of arable land of six acres, and a piece of woodland,—the underwood, after having been cut down, being fed off with sheep. The six acres I mowed twice the first year; the piece of woodland could not be mown, and therefore was fed off with sheep.

"I saw in the woodland a grass I had not specially noticed before, and therefore got a book on grasses ('Hortus Gramineus Woburnensis') to find out the name, and found it was timothy, or cat's-tail : this led to my finding out that there was a great difference in the feeding properties of the numerous grasses, and in my next attempt I ordered the grasses for myself, still ordering, as recommended by seed-merchants, a large quantity of strictly permanent rye-grass. This I watched carefully. When it came to flower and seed, the proportion of other grasses was so small that the pasture might have been taken for rye-grass

alone. I noticed in my pastures the deterioration so much complained of by others, and was determined to find out the cause, and, luckily for myself, purchased Sinclair's book—the one above mentioned. I gradually learnt to know all the most valuable grasses in nearly all stages of their growth, and found that, however careful I was in my orders, and from whatever seed-merchant I ordered my seeds, the percentage of rye-grass, soft woolly grass (Yorkshire fog), and other bad grasses and weeds, was beyond belief. In order more carefully to test the results, I fenced off a small portion of some of the newly-sown meadows. I found in a piece 8½ft. square about six plants of cocksfoot, one meadow foxtail, two meadow fescue, five or six crested dog's-tail, and the rest rye-grass, Yorkshire fog, perennial clover, and weeds. I then got an introduction to Mr. W. Carruthers, F.R.S., the Consulting Botanist of the Royal Agricultural Society, and by means of his able help and valuable information was enabled to make closer experiments. From these I learnt that good seed was most difficult to get; and, to illustrate how difficult, I will give some of my experience. I had five acres of very valuable land I wished to sow with permanent grass for seed; the land was not only very good, but very highly manured and absolutely clean, having been a hop-garden. I divided this field into three parts, one to be sown with cocksfoot, the second with meadow fescue, and the third with rough meadow-grass. I ordered with special care the three kinds of seed from one of the great seed-merchants, and looked forward next year to a good crop of seed, not suspecting that when seed was especially ordered of a particular kind from a firm of repute it would be anything but good. But after a week's growth, although I was satisfied that the cocksfoot was true, my suspicions were aroused about the others, and I sent some of the seed that was left to be examined by Mr. Carruthers. To my great amazement I was told that the meadow fescue was all rye-grass, and the rough meadow-grass *(Poa trivialis)* all smooth meadow-grass *(Poa pratensis)*. There was nothing left for it but in the best way possible to destroy all the grass, and resow it."

After describing other similar experiments with similar results he goes on to say,—

"A tenant of mine, having purchased a permanent-grass mixture from one of the large seedsmen, at a cost of £1 15s.

per acre, mowed the land sown with the seed (supposed to be twenty-eight acres), and at my request Mr. Carruthers inspected the stack, and gave the following result of the examination of the hay, the clover being excluded from the estimate :—

"Cocksfoot	12	Couch-grass	4
Meadow fescue	2	Woolly soft grass....	7
Sweet vernal	3	Oats	3
Crested dog's-tail	8	Barley	11
Rough meadow-grass	6	Brome-grass	2
Golden oat-grass	4	Rye-grass	941
Soft creeping-grass	2		
		Total	1,005

"If we exclude the oats and barley, together with the worthless grasses which may possibly have been in the ground, and treat the remaining individual grasses as if they were pounds, we have the following remarkable and instructive results: 35lb. of good grasses (the first six in the list), at an average cost of 9d. per lb., would cost £1 6s. 3d.; and 941lb. of ryegrass at 1½d. per lb., would come to £5 17s. 7d.; making a total of £7 3s. 10d. The 976lb. of mixed seed for permanent pasture, at 9d. per lb., cost £36 12s.; making, on the data supplied by the hay, a difference of £29 8s. 2d. between the real value of the seeds and the price paid to the seedsman for the mixture.

"But this loss of nearly £30 is nothing compared to the real loss when the consequential damage is taken into account.

"The land from which this crop was taken having subsequently come into my own hands, I have sown a considerable quantity of good grass-seed on it; but I have found in this case, as in others where originally a large proportion of rye-grass had been sown, it is very difficult to get other grasses to grow. I have come to the conclusion that rye-grass is certain to cause exhaustion of the soil, an opinion in which there are many to support me; although others, doubtless, are ready to dispute it.

"Having arrived at the point of the necessity of eliminating rye-grass, it may fairly be asked, How are we to get the good grasses? I have succeeded, after very much difficulty, in getting all grasses good, by getting different grass seeds from

different merchants, and, when the seed was not sufficiently good to sow, leaving it and trusting to next year; but when it was only inferior in germinating power I have sown an extra quantity to make up for want of this quality."

Such painstaking and practical experiments as Mr. Faunce-De Laune describes prove clearly that no one can have any surety of having good seed unless he either pursues a similar course, or raises seed for himself, or uses that which he knows has been carefully raised in his neighbourhood.

The seeds of some plants retain their vitality much longer than others. Those of the turnip, for instance, will germinate as well, or nearly so, at four or five years as when only one or two years old; they are thought to be better at two years old than one. But the seeds of most of the grasses are of very little value when they have been kept for two or three years; hence the importance of procuring new and fresh seeds from good plants of three years old or upwards, and guarding against sowing any mixture that is composed of old and worthless seeds, as well as immature or imperfect ones from too young plants.

It is easy to tell whether the germinative power of grass or any other seed still remains, by the following simple method; and, if the buyer should be willing to try it, he might purchase only a small quantity at first, and afterwards obtain a full supply with more confidence if the trial showed it to be good. Take two pieces of thick cloth, or old flannel, or blanket, moisten them with water, and place them one upon the other in the bottom of a saucer. Place any number of the seeds which it is desired to try upon the cloth, spreading thin, so as not to allow them to cover or touch each other. Cover them over with a third piece of cloth similar to the others, and moistened in the same manner.

Then place the saucer in a moderately warm place. Sufficient water must be turned on from time to time to keep the three thicknesses of cloth moist, but great care must be taken not to use too much water, as this would destroy the seed. There should be only enough to moisten the cloths, and not enough to allow any to stand in the saucer. Danger from this source may be avoided in a great measure, however, by tipping up the saucer so as to permit any superfluous matter in it to drain off. The cloth used for covering may be gently

raised each day to watch the progress of the swelling of the seeds, or of becoming mouldy. The good seed will be found to swell gradually, while the old or poor seed, which has lost its germinating power, will become mouldy in a very few days.

In this way, also, any one can judge whether old seed is mixed with new. The latter will germinate much more quickly than the former. He can, moreover, judge of the quantity he must sow, since he can tell whether a half, or three-fourths, or the whole will be likely to germinate, and can regulate his sowing accordingly. The seeds of the clovers, if they are new and fresh, will show their germs on the third or fourth day; other seeds will take a little longer, but, till they become coated with mould, there is hope of their germinating. As soon as the mould appears it is decisive, and the seed that moulds is worthless.

It is difficult to overestimate the importance to the farmer of a good selection and proper mixture of grass seeds for the various purposes of cultivation—for hay, for green feed, for permanent pasture, or for an alternate crop. As regards that of permanent pasturage, the following report of Mr. Carruthers, the Consulting Botanist of the Royal Agricultural Society of England, "On laying down Land to Permanent Pasture" (presented to the Council of the Society on February 1, 1882), contains much practical information:—

"In determining the grasses best fitted for laying down land in pasture, it is important to take into consideration the term of life of the different species.

"Many grasses are so short-lived that they do not survive the exhaustive process of seeding. One-third of our indigenous [English] grasses die in this way, usually at the close of a single season, and are therefore called annual grasses. Not only the portion of the plant above ground but the roots also perish, and the species is preserved from year to year only by the seed. The remaining two-thirds are grasses in which the process of flowering does not so completely exhaust the plant as to kill it. The life of the individuals in these grasses is continued from year to year, and seeds are annually produced. Though the plant may be killed down by the winter's cold, the roots with their crown remain alive, and, increasing in their hold on the soil, are able to secure a more speedy and extensive growth

than can be produced under the most favourable circumstances from seeds.

"While annual grasses, or those having a short term of life, like the rye-grasses, may be specially fitted for alternate husbandry, it is obvious that permanent pasture should be formed of those grasses which have a perennial existence. But the eighty species of indigenous perennial grasses are not all suitable for feeding purposes; many of them are rejected by stock. It is therefore necessary to make a selection from them in accordance with the tastes of the animals for which they are provided. And, further, it has long been noticed that some pastures which appear to consist of an abundant supply of good food are yet unable to fatten stock. This must limit the selection of the grasses to those which, by experiment and observation, have been found to be nutritious as well as palatable.

"A prejudice exists against some grasses, which are supposed to be coarse, and are therefore rejected when finer grasses can be obtained by the stock. But the chemical examination of some of these coarse grasses, and the careful observation of their effect on the stock, have shown that the grasses which are most productive are also those that are most nutritious.

"The number of these species is very limited. The observations of Mr. Faunce-De Laune, which are supported by the testimony of previous careful observers, show that the best permanent-pasture grasses are the following five species: *Dactylis glomerata*, or cocksfoot; *Phleum pratense*, or timothy; *Alopecurus pratensis*, or meadow foxtail; *Festuca pratensis*, or meadow fescue; and *Festuca elatior*, or tall fescue.

"These five grasses alone would supply favourite and nutritious food throughout the whole year.

"There should be added some Dutch (white) and perennial red clovers and cow-grass. And some of the smaller, or so-called finer, grasses would be advantageously introduced in order to secure a compact turf: such grasses as *Poa nemoralis*, or wood meadow-grass; *Poa trivialis*, or rough-stalked meadow-grass; *Agrostis stolonifera*, or fiorin; *Cynosurus cristatus*, or crested dog's-tail; *Anthoxanthum odoratum*, or sweet-scented vernal; and *Festuca duriuscula*, or hard fescue. But the real value of the pasture will depend upon the proportion of the five larger grasses which are found in it. Their first importance is still further shown by the fact that their roots continue to grow

from year to year, and the plants consequently get a firmer hold on the soil, and, having a more extensive root-system than annual grasses, they suffer less from drought.

"The exclusion of the short-lived rye-grasses, which are so overwhelming an ingredient in all permanent-pasture mixtures in the market, will deprive the farmer of that speedy exhibition of a green and vigorous pasture so captivating to the eye, and so often accepted as the best testimony to the value of the mixture employed, but so worthless as the basis of a permanent pasture.

"It would be an important step in advance if the farmer were to become acquainted with the value and permanence of the best grasses, and see in their growth the best guarantee for his future crop, even though they want the beautiful appearance that a field of young rye-grass presents.

"The species of grass for permanent pasture having been fixed upon, it is of next importance to obtain true, pure, and good seed. . . .

"A guarantee should be obtained from the merchant that the quantity purchased is true to the species wanted and specified, that it is free from weeds, and that a certain percentage of the seeds will germinate. Samples from the bulk should be examined and tested by a competent person, and the completion of the purchase should depend on the result of this examination and trial.

"The seed should not be left on the surface of the ground, else it may not secure the moisture necessary for its germination, or, when it has begun to germinate, and the delicate embryo has pushed its roots and stem through the covering of the seed, a continuous exposure of a few hours to the hot rays of the sun may kill it. On the other hand, if the seed be too deeply buried in the soil it will fail to germinate. A depth of from half an inch to an inch and a half is most suitable for the grasses that should be employed for permanent pastures."

In illustration of the last paragraph of Mr. Carruthers's report, the following table, containing the weight per bushel and suitable depth of covering of the seeds of most of the natural and artificial grasses described in the first, second, and third chapters, is prepared chiefly from a similar table contained in a valuable treatise on the grasses by Messrs. Lawson and Son,

of Edinburgh, the eminent seedsmen, who have paid much attention to this subject :—

WEIGHT OF GRASS-SEEDS AND DEPTH OF COVERING.

1.	2.	3.	4.	5.	6.	7.
Cocksfoot	12	40,000	0 to ¼	¾ to 1	2¼	·29
Meadow fescue	14	26,000	0 to ½	¾ to 1	2½	·60
Tall fescue	14	20,500	0 to ¼	1 to 1½	2¾	·52
Meadow foxtail ..	5	76,000	0 to ½	1 to 1¼	2¼	·57
Timothy	44	74,000	0 to ¼	¾ to 1	2	·50
Perennial rye-grass ..	18 to 30	15,000	¼ to ½	1½ to 1¾	3½	·50
Italian rye-grass ..	15	27,000	0 to ¼	1 to 1¼	3¼	..
Crested dog's-tail ..	26	28,000	..	..	..	..
Hard fescue	10	39,000	0 to ¼	¾ to 1	2¼	..
Sheep's fescue	14	64,000	0 to ¼	¾ to 1	2	·65
Rough-stalked meadow..	15	217,000	0 to ¼	½ to ¾	1½	·72
Tall oat-grass	7	21,000	½ to ¾	1½ to 1¾	4	..
Yellow oat-grass ..	5½	118,000	0 to ¼	¾ to 1	2	..
Sweet-scented vernal ..	6	71,000	0 to ½	1 to 1¼	2	·45
White clover	65	32,000	0 to ¼	½ to ¾	1½	..
Perennial clover or cow-grass	64	16,000	0 to ½	1¼ to 1½	2	..
Red clover	64	16,000	0 to ½	1¼ to 1½	2	..
Lucerne	60	12,600	..	..	..	..
Sainfoin	26	10,280	¾ to 1	2 to 2¾	4½	..

Column 1 contains the common names of the grasses.

Column 2, the average number of pounds in a bushel of the seeds.

Column 3, the average number of seeds *in an ounce*.

Column 4 shows the depth of soil, in inches and fractions of an inch, at which the greatest number of seeds germinated.

Column 5 shows the depth of soil, in inches and fractions of an inch, at which only one-half of the seeds germinated.

Column 6 shows the least depth of soil, in inches or fractions of an inch, at which none of the seeds germinated.

Column 7 shows the average percentage of loss in the weight of the grass, in making it into hay at the time of flowering.

The weight of seeds varies, of course, somewhat from that stated in the above table, according to their quality. Those given in the table are the average weights of good merchantable seed.

The number of seeds of each species in a pound may be found, of course, by multiplying the numbers in column 3 by 16, the number of ounces in a pound. It is obvious, however, that these numbers must vary, like the number of pounds in a bushel; for it is evident that the lighter the seed the greater will be the number of seeds in a pound. The numbers stated are the average obtained by careful and repeated trials, and they may be relied on as the average of well-cleaned seed. The results stated

in columns 4, 5, and 6 were obtained by careful experiment, and will be found to be very suggestive.

The fact that the soil used in the experiments to ascertain the proper depth of covering was kept moist during the process of germination, though freely exposed to the light, accounts for the large number of seeds germinated without any covering whatever. In ordinary field culture some slight covering is desirable; but the figures in column 6 show the important fact that in our modes of sowing and covering there must be a great loss of seed from burying too deep, though the depth should be governed somewhat by the nature of the soil, and its usual moisture or dryness.

In laying down land to permanent pasture it is important to bear in mind that such species as blossom at different periods should be selected, so as to secure a luxuriant growth throughout the season. Further, it is equally essential that the nature of the soil should be considered in the suitable quantity of each kind of seed composing the mixture for sowing in such soil. The following extract from Mr. Faunce-De Laune's article, already quoted from in this chapter, will explain this very clearly. He says,—

"My experience would lead me to employ the mixtures stated in the following tables. I have specified the number of seeds that these mixtures contain per acre. If all these seeds were to produce plants, the first growth would still be only half of the number that Sinclair has intimated as existed in established pastures. But my belief is that the cost of employing a sufficient quantity of seed to produce the 40,000,000 plants in an acre would be too great to make it possible to use them. And yet more important is the consideration that not only greater economy but greater certainty as to the results will be obtained if the good grasses are allowed partially to seed and sow themselves. A good thick pasture can in this way be secured at a comparatively small cost.

MIXTURE OF SEEDS FOR GOOD OR MEDIUM SOILS.

Description.	Number of Pounds per Acre.	Price per Pound in England.	Total Cost.	Number of Seeds in Entire Quantity.	Per Cent. of Germinating Power.	Total Number of Germinating Seeds in the Entire Quantity.	Quantity required to make the Number of Germinating Seeds equal to the Number of Seeds required.	Total Cost of the same in England.	Total Number of Germinating Seeds.
		s. d.	£ s. d.				lb.	£ s. d.	
Cocksfoot	7	0 9	0 5 3	3,172,617	60	1,903,568	$11\frac{2}{3}$	0 8 9	3,172,617
Meadow fescue	6	0 9	0 4 6	1,401,180	60	840,708	10	0 7 6	1,401,180
Tall fescue	3	0 9	0 2 3	700,590	60	420,354	5	0 3 9	700,590
Meadow foxtail	10	1 $1\frac{3}{4}$	0 11 $5\frac{1}{2}$	3,103,650	20	620,730	50	2 17 $3\frac{1}{2}$	3,103,650
Timothy	3	0 $6\frac{1}{2}$	0 1 $7\frac{1}{2}$	2,438,853	90	2,194,967	$3\frac{1}{7}$	0 1 $9\frac{1}{2}$	2,438,853
Crested dog's-tail	2	2 0	0 4 0	1,371,550	60	820,930	$3\frac{1}{5}$	0 6 8	1,371,550
Hard fescue	1	0 6	0 0 6	403,656	60	242,193	$1\frac{2}{3}$	0 0 10	403,656
Sheep's fescue	1	0 10	0 0 10	403,656	60	142,193	$1\frac{2}{3}$	0 1 $4\frac{1}{2}$	403,656
Rough meadow-grass	$1\frac{1}{5}$	0 10	0 1 3	2,377,530	60	1,426,519	$2\frac{1}{2}$	0 2 1	2,377,530
Fiorin	$1\frac{1}{5}$	0 10	0 1 3	4,382,446	60	2,629,467	$2\frac{1}{2}$	0 2 1	4,382,446
Yarrow	1	3 0	0 3 0	3,500,000	40	1,400,000	$2\frac{1}{2}$	0 7 6	3,500,000
White clover	1	0 11	0 0 11	656,511	100	656,511	1	0 0 11	656,511
Alsike	1	0 11	0 0 11	656,511	100	656,511	1	0 0 11	656,511
Cow-grass	1	1 2	0 1 2	300,000	100	300,000	1	0 1 2	300,000
Perennial red clover	1	1 0	0 1 0	231,203	100	231,203	1	0 1 0	231,203
	41	..	1 19 11	25,099,953	..	14,585,854	$98\frac{1}{3}$	5 3 $7\frac{1}{2}$	25,099,953

MIXTURE OF SEEDS FOR WET SOILS.

Description.	Number of Pounds per Acre.	Price per Pound in England.	Total Cost.	Number of Seeds in Entire Quantity.	Per Cent. of Germinating Power.	Total Number of Germinating Seeds in the Entire Quantity.	Quantity required to make the Number of Germinating Seeds equal to the Number of Seeds required.	Total Cost of the same in England.	Total Number of Germinating Seeds.
		s. d.	£ s. d.				lb.	£ s. d.	
Cocksfoot	10	0 9	0 7 6	4,532,310	60	2,719,385	$16\frac{2}{3}$	0 12 6	4,532,310
Meadow fescue	3	0 9	0 2 3	700,590	60	420,345	5	0 3 9	700,590
Tall fescue	8	0 9	0 6 0	1,868,240	60	1,120,944	$13\frac{1}{3}$	0 10 0	1,868,240
Meadow foxtail	4	1 $1\frac{3}{4}$	0 4 7	1,241,460	20	248,292	20	1 2 11	1,241,460
Timothy	3	0 $6\frac{1}{2}$	0 1 $7\frac{1}{2}$	2,438,853	90	2,194,967	$3\frac{1}{3}$	0 1 $9\frac{3}{4}$	2,438,853
Crested dog's-tail	2	2 0	0 4 0	1,371,550	60	822,930	$3\frac{1}{3}$	0 6 8	1,371,550
Hard fescue	1	0 6	0 0 6	430,656	60	242,193	$1\frac{2}{3}$	0 0 10	430,656
Rough meadow-grass	2	0 10	0 1 8	3,170,042	60	1,902,025	$3\frac{1}{3}$	0 2 $9\frac{1}{4}$	3,170,042
Fiorin	2	0 10	0 1 8	5,843,262	60	3,505,956	$3\frac{1}{3}$	0 2 $9\frac{1}{4}$	5,843,262
Yarrow	1	3 0	0 3 0	3,500,000	40	1,400,000	$2\frac{1}{2}$	0 7 6	3,500,000
White clover	1	0 11	0 0 11	656,511	100	656,511	1	0 0 11	656,511
Alsike	1	0 11	0 0 11	656,511	100	656,511	1	0 0 11	656,511
Cow-grass	1	1 2	0 1 2	300,000	100	300,000	1	0 1 2	300,000
Perennial red clover	1	1 0	0 1 0	231,203	100	231,203	1	0 1 0	231,203
	40	..	1 17 $9\frac{1}{2}$	26,931,198	..	15,421,262	$76\frac{1}{2}$	3 15 $5\frac{1}{4}$	26,931,198

MIXTURE OF SEEDS FOR CHALKY OR LIMESTONE SOILS.

Description.	Number of Pounds per Acre.	Price per Pound in England.	Total Cost.	Number of Seeds in Entire Quantity.	Per Cent. of Germinating Power.	Total Number of Germinating Seeds in the Entire Quantity.	Quantity required to make the Number of Germinating Seeds equal to the Number of Seeds required.	Total Cost of the same in England.	Total Number of Germinating Seeds.
		s. d.	£ s. d.				lb.	£ s. d.	
Cocksfoot	14	0 9	0 10 6	6,345,234	60	3,807,132	$23\frac{1}{3}$	0 17 6	6,345,234
Meadow fescue	2	0 6	0 1 0	467,060	60	280,236	$3\frac{1}{3}$	0 1 8	467,060
Timothy	3	0 $6\frac{1}{2}$	0 1 $7\frac{1}{2}$	2,438,853	90	2,194,967	$3\frac{1}{3}$	0 1 $9\frac{3}{4}$	2,438,853
Crested dog's-tail	5	2 0	0 10 0	3,428,875	60	2,057,325	$8\frac{1}{3}$	0 16 8	3,428,875
Hard fescue	4	0 6	0 2 0	1,614,624	60	968,772	$6\frac{2}{3}$	0 3 4	1,614,624
Sheep's fescue	4	0 10	0 3 4	1,614,624	60	968,772	$6\frac{2}{3}$	0 5 $6\frac{3}{4}$	1,614,624
Golden oat-grass	1	1 0	0 1 0	200,000	60	120,000	$1\frac{2}{3}$	0 1 3	200,000
Yarrow	2	3 0	0 6 0	7,000,000	40	2,800,000	5	0 15 0	7,000,000
White clover	1	0 11	0 0 11	656,511	100	656,511	1	0 0 11	656,511
Alsike	1	0 11	0 0 11	656,511	100	656,511	1	0 0 11	656,511
Perennial red clover	1	1 0	0 1 0	231,203	100	231,203	1	0 1 0	231,203
	38	..	1 18 $0\frac{1}{2}$	24,653,495	..	14,741,429	$61\frac{1}{3}$	3 5 $7\frac{1}{2}$	24,653,495

"Should I receive seeds possessing qualities that induce me to use them, but with germinating power lower than the average, I increase the quantity per acre in proportion to the ascertained deficiency: thus, if only 20 per cent. germinate in a seed which should give 60 per cent., I would employ 3lb. instead of 11b.

"I feel satisfied that, speaking generally, if the principles which I advocate and have practised are adopted, farmers will not encounter the disappointment which has been so universally experienced in laying down pastures, though the absence of annual plants will necessarily deprive the pastures of that verdant and vigorous growth in their first stages so much desired by seed-merchants, and so misleading to the public.

"In conclusion, I desire to add that it is far from my thoughts to imply that I have as yet learned all that I hope for on this very important and interesting subject; but I am firmly convinced that in deciding never to sow for permanent grass any but the purest seeds obtainable of the best permanent grasses I have taken an important step in the right direction. Could I have done this at the outset, I should have gained an incalculable amount of valuable time, and saved myself from the fruitless, I may say mischievous, expenditure of no inconsiderable amount of money."

Again, in the same Journal, Part II., No. xxxvi., Mr. Faunce-De Laune contributes "Additional Remarks on laying down Land to Permanent Pasture;" from which the following extracts are taken:—

"I have already urged the importance of obtaining each kind of seed separately, and of having each parcel of seed examined before sowing. I may add that, certain as my own experience had made me of this necessity, the communications I have received during the last three months have confirmed my opinion.

"Mixtures of grasses for permanent pastures have been brought before the notice of the Seed Committee of the Royal Agricultural Society, and examined by Mr. Carruthers, which had been purchased as containing the kinds and proportions of seeds recommended by me in the Society's Journal, and have been found to contain a large proportion of rye-grass, Yorkshire fog, and other worthless grasses.

* * * * *

"In my opinion landowners and farmers are to blame in

trusting to advertising firms without attempting themselves to acquire the knowledge requisite to enable them to discriminate between good and worthless seeds, or even to know, when the grasses come up, whether the seeds purchased were correct and of good quality. One result of this ignorance has been that some of the seed-merchants have not apparently been anxious to acquire a sufficient knowledge of the distinguishing characteristics of seeds and grasses, finding it more profitable to sell indiscriminately good and worthless kinds and inferior qualities.

"I have been much surprised to find that men who have spent the greater part of their lives in the seed-trade are practically unacquainted with many of its details. I have not met one seed-merchant who was able to show me the difference in the seed between rye-grass and meadow fescue. The difference may be very minute, but, when once known, is quite clear.

* * * * *

"Again, reverting to rye-grass, experience this summer (1882) has confirmed my opinion as to the absolute necessity of excluding it from all orders for seeds for permanent pasture. I do not wish to say that there may not be some value in rye-grass which is not contained in some other grasses, although I have not experienced any; but, on the contrary, I believe it has been the cause of much mischief: yet, as it is upheld by great authorities on grasses, I might not contest the advisability of ordering 1lb. or 2lb. per acre were it not that if any, however small quantity, is ordered, it at once opens the door to its being supplied in inordinate quantity mixed with other seeds; whilst, if none at all be ordered, it would be easy, when the grass comes up, to detect the quantity of rye-grass which may have been included by the seed-merchant.

"My observations lead me to believe that rye-grass is detrimental to the formation of a new pasture, not only because it is a short-lived grass, but because, owing to the shortness of its roots, it exhausts the surface of the soil; and, when it dies, the bare space left is so impoverished that, though grass-seeds may germinate upon it, they will fail to live unless manured by accident or on purpose.

* * * * *

"I have watched with care the formation of any new pastures, and have come to the conclusion there are many agencies

at work, and that it is a mistake to depend on any single agent.

"Allowing that this land is of fair quality, clean, and in moderate condition, and sown with seeds such as I have recommended, when first fed off with sheep it will be noticed that the plants are more or less detached, but as the year advances they increase in size, and the clovers send out their creeping stems and gradually unite the grasses together.

* * * * *

"I farm upwards of nine hundred acres, in which there is very good land, moderate land, poor chalky banks, and gravel; but no wet land. I have come to the conclusion, from my own experiments and the observations I have made in many parts of England, Scotland, and the Continent, that, in laying down to pasture on all lands, the selection should be made from the grasses I mentioned in my former article; and that, as on a violin all tunes must be played upon the limited number of strings in that instrument, so in laying down land to grass all pastures ought to be formed of this limited number of grasses.

* * * * *

"I wish especially to impress on my readers that the result of my experiments thus far has been that I have laid down to permanent pasture, without encountering the period of deterioration which has hitherto been the universal experience of farmers; but that, instead, my meadows have gone on from year to year improving and increasing in their productiveness for breeding and fattening purposes."

Mr. De Laune is not singular in his experiences of the difficulty of getting pure seed. There are in this colony a number of agriculturists who could tell the same tale, particularly of the adulteration of meadow-fescue seed by means of perennial rye-grass seed. There is great difficulty in distinguishing by the naked eye, and even by the magnifying glass, the seed of one species from the other, and hence the ease of the adulteration. The illustrations appended at the end of this chapter will give a good idea of the characteristics of the different seeds as they appear under a magnifying glass. It is easy enough to distinguish such seeds as the meadow foxtail, yellow oat-grass, crested dog's-tail, cocksfoot, sheep's fescue, and Yorkshire fog, by the naked eye, but not so easy to find distinguishing marks

between the seeds of meadow fescue and perennial rye-grass without the aid of a good microscope.

As it may not be generally known, it is well to mention here that in this colony all kinds of agricultural seeds can be practically tested and reported on at the School of Agriculture, Lincoln, Canterbury, and that any persons wishing to have seeds tested can communicate with the Director of the institution on the subject.

With regard to the best time for sowing permanent grasses, it was considered at one time that the spring was the most suitable, but the experience of practical farmers of late years has proved that it is best to sow grass-seed in the autumn, and by itself, as there is little doubt that it is, in most instances, an injury to both crops to sow grain and grass-seed together. The reason is obvious: the drought of summer kills the seed, and, even if the seed does germinate, the young plants have a great struggle for existence, for grass will suffer more from drought than from frost; but grass-seed when sown in autumn at the proper time will make sufficient growth to protect the roots from the frosts of winter, and in most cases furnish a fair bite in the latter end of spring to stock.

The artificial grasses of the leguminous order, such as the clovers, lucerne, and sainfoin, are, however, an exception to the above rule. They thrive best when sown in spring after the frosts have disappeared.

GRASS SEEDS, MAGNIFIED.

Fiorin, Creeping Bent.
AGROSTIS STOLONIFERA.

Sweet-scented Vernal.
ANTHOXANTHUM ODORATUM.

Yellow Oat-grass.
AVENA FLAVESCENS.

Tall Oat-grass.
ARRHENATHERUM AVENACEUM.

Meadow Foxtail.
ALOPECURUS PRATENSIS.

Crested Dogtail.
CYNOSURUS CRISTATUS.

Cocksfoot.
DACTYLIS GLOMERATA.

Meadow Fescue.
FESTUCA PRATENSIS.

GRASS SEEDS, MAGNIFIED.

Tall Fescue.
FESTUCA ELATIOR.

Hard Fescue.
FESTUCA DURIUSCULA.

Sheep's Fescue.
FESTUCA OVINA.

Perennial Rye-grass.
LOLIUM PERENNE.

Timothy Grass.
PHLEUM PRATENSE.

Rough-stalked Meadow Grass.
POA TRIVIALIS.

Yorkshire Fog.
HOLCUS LANATUS.

CHAPTER VIII.

GENERAL TREATMENT OF GRASS-LANDS.

In New Zealand there are four kinds of land which are sown with English grasses: firstly, bush-land, which, after the trees and scrub have been felled and burnt, is surface-sown, generally with one or two kinds of grasses, such as cocksfoot and perennial rye-grass, and sometimes, in addition, timothy and white clover; secondly, fern-land, which is burnt off, and sown in the same manner; thirdly, tussock-land, which is often treated in the same way as the last; and, fourthly, the two latter respectively, which, instead of being surface-sown with grass-seed, are burnt, ploughed, and harrowed, and then sown broadcast with turnip- or rape-seed, which is harrowed in, and the produce thereof is eaten off on the ground by sheep or cattle. This latter operation manures the land, and prepares it for the cultivation of grain-crops, of which successive ones are often taken, until the gradual diminution of production, from continuous cropping, warns the farmer that the land should have rest. It is such land that is generally cultivated for permanent pasture, and in the preparation of it for the reception of seed it will amply repay the farmer first to subdivide it into suitable paddocks, then to plough it twice, the second time not more than six inches deep, and harrow it thrice, twice with a tine-harrow and thirdly with a disc-harrow; and, if requiring manure, such portable manures as guano, bonedust, superphosphate of lime, or air-slaked quicklime, should be harrowed in in the second harrowing. When the seed is sown, it should be at once covered in with a tripod- or a chain-harrow, or, if either is not available, with a bush-harrow, the frame of which can be easily made by a handy man who knows how to use a saw and hammer. After the latter harrowing the ground should be thoroughly rolled with a weighty iron or wooden roller, so as to cause early

germination of the seed, and again when the plants are showing about one inch above the ground, to promote their tillering.

When the plants attain a growth of four or five inches they should be lightly eaten down by either sheep or young cattle, and the stock removed to a fresh paddock. The first one should then be looked over, and any places which seem bare of grass plants should be harrowed with a tripod-harrow, and the same kinds of seed as first used sown over them, after which it should be harrowed again with a chain- or bush-harrow to cover the fresh seed, as well as to spread the sheep or cattle droppings. It should then be shut up until it reaches a second growth of four or five inches, when stock can again be put on. This process should be systematically continued over the several paddocks in rotation for at least three years before they should be mown, if necessary to do so, for either hay or seed. In the two latter cases the aftermath, or second growth, should be only eaten down very lightly, and the same system of periodical rest pursued as already enjoined. No paddock, however, should be shut up for a hay or seed crop more than once in three years to avoid exhaustion. This should be easily managed by having a sufficient number of properly-fenced paddocks of size consistent with the extent of the farm and the quantity of stock it can profitably carry.

Many farmers may perhaps consider the above mode of dealing with grass-land too troublesome, overlooking the fact that the best grass-land will surely and rapidly deteriorate, and consequently become unprofitable, if not treated on rational principles. No grass-land should be eaten too bare, unless, as is sometimes done, for the extermination of docks or other vigorous weeds, when other remedies are not available; but as soon as such plants are nibbled close enough—and they often require several repetitions of that process to extirpate them—the stock should be removed, the bare places resown, the grass well chain- or bush-harrowed, and then shut up for a time until its turn should come round for being again grazed. This mode, however, of getting rid of weeds should not be resorted to if it can be helped, as the young grasses will suffer considerably from being too closely eaten down.

One great trouble with newly-laid-down grass-land particularly is the usurpation of weeds and useless grasses over the proper grasses.

The rampant perennial growth in the pastures and other cultivated lands in New Zealand of weeds, the seeds of which have been originally imported accidentally, renders their complete extirpation by no means an easy matter. That some weeds have in the economy of nature their uses—amongst others, as precursors of better herbage in uncultivated lands—there is no doubt, and they are therefore not an unmixed evil: nevertheless they take up the room of plants of a more profitable character, and interfere considerably with the operations of the farmer, unless, from the outset, he wages a continual war against them, which, in many cases, is completely neutralized by the weed-seeds blown on to his land off the lands of careless and indolent neighbours, who take no pains to adopt the same measures of extermination and prevention which he does. The thistle, which at one time was considered a serious pest, gradually dies out in a few years by either exhausting from the soil wherein it grows the elements of its nutrition or being choked out by the growth of vigorous grasses and clovers with which the soil is in greater affinity than with the thistle. Besides, when such plants have attained a close sward the thistle-seeds that may fall on it do not find a very receptive seed-bed in which to germinate. The dock, with its great tap-root, is the worst to annihilate, and, although it can be eaten down when young and gradually exterminated by crowding stock on the land which it affects, yet that mode of treatment should not be tried too often, for the reasons already given.

The common indigenous fern is likewise most difficult to destroy, notwithstanding repeated burnings, as well as crowding of stock on it to eat and also trample it down. The results of recent practical investigations of certain eminent agricultural chemists have, however, proved that the real battle of the meadow with weeds, as well as useless grasses—for instance, Yorkshire fog *(Holcus lanatus)*—must be fought with manures. The systematic experiments which Sir John B. Lawes and his assistants have carried on at Rothamsted Park "for more than twenty years in succession on the same land"* have demonstrated that "grass may be made of any character by manure

* See "The Philosophical Transactions of the Royal Society of London," Vol. 171, Part I., 1880; and Vol. 173, Part IV., 1882, entitled "Agricultural, Botanical, and Chemical Results of Experiments on the Mixed Herbage of Permanent Meadows."

alone," and that "to choke out weeds or non-nutritious grasses can be effected by the application of such manures as will not affect them except for destruction, but stimulate the good grasses to crowd them out."

Herein is an interesting field for the intelligent and observant agriculturist who has the capacity to acquire, and is endowed with the means and energy to apply, the knowledge he will gain by a study of the experiments referred to. With a fair practical knowledge of economic geology, botany, and agricultural chemistry he will be able to discern in a great measure the character of land from the herbage which grows thereon, and to judge therefrom what antidotes to use in the form of manures which will be destructive to weeds on the one hand while benefiting the grass, or any other crop which may be growing on the land, on the other.

As pertinent to the subject the following extract from the article on "Lime" in "Chambers's Encyclopædia" will explain what a powerful factor the proper application of that mineral is in agricultural operations, and especially its efficacy in the prevention or eradication of weeds: "Lime has been used for many centuries as a means of increasing the fertility of land. All crops require a certain amount, as is found by analysing the ash which remains after combustion. It is sometimes supplied, without previous preparation, in the form of marl and chalk; but in most cases it is first calcined, and reduced to a fine powder by slaking with water, or air-slaked by being mixed in the field with the soil. In Great Britain the quantity of calcined lime applied varies from three to eight tons to the acre. The smaller quantity may be sufficient for light land containing little vegetable matter, while the larger may be required for strong land, or for land holding much organic matter in an inert state. The large quantity of lime applied shows that its manurial effect is due more to its producing a certain chemical effect on the land than to its affording nutriment to the crops. Lime promotes the decomposition of all kinds of vegetable matter in the soil, and, further, it corrects any acidity in the organic matter, and thus destroys those weeds, such as cape- or hawk-weed, sorrel, docks, and fern, which are favoured by such a condition of the soil. It arrests the decomposition of certain salts whose bases form the food of plants, and in this way it may be said to digest or prepare their food. On certain kinds of land the finer

grasses do not thrive until the land has been limed, and in these cases its use becomes all-important. Lime is the only cure, too, that can be relied on for 'finger-and-toe' in turnips, and its use is, from this, becoming more general." In addition to turnips, the following are crops specially requiring a liberal supply of lime: Clover, peas, beans, vetches, and sainfoin. On land that has been properly limed clover-sickness is said to be less known than where this old practice has been neglected. In New Zealand, when lime cannot be procured, either because of its non-existence as a production, or being too dear in price, or expensive to transport, or both, bone-dust or superphosphate of lime should be used, particularly the latter, as, independent of being more economical, particularly from its portability, it is more quickly rendered effective by more rapid solubility than either lime or bone-dust.

After grass-land has been permanently established, the question is, how to maintain its productiveness, while, at the same time, it is grazed by stock. The idea once prevalent that pasture-lands are enriched by the animals which feed on them is a fallacy. For instance, milch cows do not return the essential elements of the plants they feed on to the soil in so large a proportion to what they take from it as some other animals. These elements are required in great quantities to form their milk, while in other animals they are required for bone and muscle. The manure made by cows is, therefore, less valuable and fertilizing than that of some other animals. The consequence is that lands fed wholly by cows are exhausted sooner than those fed by other animals; for it is evident that, where more is taken from the soil than is returned, exhaustion must follow.

Animal and vegetable matters are applied to the earth to supply it with substances which the growth of plants has taken from it. The constituent parts of a plant are taken up from the earth and the air, in somewhat the same manner as food and drink become, in beings or animals, bone and flesh. All applications for the improvement of the soil are nothing more than the supply of food for plants. For the food of plants is found in all manures, and the value of these depends upon the quantity they contain.

The methods of renovating meadow- and pasture-lands by means of top-dressings do not essentially differ. But the main

point to be observed is that, according to the nature of the soil, so should the top-dressing be of congenial materials; otherwise an application of a contrary kind might be inefficacious, if not detrimental. For instance, gravelly and sandy soils require mud and clay; peat or bog mud, after being exposed to sun, wind, or frost, to neutralize its acid properties, is a rich vegetable food, and, with a small proportion of potash or wood-ashes added, it is a valuable manure. Stiff clay soils, on the other hand, are benefited by applications in which sand, or marly light gravel, predominates, which makes them lighter and more permeable, so that they become disintegrated by the aëration which ensues, and are thereby rendered more capable of supplying nutrition to plant-life than in their primitive state. Lime and sand, however, should never go together in top-dressing, as with the first rain they would form a mortar. Neither should lime be applied to sandy soils for the same reason, besides being inapplicable as a manure. Lime acts best on peat and clay soils, and its addition to the compost-heap is of great value. It accelerates the decay of all vegetable substances; but it should not be applied direct to decaying or fermenting animal substances, unless covered by a thick coating of peat or clay to act as an absorbent. Whenever lime is used in a compost,—unless it be for hastening the fermentation of vegetable substances,—it should be mixed with salt, by dissolving the salt first in water and slaking the lime with it. A bushel of salt will thus prepare four bushels of lime. Refuse brine will answer very well. Lime should not, however, be applied to farmyard manure without being first mixed with peat, muck, clay, or charcoal.

There are many other substances which are valuable ingredients in top-dressing mixtures for pasture-lands, of which the principal are as follow: Gypsum, or sulphate of lime; the nitrates of soda and potash; superphosphate of lime made of ground bones mixed with sulphuric acid, or leached wood-ashes; fish and seaweed, where lands contiguous to the sea afford the opportunity of catching the one and gathering the other, but either, when caught or gathered, should be at once covered over with clay or peat to absorb and fix its chemical properties while in the state of fermentation that will ensue; guano, which should be mixed with loam; well-rotted dung; wood and all other ashes of a vegetable nature, also charcoal and coal-ashes.

In forming a compost-heap for top-dressing purposes the lower layer should be of loam or mud, and every suitable thing capable of fermentation should be added to it, particularly bones, refuse of slaughterhouses, dead animals, and farmyard dung, over each layer of which a mixture of lime and clay, mud, or peat, should be thickly spread, but, if lime is not easily available, then plenty of the latter substances, as absorbents. Weeds, leaves, useless grasses, moss, straw, vegetable and potato stalks, rushes, and other refuse substances of like nature should be formed into heaps, and covered in with clay or muck, then burned, and the ashes added to the compost-heap.

Surface irrigation where practicable is also a valuable means of improving grass-lands, but it is not so simple as many would suppose. It requires skill in first laying it out on a proper system so as to utilize the supply effectively, as well as practice in the regulation of its application according to the nature of the land it is intended to fertilize; otherwise the experiment may be a failure.

Proper drainage is likewise an important factor in the improvement of meadow- and pasture-lands, particularly of low wet lands: it increases their temperature several degrees, and admits the air to circulate more freely around the roots of the plants. The useless aquatic grasses and rushes which require large and constant supplies of moisture will cease to grow, and the soil being thus changed and improved will admit of more valuable species of grass being cultivated.

CHAPTER IX.

THE GRASS-SEED INDUSTRY.

The statistics of the colony show that in the years 1883, 1884, and 1885 the total imports and exports of grass-seeds were as follow:—

Imports.

	Bushels.	Value.
Year 1883	34,598	£49,628
„ 1884	47,450	70,993
„ 1885	89,462	91,915

Exports.

	Bushels.	Value.
Year 1883	113,917	£34,057
„ 1884	191,540	39,871
„ 1885	160,102	32,516

Although it does not follow from the above figures that the diminution in the exports of 1885 is a sign of diminished production,—for the contrary is the case, and it is only what is the surplus after providing for local requirements that can be available for export,—yet the returns of exports plainly show that, at any rate, the importation of grass- and clover-seeds is largely on the increase. Now, there is no reason why the same descriptions of seeds so imported, or any other agricultural seeds, should not be grown within the colony, and even to spare for exportation, the same as cocksfoot, ryegrass, and tall fescue, which form the bulk of the seed exports. The following article on "Agricultural Seeds," in the *Canterbury Times* of the 20th November, 1885, puts the matter very clearly and forcibly:—

"Agricultural Seeds.

"As a general thing we do not think that the farmers of this country are open to the reproach of indifference or carelessness in the purchase and selection of agricultural seeds. A good

many short-sighted ones there are, no doubt, who think that it saves money to buy cheap and inferior seeds, although, perhaps, in cases in which this mistake is made it more frequently arises from the want of cash than from any lack of knowledge of what is likely to pay best in the long-run. The nature and condition of the soil are, of course, the primary conditions in the production of a crop of any kind; but next to this comes the consideration of seed. The leading agricultural societies at Home have done much during the past few years in the way of protecting farmers from the tricks of the wily seedsman. In most trades there is probably a certain latitude of conscience allowed, but the tricks of the seed trade as practised by its less scrupulous representatives were found to be especially numerous, and so ingenious as to evade without difficulty the operation of the Seeds Adulteration Act. The practice established, however, by the Royal and other leading agricultural societies of insisting upon purity and a certain percentage of germination of the seeds, the sample to be guaranteed and subject to the examination of a disinterested expert, has done much more for the farmer than any special legislation upon the subject. The samples submitted for inspection to the botanist of the Royal Agricultural Society of England have shown a marked improvement in quality since the guarantee system was started.

"The great bulk of the imported seeds used in this colony are obtained from firms of seedsmen of the highest standing, and are therefore mostly of good quality. The agricultural interest undoubtedly owes much to the skill and enterprise of the leading seedsmen at Home, such as Sutton, Carter, Webb, and others. Most of the improved sorts of cereals, grasses, and roots are due to the skill of the seedsmen. We have lately met with an account of the seed-farms of Messrs. Webb and Sons. These farms include an area of 1,600 acres, and, according to the account we have read, are 'not only a huge trial-ground for producing the best from the best among the cereals and seeds which have been brought to such perfection by Messrs. Webb and Sons, but the scene of seed-raising on a large scale for trade purposes.' 'Turn where we will,' the writer goes on to say, 'admiration cannot weary among the grain, roots, clovers, grasses, &c., for the farm and the thousands of garden products with which the land is dotted over in a persistent attempt to perfect our various crops, and establish new and

improved varieties. The rows, plots, and beds in endless succession enable the firm to test their own products, and they are their own severest critics.' The 1,600 acres of which Messrs. Webb and Sons' seed-farms consist are, however, quite inadequate to supply the wants of their customers, and the firm employs a total of not less than 15,000 acres in different parts of the country for raising seeds from their own 'stock,' arrangements being made with farmers for the production being carried out under the most stringent conditions. Periodical inspection is made by trusted servants of the firm, and every precaution is taken to insure the purity and good quality of the seeds. Other leading firms of seedsmen, such as those whose names we have already mentioned, also conduct their operations on an immense scale, and with equal skill and care in regard to the purity of seeds and the improvement of varieties. Persons dealing direct with these great firms may depend upon getting what they order and pay for; but it is the host of smaller dealers scattered through the country who have been in the habit of practising upon the farmers, and especially upon those of the 'penny-wise and pound-foolish' sort.

"In this colony we annually import an immense quantity of agricultural seeds. As we have already said, most of these seeds come from the best firms, and therefore we have the satisfaction of knowing that, though the drain in money upon the country is considerable, it is spent in quarters where it is likely to secure the best value. It has become well known among English exporting firms that the colonies generally refuse to accept cheap rubbish, and that a market for inferior seeds is more easily found at Home than among colonial purchasers. It is a question of some importance, however, whether, in a country like this, we should not be in a position to produce the bulk of the seeds we use. Ryegrass and cocksfoot are the only grass-seeds quoted in our markets. All other grass-seeds, clover, and turnip seeds are imported, and yet we have all that is wanted in the way of climate and soil for the production of such agricultural seeds as we require. This surely is a local industry well worthy of attention. The production of agricultural seeds of good quality, though involving much skill and patient attention, is not an industry requiring an abundant supply of the cheapest labour. We are at no disadvantage in respect of soil and climate; technical knowledge may be acquired, or, if neces-

sary, imported; and, this being the case, it does seem that the fact of so much money going out of the country every year in the purchase of seeds must be attributed chiefly to want of enterprise, and to a characteristic tardiness in utilizing the resources of the country. Colonial seed-producers would be protected against the Home seedsmen by much more than distance and expense of carriage half round the globe, for there are many kinds of seeds which suffer on the voyage. The seeds of some artificial grasses, for instance, have a low germinating power under the most favourable circumstances, and the uncertainty of growth is much increased by the influence of sea-air and other conditions involved in transport. The leading English seedsmen have brought their business to so much perfection that it will probably be long before the colony will be able to dispense with their assistance; but that we should not be so largely dependent on them as we are at present is a matter that admits of no question. A new country begins of necessity by importing many commodities which require special skill in the production of them, and continues to import them from force of custom long after they should be included in the list of colonial industries."

CHAPTER X.

PARASITES AND PESTS OF THE GRASSES.

As there is a great lack of information on the parasitic plants and insect-pests that infest our pastures and forage-plants—which often, particularly the former, find their way there through the medium of the seed—the following description of a few of the worst of these enemies to agriculture should afford an interesting and useful study to the practical farmer.

"Parasite"—in botany—is a plant which lives on another. There are certain plants which are without the means of providing nutriment for themselves, or of elaborating the crude sap into proper juice, but obtain their nourishment immediately from the plants to which they attach themselves, and whose juices they absorb. Such plants are true Parasites. Of this species there are two especially, dodder and broom-rape, which attack the clovers. There is also another parasite, ergot—a fungus which grows on the ovary of rye-grass, cocksfoot, tall fescue, and rye-corn, as well as on some of the indigenous grasses of New Zealand, such as the toetoe-grass and the oat-grasses, particularly *Danthonia semi-annularis*.

Clover Dodder (*Cuscuta trifolii*).

Fig. 41.

This is a most destructive parasitical plant, the seeds of which are very difficult to detect, being so small and of an earthy-brown colour, resembling minute pieces of soil.

In season 1877–78 the seed-testing station in Switzerland found that 46 per cent. of the samples of red-clover seed submitted to them contained more or less of dodder. It is the most terrible enemy of the clover-plant. It is sown with the seed, and develops simultaneously; it winds its hair-like stems round the plant, and fixes itself on to it by means of suckers, which extract the sap from the plant. The roots, which the dodder possesses in the early stages of its growth, wither after awhile, and then the parasite is altogether dependent on the sap it draws from the clover-plant, in consequence of which the latter wastes and perishes. In appearance it resembles a number of fleshy threads twisted round a branch. It is like a large mass of yellow horse-hair shooting up through the clover and twining itself round every stalk of it. It commences in small patches all over the field, and gradually extends itself, destroying in its progress all vegetation, and leaving the whole area as black as if a fire had existed on the spot.

As the seed of dodder is, with the exception of white-clover seed, not much more than half the size of any other clover seed, it is easy to get rid of it by sifting.

When dodder appears, the only remedy is to dig up and for a considerable space around the spots where it appeared, and then to burn all the clover and dodder plants along with the pared soil. If it is allowed to mature and shed its seeds it may lie dormant in the soil for many years.

Clover dodder has unfortunately found its way to New Zealand, and has established itself in the Waikato district, Auckland, and also in Canterbury. There is besides an indigenous parasite of a similar character, which has been found in the bush in the Takaka district, Nelson.

Fig 41.

Clover-Dodder Seed, natural size and enlarged.

Clover Dodder.
CUSCUTA TRIFOLII.

Lesser and Greater Broom-rape.

(*Orobanche minor* and *Orobanche elatior*.)

Fig. 42.

These also attack clover, attaching themselves to the roots of the seedling clover, and drawing nourishment therefrom. The tall broom-rape sometimes has a stem as much as an inch and a half thick and a foot and a half high, and looks as much out of place growing on the clover stump as does the young cuckoo in the hedge-sparrow's nest. The qualities of this parasitic plant are powerfully astringent. When it has once established itself it can only be removed by hand-picking.

The broom-rape has also been found in the neighbourhood of Auckland, but it has not been observed to attach itself particularly to clover-plants: its special affinity in that district is the dandelion-plant.

Fig. 42.

LESSER BROOM RAPE.
OROBANCHE MINOR.

Ergot and Ergotism.

Fig. 43.

Ergot has been described as a monstrous condition of the grain, in which the enlarged and diseased ovary protrudes from the floret in a curved form, resembling a cock's spur (hence the name "ergot"—from the French—meaning a spur). This spur is of a blackish-brown shade outside, while internally it is whitish, and contains much oil. In this condition it is taken by animals in grass and hay; causing, when taken in sufficient quantities, abortion of in-calf cows that have arrived at a certain stage of pregnancy, and disease of a more or less acute character in other animals.

Ergot-spurs ripen with the grasses in the autumn and, falling to the ground, remain there during winter and spring—unchanged and unaffected by frost or rain. About the beginning of summer the ergot commences to develop minute fungi, which ripen in about five or six weeks, and discharge spores in every direction. Such of the spores as alight on the grasses when in flower attach themselves to the seed-case, cast the embryo seed from its position, and commence at once to grow as parasites. When ergot reaches its full growth in autumn it has a second stage of reproductiveness, giving off spores from its tip or snout in greater numbers than those which were developed from the fungi. Misty, foggy weather and light rains assist the propagation of the spores, but heavy rains are apt to wash them away. Dry, hilly pastures—without trees or hedges to prevent free currents of air — are not favourable to the growth of this parasite. In medicine, ergot is employed in modern practice to stimulate the motor nerve-centres which are connected with the womb, in order to cause active contraction when that organ has lost its muscular force. In large doses ergot is an acrid poison, causing dulness, vertigo, dilated pupils, intoxication, muscular tremblings, and tetanic spasm, especially in the hind-extremities, which afterwards become paralysed. Dry gangrene is a final result of the action of the poison; and by degrees the extremities, and even portions of the trunk, are rotted and fall off.

"Ergot," says Mr. Walker, in his book on "The Cow and Calf," "taken in such quantities as it is found in our grasses, acts as an excitant upon the womb of the pregnant cow, whereby the parts contract, and give the animal a desire to abort the calf. Its malignant influences are little dreamt of by the majority of graziers. Thousands of cows annually abort during wet seasons from eating the ergot grains among the grass and fodder. It is no imaginary evil, but has been proved by direct experiments instituted by men of undoubted veracity. It has been given to the mare, the cow, the ewe, and the cat, and has never failed to cause untimely birth when given in proper quantities, and when the animal had arrived at a certain stage of pregnancy."

In many cases it has been noticed that when a cow aborts in a herd many others follow suit. This is commonly ascribed to some infection or sympathy; but it is quite clear that many cases assigned to sympathy are really caused by the poisonous ergot. A case is mentioned in the *Field* where ergotism appeared amongst eighteen cows in a dairy. The animals' legs began to swell as high as the hock-joint, and in about a week the hoofs began to slough off. Some cases assumed a more severe form. The appetite failed, scab formed from the top of the hoof to above the fetlocks, and the parts below the line of the scab rotted off.

This subject is worthy of the most serious attention, for losses, one year with another, from abortion and other animal ailments incurred by ergot may be estimated at as much as is caused by foot-and-mouth disease.

Treatment of ergotism, as a matter of course, includes the removal of the animals from the place where ergot is found, or, in the case of ergotised fodder having been supplied, a change at once. Medical treatment, including the use of antiseptics and restoratives, will prove in some instances beneficial; but it is obvious that in this disease prevention is far more important than cure, and what is wanted is a determined effort to stamp out the pest. Meadow grasses should be cut before the period when the ergot-spurs develop on the flower-head. Special attention should be paid to the corners of fields, to places under the shade of trees, and to the banks of streams and ditches. It is in such situations, where coarse grasses grow, that ergot is most likely to be found, and care should be taken to cut down such grasses in good time to prevent the pest being propagated.

To destroy ergot the best course to pursue is to cut and collect the ergoted grasses and burn them; taking care that they are shaken and tossed about as little as possible, as the grains of ergot have only a slight hold on the seed-stalk, therefore are easily detached, and if allowed to drop off and remain on land each grain will serve as a centre for the propagation of the pest at a future time.

Fig. 43.

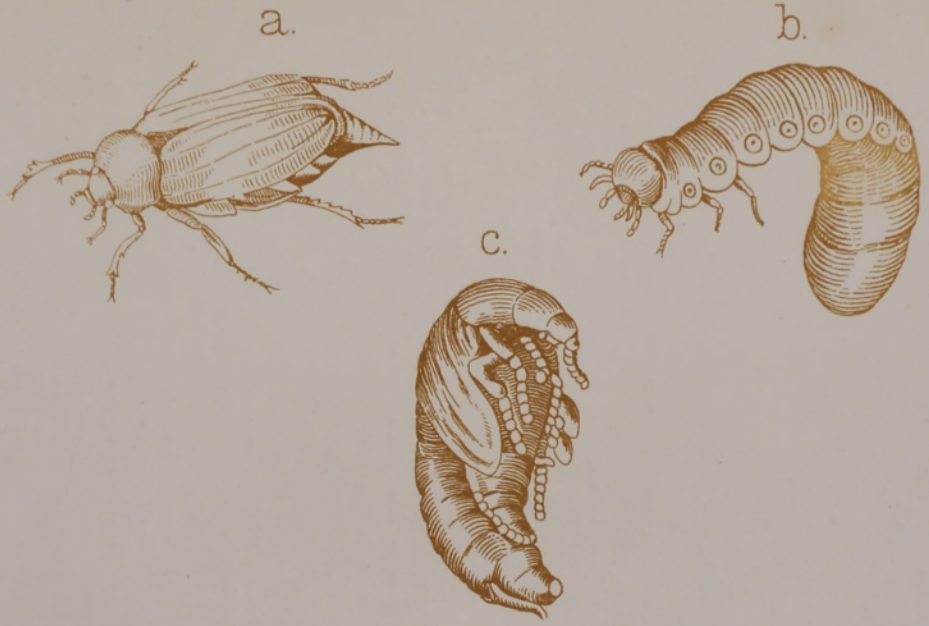
Head and Spike of Grasses showing Spurs of Ergot.

Insect-pests of the Grasses.

Fig. 44.

Of these the only one of a specially destructive character is the cockchafer (*Melolontha vulgaris*), a beetle of the family of Lamellicornes and section Phyllophagi (leaf-eaters). The cockchafer is fully an inch in length, of a pitchy-black colour, with a whitish down, giving a sort of powdered appearance; the sides of the abdomen marked by a range of triangular spots, the abdomen terminating in a point; the antennæ short, terminating in a club formed of six or seven leaflets; the grub is about an inch and a half long, thick, whitish, with a red head and six legs. The cockchafer does not live long after it has passed into its perfect state, but it lives nearly four years in the grub or larva state. The female cockchafer deposits her eggs in the earth. The whole grass of a field has often been destroyed in a short time by these grubs, and the beetles themselves strip off the foliage of trees like locusts. Rooks and other birds render great service by preventing the excessive multiplication of cockchafers; but it is a difficult matter to destroy the grub, from the depth (four inches) in which the insect deposits her eggs in the earth.

Fig. 44.



COCKCHAFER.
MELOLONTHA VULGARIS.

CHAPTER XI.

SILOS AND SILAGE.

These subjects, which have so largely engaged the attention of advanced agriculturists and agricultural chemists in Great Britain for some years, although somewhat beyond the original scope of this manual, are intimately connected with its object; and, from the increasing interest which is taken in them in the colony, the following information, composed of extracts from a work lately published, entitled "The Construction of Silos,"* will prove useful to those who may be desirous of adopting the process :—

"What is a silo, and what is silage?

"These are questions which may puzzle the majority of persons unconnected with agriculture, and a few years since would have been unsolved enigmas to most agriculturists as well. Of late, however, silage has been much talked of and written about—praised on the one hand and condemned on the other. The very names 'silos' and 'silage' have an air of mystery about them, their origin exciting the curiosity of pains-taking inquirers. Like most matters which have not previously been heard of or read about, we are told that silage is but an illustration of the old saying, 'There is nothing new under the sun,' for is it not written in Jeremiah, 'Slay not, for we have treasures in the field of wheat, and of barley, and of oil, and of honey'?

"But the reply to the questions, 'What is a silo, and what is silage?' may be summed up in a few words. A silo is a receptacle in which green crops, such as grass, clover, or vetches, are deposited as soon as cut, and preserved in a succulent state by means of compression, for use as cattle-food in winter; and

* "The Construction of Silos, and the Compression of Green Crops for Silage." By Thomas Potter, author of "Concrete, its Use for Building." London: B. T. Batsford, 52 High Holborn. 1886.

silage is the name given the material—no matter its original designation—appropriated to this purpose.

* * * * *

"The object of compression by weighting is to exclude—as much as possible—the atmosphere; and the theory set up is that the small amount of air capable of permeating the materials, containing a relative proportion of oxygen—the exciting agent in producing fermentation—has the power only of producing a ferment of so innocuous a character that the original nutritive and succulent character of the green crop is practically unaffected, no matter how long it may remain unused, conditionally, however, that the heavy pressure is maintained during the interval—that is to say, that the weight, or pressure, whatever it may be, is not removed from the time the crop is deposited in the silo till it is required for consumption.

"We gather from chemists like Dr. Voelcker that the silage itself may pass through various degrees or stages of fermentation; that when in the conditions of ferment which produce first lactic, then alcoholic, and subsequently acetic acid, the silage is in its best condition for cattle-food; but if it passes these stages, and putrescent fermentation sets in, it may possibly bring about injurious results to the stock which consume it, assuming it has not reached that stage of putrescence when cattle will altogether refuse it.

"The object aimed at, therefore, is how to produce silage in its best form of having undergone a process of fermentation, which is arrested when the acetic-acid stage is reached, or for sweet silage before arriving at that stage, and what are the means most likely to bring about the desirable result. A fairly air-tight and completely water-tight silo has been usually considered the first essential, and a certain amount of pressure an absolute necessity; but how much pressure is required, how best to produce that pressure, or even when to apply it, are questions which have given rise to many conflicting opinions."

There are numerous descriptions and sixty-two illustrations of different kinds of silos given in the book; but the simplest and most applicable form of silo for this country is described in Chapter XI.:—

"Silage-stacks and Means of Compression.

"The sequel to the introduction of silos and silage into this country has been the adoption, to some considerable extent, of

silage-stacks, which differ in no material way from their prototype—an ordinary haystack—except that the inevitable pressure is bound to be obtained in some form or other. The simplicity with which the green crop can be weighted in a silo with any kind of heavy materials that are nearest to hand, is not attainable when it is simply stacked; one portion may settle more than another, or the weights apparently have more effect on one side than on the opposite side, and the wind may be in the wrong direction to assist in counteracting this disposition, and so altogether it may happen that the weights will slide off, and the stack itself be disposed to heel over.

"Mr. Johnson, of Oakwood Croft, Darlington, who was about one of the first in this country to practise making silage by mechanical pressure, was also one of the first to experiment with silage-stacks, and, as usual with pioneers in new undertakings, met with variable success and some difficulties. Mr. Johnson gives his experience thus: 'I began making silage-stacks in 1884, and in that year put up three for myself and one for a friend. The first of the three was intended to have been pressed by mechanical pressure, but the mechanism failed, and the fodder had to be saved by using stones as dead weights; the second stack, which was fifteen feet square and contained about seventy tons, was also weighted by stones on a covering of boards, then straw laid on the stones, and afterwards the stack thatched in the usual way. Unfortunately it took to heeling over, and many of the stones rolled off, the stack itself nearly going over through the force of the wind, which caused unequal settling; but the silage turned out well, although I could clearly foresee that without mechanical pressure in some shape or other it would be impossible to build a stack high enough—without considerable risk of its tumbling down—to make the game worth the candle. Moreover, the stack must inevitably finish with a flat top for the purpose of accommodating the dead weights, and have to be made up with straw, and thatched so as to allow the water to run off, all of which is troublesome and costly. So I set to work to scheme some system of mechanical pressure that might permit a rounded or pointed top being made (with the ultimate result as hereafter described), and myself and others have found that, with proper means at disposal for weighting, silage-stacks are a decided success.'

"In 1885 Mr. Johnson put up a stack of one hundred and thirty tons of first-crop winter-sown tares and meadow-grass, and this gained the prize offered by the Royal Agricultural Society for silage-stacks. Mr. Johnson's experience will no doubt fairly represent that of others. The main difficulty is keeping the stack from heeling over, unless the weight or system of pressure which may be adopted is controlled, and, as will be seen, in all but one of the appliances hitherto adopted this control is gained by literally tying the stack to the ground, or to the wood base or platform upon which it is laid. Practically, therefore, the disputation with regard to dead weights and mechanical pressure, which has troubled the minds of those who intended making silage in a silo, does not enter into the question when stacked; but mechanical pressure appears to be all but absolutely necessary, except the stack be very small and low in proportion.

"As might be expected, there are many who look upon silage-stacks as the best system to adopt, while others maintain that a properly-constructed silo prevents all the difficulties pertaining to stacking. The advocates of the latter system say that as keeping air out of the green crop is the prime factor in making good silage—and which is all but generally acknowledged—it is self-evident that, let the pressure be never so effective, a certain amount of waste to all exposed sides of a silage-stack is inevitable, and to this assertion there is practically no denial, but which those who are in favour of stacks maintain is much less in value than the interest would amount to on the capital expenditure in building a silo. Here, however, much depends upon circumstances, for, assuming the waste to be six inches all round a stack measuring ten feet each way (Mr. Johnson puts it at six to nine inches), there would be nineteen cubic feet of waste on every foot in height of the stack, the contents being one hundred cubic feet for every foot in height, or nearly 20 per cent. of loss, whereas in a stack measuring twenty feet each way, with the same depth of waste all round (six inches), the loss would be only 8½ per cent.

"Mr. Blunt, of Blaby Hill, Leicester, gives the waste on silage-stacks, the result of his own experience, as follows:—No. 1 stack, eighteen feet long by sixteen feet wide; average waste at sides, six inches; taking the weight of the outside at one-half of that of the bulk, the proportion of loss was 6 per

cent. No. 2 stack, a round one, sixteen feet in diameter; average waste at sides, nine inches; proportion of loss, 9½ per cent. No. 3 stack, a round one ten feet in diameter; average waste at sides, three inches; proportion of loss, 5 per cent. With these data Mr. Blunt calculates 5 per cent. as the average loss of silage when stacked. To lessen the waste, the outsides of stacks have in some instances been treated with a dressing of salt and other preservatives.

"The formula of Mr. Hunt, of Brentry Farm, Westbury-on-Trym, is as follows: 17cwt. salt, 56 pounds fenugreek, 2½cwt. raw sugar, mixed so as to form a paste capable of being applied with a brush; but it is necessary to say that this prescription has been patented, and can therefore only be applied by permission of Mr. Hunt, or the composition obtained from him. A mixture somewhat similar is also supplied by Mr. Tucker, of Banbury.

"In favour of stacking there is a further set-off in the value of the outsides as a rough bedding material for live stock, and in the fact that, owing to the outsides being at the extreme edge of the pressing arrangements, the percentage of loss by weight would be much less (Mr. Blunt, as will be seen, puts it at one-half) than the percentage of loss by bulk if weight was the factor in the calculation. There is the question also of the top of the stack being exposed to the elements. By Mr. Johnson's system of making it a span-roof shape, similar to a haystack, it is asserted the materials get consolidated sufficiently to turn off the rain without injuring the silage during construction, and on completion the stack is thatched over the wire ropes in the same way as an ordinary haystack. Where other systems of compression, necessitating a flat top, are practised, it is usual to place a layer of roofing-felt or Willesden paper beneath the cover platform, or (more costly but more effectual) corrugated galvanized sheets laid over the platform, giving them a slight tilt to turn off the water, and depositing some weighty material thereon to prevent the wind from carrying them away.

"Mr. Blunt recommends the placing some waste dry litter on the platform, bringing it up to a peak shape, and thatching the stack in the ordinary way; the item of thatching, however, is one which, when the stack is made in the open, is against stacking and in favour of silos, for we get a direct expenditure that would—adding together the value of straw and labour—make a

serious hole in the annual interest on capital outlay upon a silo capable of holding the silage-stack; probably the increased value of straw which will inevitably follow a decreasing area of corn crops, will lead to the necessity of adopting galvanized iron as a roofing material for both hay- and silage-stacks. But the advantages of silage-stacks over silos will be judged from other standpoints than the one only of comparative cost. On outlying portions of large farms, and rough land, where it would be injudicious to erect a silo, but where silage could be occasionally made and consumed, it would probably be sound policy to make a stack in preference to building a silo; or, as was instanced in the *Field*, 'a farmer may have a crop of grass cut with the intention of making it into hay, but wet weather intervenes and prevents his carrying out this intention. He may possess no silo, or his silos may be full, and if the grass lies on the ground many days its value will be very greatly deteriorated, if not rendered practically worthless. He cannot construct a silo at an hour's notice, but he may build a stack of wet grass instead of dry hay, and the very wetness would enable him to dispense with weights or apparatus to a greater extent than he otherwise could do.' Silage made under a roof and between enclosing walls appears to be the most convenient and handiest in a general way for small and medium-size holdings, and where the silage is always consumed at the farmstead; but time and experience with regard to both systems, to enable their advantages and disadvantages to be put in the scales, is absolutely necessary; and this must be done by unprejudiced practitioners, under equal conditions, with the same kind of green crops, and the results carefully noted. Very many decided expressions of opinion as to the relative merits of silos and stacks are given by persons who have only adopted one or other; and so with compressive appliances: witnesses have intimated that dead weights are the best system of compression, or *vice versâ*, and when questioned affirmed they had tried no alternative method. Undoubtedly the opinion of Mr. Johnson, of Croft, who has for several years given both stacks and silos an impartial trial, and now pronounces in favour of the former, must carry great weight. The main factors upon which Mr. Johnson bases his decision are these:—

"1. The first cost is less.

"2. It is easier to make sweet silage in stacks than in silos,

for it has been found, as a rule, that if the crop is cut while still succulent (not at all over-ripe), as much stacked each day as can be conveniently carried, the pressure applied each night, and the stacking continued each day without intermission, just the right degree of heat is reached which makes the best sweet silage, and without the need of any thermometer or the exercise of any special skill or judgment. With silos the filling must be delayed by intervals of one or more days to allow the heat to rise, and this is both troublesome and uncertain.

"3. Stacks are more elastic as to quantity than silos, as the size of the crop may be suited by varying the width of the stack, and there is, comparatively speaking, no restriction as to height.

"4. The stack-press gear is portable, so that the crop may be stacked in whatever field it is grown, or at the place where it is intended it shall be consumed.* It is usually affirmed by advocates for stacks, and accepted without protest by advocates for silos, that there must always be from 2 to 5 per cent. waste of silage when made in a silo, arising from contact with the walls; but, as before stated, if the walls are dry and fairly waterproof, which newly-built silos cannot be any more than newly-built houses till time is allowed for the water used in construction to exude, it would appear difficult to discover the reason for any waste whatever. There are many persons who have found no waste in their silos, and if the latter are seasoned there would probably never be any, assuming, of course, that proper care was exercised in other respects. And if early spring and late autumn crops were ensiled, an arrangement which has of late been advocated, to enable silos to do double duty, this will be a point in their favour, as they would not be out of use during the summer months, as many are at present.

"Mr. E. T. Blunt gives, as the result of considerable experience in making silage-stacks, the following information in connection therewith :—

"First, to estimate a crop for silage. A crop of grass or clover sufficient to make one ton of hay will yield four to five tons of silage. Stacks may be built of various shapes and sizes; one twenty feet long and fifteen feet wide is a very convenient size, and will contain six tons of silage for every foot in height.† A sound and level piece of ground should be

* Several of the silo compressive arrangements are also portable.

† Fifty pounds per cubic foot would show seven tons of silage nearly for every foot in height.

chosen to build the stack upon; and if in such a position that the carts can be drawn up on both sides for unloading so much the better; and no artificial bottom should be used. It is of the utmost importance that the sides should be kept considerably higher than the middle, the sides trampled as *much*, and the middle as *little*, as possible; if this is done, there will not be much danger of the sides slipping or bulging; but, till the men get used to building the stack, or at any time during the stacking, it can be prevented by placing a few boards upright at intervals of four or five feet round the stack, and binding them with a wagon-rope for a few days. Should it be found, when the weight is applied, that the sides are sinking more than the middle, it will be better to at once remove the covering-boards, and raise the sides by silage taken from the middle; otherwise there would be a large proportion of waste or damaged silage at the sides.

"To make sour silage, the crop should be in a succulent or even wet state, and the stack built up as quickly and pressed as soon as possible.

"To make sweet silage, the crop should not be in too succulent a condition, and the stack should be built up slowly, not more than five or six feet in a day; and should it be found convenient to miss two or three days between one stacking and another, no damage will be caused to the silage; but not more than four days should elapse between each stacking, unless the pressure is applied, and this can be removed and replaced if it is desired to add to the stack at any time afterwards. Before putting the pressure on, it should be seen that the sides of the stack are level all round and fairly solid, and from one to two feet higher than the middle. When the stack is not under a hay-barn or other permanent roof, it must be protected while being built from heavy rain by a temporary covering, such as a rick-sheet, &c. After the last stacking, and the pressure is properly performed, a roof may be made of straw, and thatched in the ordinary way.

"Grasses and clovers cannot well be cut too young, and may be stacked at any time or in any weather; but tares or vetches, and similar succulent crops, must not be stacked wet. These latter should certainly be made into sweet silage, and, to insure this, should not be cut till they are in pod.

"Fig. 45 is a side and end elevation of a stack under compression by Mr. Johnson's system; Fig. 46 is a sketch to a larger scale of a crutch and cross-head to which the ratchet and lacing-ropes are attached; and Fig. 47 is a perspective view of the stack which gained the prize of £25 offered by the Royal Agricultural Society in 1885.

"The method of obtaining pressure is this: A flexible galvanized-wire rope, having a loop at one end, is looped on to a crutch at one end of one of the cross-heads, which move loosely up and down on ratchet-bars made fast to logs of wood, held down by the weight of the stack resting upon them. The wire rope is then passed over the top of the stack and hitched on to a corresponding crutch at the other side, and, returning at short intervals, is laced over the whole series of crutches on all the cross-heads in one continuous length of rope, and is then made fast by hitching it round the last crutch, thus forming a wire-rope saddle over the stack. The cross-heads are then tightened down by working the lever, which has pivoted on its end a pawl, which engages with the teeth of the ratchet-bar. Another pawl attached to the cross-head also engages with the teeth of the ratchet-bar, and so holds good the cross-head in the position it has reached until the next stroke of the lever and pawl presses it down another tooth on the ratchet-bar. The wire-rope saddle is thus drawn down until the stack has been sufficiently pressed. The reel shown at the side of the stack is not for tightening, but merely for winding the rope on.

"The length of leverage is adjusted so that every stroke of the lever moves the cross-head down three-quarters of an inch, and a man pressing with a force equal to 112lb. puts a strain of three tons on each cross-head, and therefore a stack sixteen feet wide has a pressure of 200lb. per square foot.

"The logs of wood to which the ratchet-bars are fastened may be round, flat, or square, and should be not less than eight inches in diameter, and placed four feet apart from centre to centre. A rough plank, hurdle, or timber bottom, such as usually forms the base for a haystack, should be placed across the logs to give better hold of the mass. A platform of boards, placed on a pair of tressels about thirteen feet in height from the ground, is desirable, so that after the stack has attained a certain height the grass may be forked from the cart on to the platform, and thence on to the stack: this provision enables

the stack to be carried twenty-two or twenty-three feet high to the eaves before settling.

"The following is the list of prices for Mr. Johnson's appliances :—

	£	s.	d.
"30-ton stacks, 11ft. square by 11ft. high to the eaves when settled, including 3 pairs of cross-heads, with ratchet-bars and ring-bolt to attach to timber, 1 lever and pawl, wire-rope and reel to wind it on ...	12	0	0
75-ton stacks, 15ft. square by 15ft. high to the eaves when settled, including 4 pairs of cross-heads, with ratchet-bars and ring-bolt to attach to timber, 2 levers and pawls, wire-rope and reel to wind it on ...	15	0	0
100-ton stacks, 19ft. long by 16ft. wide by 15ft. high to the eaves, including 5 pairs of cross-heads, with ratchet-bar and ring-bolt to attach to timber, 2 levers and pawls, wire-rope and reel to wind it on ...	18	0	0
For larger stacks the length may be increased, but not the width; otherwise the pressure will be reduced. Each extra pair of cross-heads, with ratchet-bar and ring-bolt, and requisite extra length of wire-rope, giving 4ft. extra length of stack and 20 tons additional ensilage	3	10	0

(*These prices are for net cash on rail at Darlington.*)

"It becomes a question as to what Mr. Johnson's patent covers in connection with this system, and it is therefore as well to add that the claim is, 'The sole right to use ropes, or other flexible bands, with or without the interposition of longitudinal poles or bars, over the rounded or peaked top of silage-stacks, with the object of obtaining pressure.' Some patentees and practitioners recommend the paring of the sides of the stacks, and throwing the cuttings on the top so as not to waste any portion of the green crop. Mr. Johnson recommends raking the sides and ends as the stack is being built.

"It is advisable to prop the stack occasionally, in case the heat generated by the green crop may give it a tendency to heel before the pressure can be applied.

* * * * *

"But besides the systems described for producing mechanical pressure, both for silos and silage-stacks, several others have been tried, and more, no doubt, will eventually be introduced and represented as the best hitherto devised. The 'survival of the fittest,' in this as in other things, will reduce the number in common use to a minimum, and the simplest and best remain

at last free from that endless competition which a new want seems to bring about. Whether lever-pressure, or the application of screws, which appear to be the primary means of successful compression, either pure and simple, or in combination with cog-wheels, winches, springs, and other mechanical auxiliaries, will come to the front, cannot at present be decided; and until the best-known systems are tried in fair and open competition, and judged upon their merits, it would be invidious to proclaim this, that, or the other arrangement as the only reliable compressive appliances. Advocates for different methods of compression will eventually come to recognize the advantages possessed by certain systems over others, and the least popular will have to give way in favour of those which have stood the test without failure, and assisted in producing the most satisfactory results with the least trouble and cost. If the success attending the introduction of silage as a cattle-food makes the same progress in public favour during the next three years that it has done during the past three years, and silos, silage-stacks, and mechanical compressive appliances for producing silage come into general use, we shall before long undoubtedly have solved some of the knotty points in connection with these subjects.

"As a fitting conclusion to a subject full of interest to every one connected with the cultivation of the land, and as reliable testimony of an impartial character gained by three years' careful observations and experiments, free from any tinge of bias, the following notes by Mr. Johnson may be of service.

"Best Kinds of Silage.

"Sweet silage is better than sour, because chemical analysis shows that if not overheated (about which there is no difficulty) more of the valuable ingredients of the fodder are preserved than is the case with sour.

"(Dr. Voelcker, in his evidence before the Ensilage Commission in March, 1886, stated that the valuable properties of the fodder are more completely secured in sweet silage than in sour, if the overheating was prevented.)

"Cattle invariably take to it immediately, whereas with sour silage some animals require to get used to it before freely feeding thereon.

"Dairy produce is never tainted by the use of sweet silage, not even when the stock are fed upon nothing else.

"Dairy stock will do well upon sweet silage if fed entirely upon it, without the use of cake, meal, or any other food.

"There is little or no smell arising from sweet silage.

"Desirable Crops for Silage.

"Meadow-grass seeds, and clover (first and second crop), tares, trifolium, sainfoin, maize, lucerne, grain crops cut when just in ear, but still succulent in stalk, and sprets (*Juncus articulatus*), or the coarse grass growing on moors and hill farms, oftentimes on account of the lateness of the season and autumnal rains difficult to secure as hay.

"For arable land a most valuable crop is a mixture of tares, beans, peas, and oats, cut when podded and in ear, but when the stalk is still succulent (if winter-sown), and this yields the best crop; wheat or rye may be substituted in climates where oats do not stand well over the winter, care being taken to cut the rye before it is over-ripe and has therefrom lost the succulence of stalk which is absolutely necessary for perfect success. In most places the rye ripens earlier than the tares and beans, and, although convenient for the purpose of keeping the tares off the ground, it should be used in small proportion.

"In some places a catch crop may be secured for making silage after winter-sown tares, as maize, buckwheat, &c., or white turnips and cow-cabbages.

"Silage by itself seems to take the place of roots, and hay or straw with grain or cake combined, and which, when wheat could be grown to pay, was all very well as a means of utilizing the straw, but is far too costly at the present time.

"Diet recommended.

"Three seasons' practical experience gives the following results:—

"Milch cows do well on sweet silage alone *ad lib.* Large-sized cows consume about 18cwt. per month, or nearly 70lb. per day, and require no cake, meal, or other food of any description. Variety and change may be obtained by giving different kinds of ensiled fodder, either mixed or in succession at different meals.

"For fattening stock, sweet silage alone is a complete and successful substitute for roots and hay or straw combined, but,

for forcing, cake or meal should in addition be given, just as is done in ordinary practice with roots, &c."

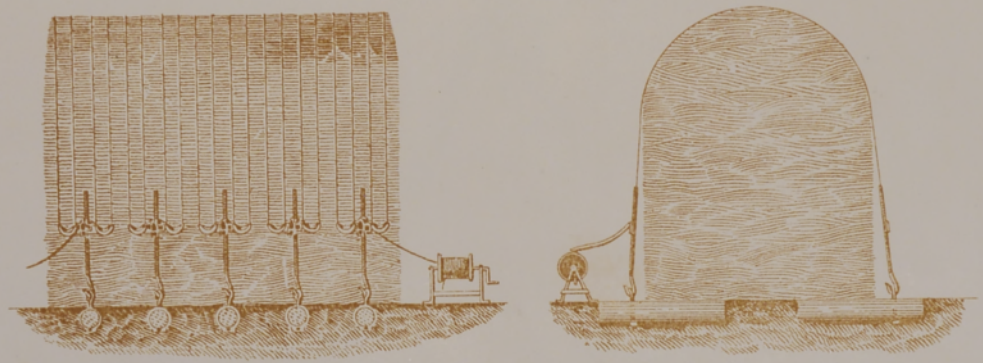
The following clipping from the *Canterbury Times* of the 17th June, 1887, contains further valuable information on the subject :—

"SILAGE VERSUS DRY FODDER.

"In green succulent foods the cellular tissues have not been converted into woody fibre, and in mastication and digestion all of the nutritive substances in these cells are quickly acted upon by the saliva of the mouth and then the gastric juices of the stomach, and all the nutriment is assimilated with only a minimum expenditure of force by the animal economy to digest it. The natural moisture of the plants when green also acts as a compensation, and requires but little besides the gastric juice to make the food fluid enough for digestion. With dry food nature is heavily taxed at all points to make good the loss of the juices or moisture of the food. The secretions of the mouth are called upon to moisten the dry food. The woody fibre of the plants must be broken down and disintegrated by the power of gastric force to set free the real nutriment of the food. This force is several times greater than is necessary when succulent food is fed. All this extra expenditure of force must be supplied by the animal, and therefore calls for an increased amount of food to make good this demand, or else the animal falls off in flesh. In ensilage there may be a slight loss in the carbo-hydrate elements, and a gain is made in protein, and increased digestibility of the rest, which gives feeding value to what has often been termed the water in ensilage. It is not only easily digested, but also helps to digest other richer foods, including grain; and, thus adding the natural juices of plants to the mixed ration, aids nature to assimilate them without calling upon the digestive economy of the animal to do all the work. In the other cases all this matter is dried down to a hard condition, and must have water to re-absorb it, freshen it up, and dissolve it, which requires a good deal of time and a good deal of extra force. If you take an apple you will find the nutriment all in a soluble condition, and when you take it into the stomach it is ready to go into the circulation at once. If you dry that apple all the nutriment becomes like raw hide, and it must be soaked up, and when you have done that you have changed its condition; you can never get it back in the same

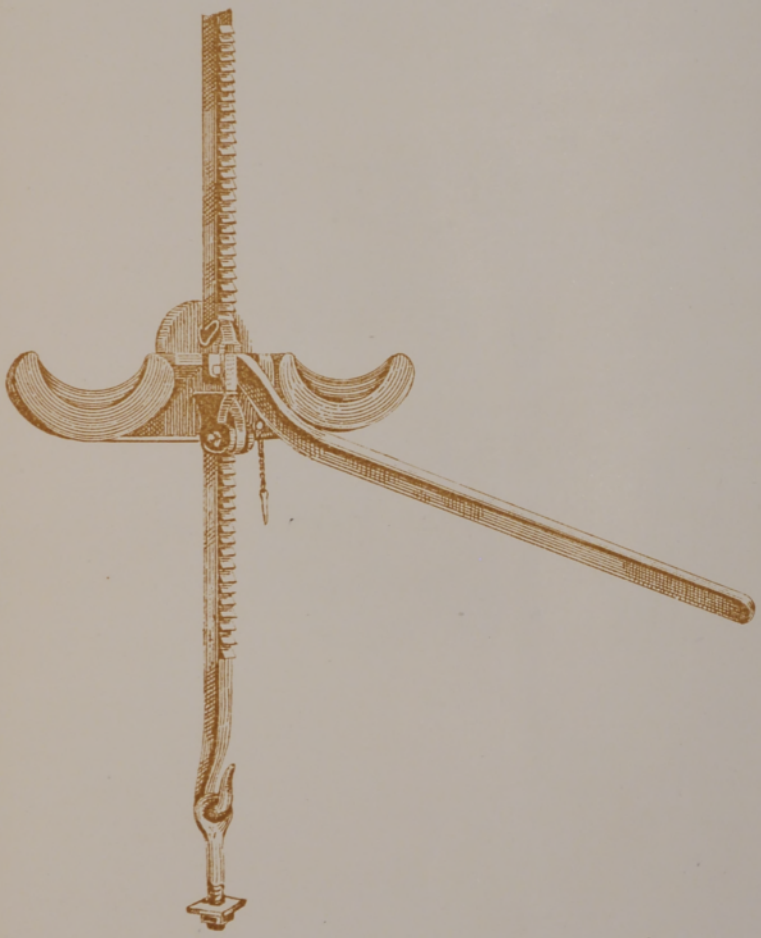
condition it was before the drying was done, and it takes more energy and force to digest that dry food than in its green state. That is the pith of the whole matter. The nutriment or the sugar in dry food is not necessarily changed by the evaporation of the water, but it is simply breaking the chemical union of the water with the rest of the compound, and that chemical union has got to be restored by energies of the stomach, which makes extra work, and makes it slow. In feeding a cow you want to give her what she can eat in a given time. A dry feed may contain as much nutriment, but you cannot get as much out of it, because it takes so long to do it that the animal has got to support itself while it is being digested. The point is simply this: that in the green stage the albumen and other matter is, to a large extent, already in solution in a condition in which, when it is separated from the fibrous matter, it can be taken right into the circulation and appropriated. In wetting or steaming fodder it will help considerably, but not overcome the change which the feed undergoes in the desiccation and soaking-up again.—Professor Arnold."

Fig. 45.



JOHNSON'S SILAGE-STACK PRESS.

Fig. 46.



JOHNSON'S SILAGE-STACK PRESS.
DETAIL.

Fig. 47.

R.A.S.E. Prize Silage Stack.

APPENDIX.

ON THE TURNIP CROP IN CANTERBURY.

By W. E. Ivey, M.R.A.C., F.I.C., F.C.S., Director, and G. Gray, F.C.S., Lecturer on Chemistry, School of Agriculture, Lincoln.

In this part of New Zealand the turnip-crop should be the mainstay of the farmer for winter feed, although the climate, from its comparative dryness, may not be so favourable for roots as that of some other parts of the colony. With proper cultivation there would appear, however, to be but little difficulty in securing a crop, as, even though the season may be a dry one, there are, as a rule, periods during which there falls sufficient moisture to insure germination of the seed and to tide the young plant over the first few days of its growth, and until its roots have penetrated deeply enough to obtain a supply of moisture from below. But in order to secure the benefit of these moist periods, and to insure that after germination of the seed the young plant shall have the best chance of flourishing, it is absolutely necessary that the land be thoroughly well cultivated. A good tilth is the first consideration in the growth of turnips, and without it—unless the season be exceptionally wet—the attempt to grow a good crop of this root will probably prove a failure. That the crop often does fail on a single furrow out of grass is generally due to the fact that the land is rough, harsh, and altogether unsuited for the reception of a small seed like that of the turnip, or for the delicate rootlet of the tender plant. When land has been down in grass for some years the particles of soil tend to aggregate into lumps,—in a virgin soil this is especially noticeable,—and no amount of working will bring land in this state into a good tilth; it must be exposed to weather action. There is always also more or less acidity in such soils, which militates against the success of such a crop as the turnip.

Considering that the turnip-crop is really the basis of all good farming in similar climates to ours, as distinguished from "cropping" or "stripping," better attention than it too often gets is certainly its due. Too frequently land is broken up during the dry spring, worked down, the seed sown broadcast, the only chance of a crop depending upon a succession of wet days. This method is cheap, and sometimes a fair crop is grown, but more likely—unless the land be exceptionally well suited—two or three sowings may have to be made, not even always then resulting in a crop. The exigencies of their position no doubt at times force farmers into these rough-and-ready modes, and where land is of small value, being, perhaps, not of good quality and distant from the market, it is hard to recognise the advisability of expending upon the turnip-crop an amount of money largely proportionate to the value of the land. But on valuable land the loss of the turnip-crop is a serious matter; it means little winter feed for stock, and therefore a lessened number throughout the year, and from lessened sheep dressing a smaller yield of grain and grasses. Therefore no steps should be omitted which would tend to success in raising this crop, above all others. On those lands where large rents or heavy interest must be paid, the soil must not be idle. It becomes a vital question whether we should not, by the best cultivation, and, where necessary, by the use of suitable manures, aim at growing as heavy crops of roots as possible. With grain at even very moderate prices I feel sure that this is the most profitable course, and, even if we decide to grow almost exclusively live stock, there can be but little doubt but that a certain number of acres in turnips will, by providing feed, enable the farmer to carry throughout the year a much greater number of stock than he otherwise could, whilst a succeeding crop of spring corn and a following clover-hay crop would furnish him with dry food so necessary for sheep when on turnips.

The best time to take a turnip-crop is undoubtedly after a grain-crop. The land should be ploughed as soon as the autumn wheat-sowing is finished, and allowed to lie exposed to atmospheric influences until spring work is completed, when it may be crossed and worked down, it then falling, or crumbling, down before the implements, and we obtain that most desirable condition, a good tilth, suitable for the reception of the small seed, and for the support and nourishment of the young plant. Where the climate is dry it is very important that the soil should be thus thoroughly and naturally pulverised by atmospheric action, so that a supply of moisture be obtained from below, and that the conditions necessary for the rising of that supply—which were broken by the plough—be as thoroughly restored as possible, and as quickly as may be.

Water rises in soil by capillary attraction, the capillary or hair-like tubes being here represented by the interstices between the particles of soil, which may be taken to be very irregular tubes; and, as the finer the tube the higher the water will rise in it, so the finer the particles of soil the smaller the interstices between them; the finer the irregular tubes the higher will the water rise in the soil. Therefore it is desirable that the soil should be friable throughout the thickness of the furrow-slice, and worked into a uniform condition to that depth, so that there should be no greater break than can be avoided between the cultivated soil and the uncultivated subsoil, that there should be as little breach of continuity as may be between the two, so that the water of the subsoil may rise as high as possible into the soil.

Land in such a condition retains moisture, and affords a better supply to the young plant than where it has been ploughed late in spring, is too hard and harsh to break down, and lies so roughly as to allow of the penetration of hot drying winds. Compare land properly prepared with that broken up out of grass—especially if the land has been down for several years. In the latter case it is ploughed late in spring, so as to secure the use of the grass land as late as possible for lambing ewes or other stock; it breaks up roughly, and soon bakes more or less in the sun, however soon it may be worked down. The face of the sod is turned down and forms an effective barrier to the continuity of the surface soil with the subsoil, and not only prevents the rising of moisture, but, on shrinking, serves to allow of the circulation of dry air from above. Implements seldom or never penetrate to the full depth of the furrow-slice, the whole surface is never thoroughly broken, and the whole thickness is, except perhaps on sandy lands, more or less rough, harsh, and lumpy throughout, and is, as already pointed out, utterly unfitted for the reception of the small turnip-seed, which, under these conditions, can only in a wet season grow and produce a crop. Should there fall even a sufficiency of rain to germinate the seed, unless rain falls at short intervals the shrinking of the soil aggravates its lumpy condition, increasing the width of the fissures between the lumps, allowing the passage of dry air, and either the plant dies, or is more or less starved by death of roots.

The objections raised to taking roots after grain are that the land is too long idle, is weedy, and requires more labour than if the turnips were taken after grass. The first objection will not bear examination, for the stubble would be ploughed for a second grain-crop if not for turnips, and there would on the other hand be a positive loss of grass by ploughing lea land in spring. Croppers might raise the second objection especially in the case of sorrel after several grain-crops, and the third would follow; but in properly stocked and cropped land sorrel would have obtained no hold after the first grain-crop, whilst for the destruction of annual weeds, or the fast-increasing twitch, no better opportunity offers than during the cultivation which takes place during the hot months of early summer. Land in good tilth after a grain-crop will no doubt send up a much greater quantity of annual weeds than rough land out of grass, but if a sound method of treatment be adopted the crop in the former case will be almost free from weeds, and in the latter may not. Farmers preferring to take turnips after grass aim—as I have already said—at ploughing late in spring, and often, in order to make use of the moisture in the newly-ploughed land, work down and sow immediately. If there follows rain and the turnip-seed germinates, so do the weed-seeds, often in sufficient numbers to affect the crop. But where the land is in good tilth it is properly, after spring and early summer working, allowed to lie idle for a short time so that moisture may rise from below, and during this time the weed-seeds near the surface germinate, and may be killed by the use of a broad share- or disc-harrow prior to the drilling of the turnip seed. The land is

then almost absolutely clean, and the drilled turnips only require thinning by a 7ft.- or 8ft.-broad horse-hoe sent across the drills, which also breaks the surface and favours the growth of the roots not cut out. Even without the use of artificial manures late sowing on well-cultivated land is better than early sowing on that not in good tilth; there is less trouble with weeds, and observation points out that about the end of the year rain usually falls in fair quantities. And there can be little doubt but that in well-farmed land there is plenty of time for the growth even after Christmas of a crop of any turnip, except Swedes, and perhaps on some lands the so-called Aberdeen varieties. It may also be advanced in favour of late sowing that birds and insects are less destructive towards the end of the year than they are earlier.

The cost of cultivation may be somewhat greater under the system I advocate; but, if the probability of having under a rougher method to sow a second and even a third time be considered, there is not much difference, and what there is is undoubtedly made up over and over again in the increased yield of roots.

In illustrating my subject, I propose to utilise my experience in growing and feeding off turnips on the College farm, and, in doing so, wish to bring under notice more especially the results of the use of artificial manures, and the value of the method of drilling adopted, and likewise the cost of cultivation, of folding when feeding off, and the weight of roots grown and number of stock kept.

The main crop of turnips on this farm is taken after wheat, the treatment being as above described, but at least one piece annually after grass. Broadcast sowing in the latter case has been tried every year. The crop taken after grass is merely a "catch crop" and not part of the turnip break, and failure is not therefore of very serious moment, and the cost of manure has also been taken into consideration. On the grass land the rule has been two sowings, and the crop then has been too often open to criticism, being thin, and not comparable with that sown in the regular course, so much so that it is very questionable if, during my charge, turnips are again sown broadcast, even for a catch crop.

My practice has been to use more or less artificial manure when drilling turnips. With land in fair heart, I do not think that this is necessary in order to grow a fair crop, especially as our lands are as yet in no wise turnip-sick; but the application of manure very materially increases the yield, the increase being naturally most marked on the poorest land. A water-drill is used for distributing the manure in the rows and for moistening the soil under the seed; and in fresh land in good tilth I would—with water only—trust to the drill for a crop. On such land it is possible that the increased yield might be purchased at too high a price if manure be used, although even here we should remember that it is the extra few tons per acre which pay best, as the cost of cultivation, rent, &c., are the same in both cases. On medium and poor land, however, the success on the manured land is so marked as to leave but little doubt as to the advisability of incurring the increased expenditure where the land is of value. It must be borne in mind—as I shall point out later—that we must not look to the increased turnip-crop only for the return of our expenditure on manure, but to increased yield from the succeeding spring-corn and clover crops, due to the increased manuring by sheep, and to the use by these crops of that portion of the applied manure not utilised by the turnips.

But the cost of manure and water is not represented by the increased yield only, for to their use the certainty, almost, of success in securing a crop is due. Not only is the germination of the seed assured, but by the forcing effects of the manure upon the young plant this is pushed quickly through the most dangerous period of its existence—when it is putting forth its first rough leaves—at which time it is very subject to the attacks of insects and birds. This quicker growth enables us to sow later in the season, and, as already stated, by so doing, to some extent avoid a time when these pests are more troublesome, their supplies of food being less plentiful than later in the summer.

The yield of the manured crops has been ascertained by weighing each year many plots, chiefly in connection with manure experiments, but also to obtain accurate information as to general yield. The results may be tabulated as under, and in giving them I would state that, at any rate, the turnips in No. 18 in 1883 and in No. 2 in 1884 were not the best on the farm. In fact, in no instance have the weights been taken of a *heaviest* crop, but with reference to the effects of certain manures.

TABLE SHOWING YIELD OF TURNIPS, WITH PARTICULARS AS TO KIND SOWN AND KIND AND QUANTITY OF MANURE USED.

Year.	No. of Field.	Kind of Turnip.	Kind and Quantity of Manure.	Weight of Crop.		Total Weight per Acre.
				Bulbs.	Tops.	
				T. cwt.	T. cwt.	T. cwt.
1882	22	Devonshire Grey Stone	2cwt. Odams's superphos.	27 0	5 8	32 8
"	18	Purple-top Mammoth	2½cwt. super. ..	29 0	4 10	33 10
		Imperial Green Globe	" ..	27 4	3 15	30 19
		Lincolnshire Red ..	" ..	25 2	9 2	34 4
		Purple-top Aberdeen	" ..	23 11	5 8	28 19
		Devonshire Grey Stone	2¾cwt. bones and superphos.	27 0	5 17	32 17
		"	2½cwt. Odams's superphos.	25 2	5 3	30 5
		"	2½cwt. Belfast superphos.	24 1	6 6	30 7
1884	2	Imperial Green Globe	2cwt. Odams's superphos.	25 5	5 5	31 0
1885	7	"	2cwt. Lawes's superphos.	..	..	41 19
		"	2cwt. Odams's superphos.	..	..	43 11
		"	2½cwt. Belfast superphos.	..	..	39 17
		"	4cwt. Belfast guano	..	..	37 10
		"	2½cwt. mixed bones and superphos.	..	..	40 0
		"	2½cwt. Belfast superphos.	..	..	39 2
"	16	Devonshire Grey Stone	2½cwt. mixed bones and superphos.	..	..	41 5
		"	Water only ..	..	..	30 0

The cost of cultivation on this farm is about as follows, viz.:—

	s.	d.	
Ploughing in winter Cross-ploughing in spring	11	0	per acre.
Harrowing	3	6	"
Rolling	2	0	"
Drilling and carting water	4	0	"
Two cwt. artificial manure	16	0	"
Seed	1	8	"
Horse-hoeing	1	6	"
Total	39	8	"

If the crop were sown broadcast without manure there would be saved—cost of manure, 16s.; drilling, 3s. 6d.; seed, 1s.=20s. 6d.; but against this must be placed the probability of having to sow at least twice. Resowing would cost at least 4s. for disc-harrows or broadshare, rolling, sowing, harrowing, and seed. The difference is therefore merely the cost of the manure, unless the crop is taken after grass, when some portion of the cost of the ploughing would be saved.

In comparing the two systems, the question of yield comes at once to the front, in supposing that the almost absolute certainty of the one in assuring a crop be not compared with the dependence upon season in the other. Even though this important advantage be ignored in making our calculations, I think,

from yield alone, the more profitable results of the better system of cultivation will be apparent.

In no instance have I grown by sowing broadcast half the weight of turnips the drill and manure have produced. I have not the weights, but they would be useless if I had, as the conditions of soil, &c., would not allow of comparison. With water alone, drilled turnips gave last year 30 tons against 41 tons 5cwt. where manure was used, but in less favourable years the crop without manure would compare less favourably. I have no hesitation in stating the proportion to be quite 35 to 20 tons in the case of properly cultivated and manured land compared with rougher land sown broadcast.

The average of the above given weighed results gives an average of 35½ tons per acre (with tops). I feel certain the same land not thus treated would not have yielded 22 tons per acre. But, for the sake of calculation, say the excess due to better cultivation and manure would have been 12 tons per acre. If we allow that an average flock of sheep—part wethers, part hoggets—will eat daily throughout the winter 25lb. of turnips each—without other food—20 tons of turnips, allowing 10 per cent. for waste, would keep about 230 sheep one week, and, if the keep of a sheep is worth about 1¾d. for that time, a 20-ton crop of turnips would be worth 33s. 6d. per acre, and a 32-ton crop 53s. 7d. per acre; or if the value be 1¼d. per head per week we get the values 28s. 9d. and 46s. per acre, in either case the excess in value being more than sufficient to pay the cost of the manure used.

We, however, do not look to our sheep for our profit on the turnip crop. This comes out of the following grain and clover crops, which are increased through the manuring of the surface-soil with the droppings of the sheep. The residue of a crop left left on the ground by the sheep is quite 95 per cent. of the crop grown: if therefore the droppings from a 20-ton crop will markedly increase the yield of grain, &c., in the following years, that from 32 tons must further increase that yield, and the difference between the two yields must be entirely profit, for I have shown that the sheep will pay for the cost of the manure applied, the cost of cultivation and rent are the same for our grain and clover crops whether the yield be large or small, the only excess of cost in the case of heavy crops being for harvesting.

It may be argued that, after all, all the substance of the sheep-dressing actually came out of the land in the turnip-crop, and therefore there is no real addition of manurial matter. But even although it were allowed that it did come out of the land, it by no means follows that manure has not been added. To explain this, let us take the case of grain. The manurial substance or food chiefly required by grain is nitrogen in a certain state of combination known as a "nitrate." In no other condition is it of immediate value. The soil, whilst generally containing plenty of nitrogen, furnishes but a very scanty supply of nitrates, the great bulk being in a state of combination with carbon, &c., in decaying vegetable matter, in which it cannot be taken up by grain crops. The effect of feeding off the turnip crop with sheep is to change a certain amount of this useless nitrogenous compound into another which is a valuable manure. In fact, we actually add to our surface-soil so much manure which was not there before.

It is the urine of the sheep which contains this valuable nitrogenous substance, and, as most of the nitrogen voided by animals passes off in the urine, we find that most of the nitrogen contained in the turnip crop is returned in this valuable condition; but even that contained in the solid excrement is in a far more valuable condition than in the turnips before they were passed through the digestive organs of the sheep. We may therefore truthfully say that the sheep has manufactured out of inert, almost valueless matter a most valuable manure, and added it to our soil.

Twenty tons of turnips contain about 100lb. nitrogen, and therefore 32 tons contain 160lb. A 40-bushel crop of wheat contains, according to kind, climate, &c., say from 45lb. to 60lb. nitrogen in grain and straw. As 95 per cent. of the nitrogen contained in the turnip-crop is returned to the land in the excrement of the sheep fed thereon, it is easy to conceive that from the excess of 12 tons of turnips per acre, in a manured crop, there may be deposited, on consumption by sheep, sufficient nitrogen in an immediately available condition for 30 to 40 bushels of wheat, and, as in a 32-ton crop we have deposited also the nitrogen from the 20 tons, we may, I think, after also crediting the soil with containing

some available nitrogen, fairly expect on our manured land an increase of say 8 to 10 bushels of wheat over that unmanured. We have added plenty of manure, and if we do not get our return we must blame bad mechanical condition of the soil through poaching by sheep's feet in wet weather, or a bad season,—both, no doubt, elements which should be seriously considered in our calculations.

I think there can be but little doubt but that it will pay to fold sheep on turnips. The more frequently sheep are moved the better, but the low value of mutton and the high price of labour must prevent our giving them a fresh pitch as often as we should like. I move them once a week, and even this effects a great saving of feed, and is much better for the sheep than allowing them to run over a large piece of turnips, perhaps sufficient for six or eight weeks. In the former case the sheep are fed more evenly, for if they are turned on to a large piece of turnips they have at first a flush of feed, and for a few days the choice pickings; they then run over the whole piece, biting every turnip. The bitten turnips quickly deteriorate from exposure to wind, rain, and frost, and after two or three weeks the sheep care little for them, and towards the latter portion of the time, when they are too often forced by sheer hunger to scoop out the shells and consume previously rejected roots, they go back in condition, and actually lose much of the weight they had previously put on. Again, by folding there is much less loss of turnips by waste, and lastly we are enabled to use our ewe flock for finishing up turnips after our fatting sheep, thus allowing of our moving the latter to fresh turnips before they have begun to get tired of those they have been already on for some days. They are thus kept in a progressive condition without check.

The cost of folding, using wire net and sawn stakes, amounts to about 3s. per acre, which amount includes labour, cost of material, &c. The saving in turnips, I think, is quite 25 per cent.: *i.e.*, a piece of turnips which would last a flock of sheep eight weeks would, if the sheep were folded, last ten weeks. The saving would be, on the basis of the crops alluded to in this paper, at least seven or eight tons per acre, representing an expenditure, including rent, of 12s. to 15s. per acre; the improved condition of the sheep is even then not taken into consideration.

It is a great mistake to put sheep on to turnips without hay or other dry food. Hoggets especially are very liable to suffer by such treatment, whilst, on the other hand, with a little hay, ewes may be kept on turnips quite up to lambing without loss of lambs.

Hay may be grown and made here quite cheaply enough to be used as an equivalent for turnips. The cost of cutting, making, and stacking, using hay-sweeps and straw-elevators, does not on this farm exceed 4s. 3d. per ton. Adding rent, thatching, cutting, and carting to sheep in winter, the cost on the turnip land would be under 15s. per ton, or about $\frac{1}{4}$th of a penny per lb. The feeding-value of 1lb. of hay is about equal to that of 7lb. of turnips, and sheep getting 1lb. of hay a day will each eat daily about 17lb. to 18lb. of turnips: *i.e.*, 7lb. of hay costing $\frac{1}{2}$d. will save 50lb. to 56lb. of turnips, worth for food as nearly as possible the same money. Calculating the feeding-value of green clover at 1$\frac{3}{4}$d. or 1$\frac{1}{2}$d. per head of sheep per week, there is no appreciable loss in shutting up a clover paddock in spring for hay, whilst the advantages of having hay are too obvious to need pointing out. If only we save the too usual loss of hoggets, are enabled by its use to safely keep our ewes on turnips until lambing, and thus save our grass for the use of the ewes when lambing, we should never be without. But also, as hay can be so economically made as to be as cheap as turnips for sheep, if we have a good stock of hay we can, by using more or less, easily regulate the rate at which our turnips are being consumed, and often may be enabled to take advantage of the fluctuation of the stock markets.

Chaffed oat sheaves will not compare with clover hay for cheapness for sheep feed. Used for this purpose and at the same rate per head as has already been taken as in the case of hay and turnips, and calculating the equivalent value of these foods, I find that the return for oats would be about 8d. per bushel unthreshed.

Of the many varieties of turnips tried on the farm, I prefer those named hereunder, viz.:—

For early feeding, say until the end of May, the Devonshire Grey Stone; to succeed these for use until the middle of July, the Imperial Green Globe; and to

follow, the Fosterton Hybrid—a turnip that, whilst lasting in a perfectly sound condition until the end of September, is not so hard as the Aberdeen varieties, whilst its feeding value is equally good.

For information upon this question of the feeding-value of the various kinds of turnips and the effects of certain manurial substances thereon, I would direct attention to Mr. Gray's excellent paper hereunder—one which is the result of a great deal of patient research in the laboratory, work which, when tabulated, conveys to the ordinary observer but a faint conception of the real labour involved.

I would point out, as the most interesting portion of these results, first, the varying percentage of albuminoid nitrogen—the portion which is alone of value in the formation of flesh—in the different kinds of turnip; and, secondly, the apparent effects of the different manures used in causing variations of these percentages in the same kind of turnip. The use of nitrogen as a manure for turnips should be avoided, for it increases the percentage of tops (see my report for 1883), as well as decreasing the ratio of albuminoid to non-albuminoid nitrogen in the bulb.

On the Composition and Feeding-value of Turnips.

For the past two years fair average specimens of the turnips grown on the School Farm have been analysed, and, since the analyses were made somewhat in detail, especially as regards the nitrogen, it has been thought desirable to publish the combined results, with a few remarks on the composition and feeding-value of turnips generally.

The results, therefore, contained in the following paper will include those published in the report of the school for the first term, 1884, which have been revised and in some cases recalculated in order to compare with the results of the turnips grown in 1885.

In selecting the samples for analysis care was taken that they should represent as far as possible the crops as a whole; and the opinions, therefore, of at least two, and in some cases three, persons were taken on this point. Segments of each root were taken for analysis cut from the top to the bottom, thereby representing the entire turnip.

The results of the analyses are contained in the following table :—

Table I.—Analyses of Turnips.

Name of Turnip.	No. of Field.	Weight.	Age in Days.	Specific Gravity.	Water.	Sugar.	Fat, &c.	Cellulose.	Ash.	Albuminoids.	Extractive Matter.	Total.
		lb.										
1884.												
Aberdeen Yellow	19	6·31	188	·913	89·985	4·820	·183	1·025	·990	·493	2·504	100·000
Green Globe	19	7·50	141	·898	91·115	4·460	·223	·745	·585	·400	2·472	100·000
Devonshire Grey Stone ...	19	5·25	162	·936	91·010	4·050	·133	·792	·590	·243	3·182	100·000
Lincolnshire Red ...	19	4·68	141	·837	91·140	4·840	·218	·880	·572	·240	2·110	100·000
1885.												
Lincolnshire	16	5·42	...	·841	90·295	5·397	·284	·853	·785	·326	2·060	100·000
Devonshire (not manured) ...	16	3·26	...	·874	90·625	5·277	·340	·927	·670	·349	1·812	100·000
,, (manured)	16	4·96	...	·873	91·240	5·135	·297	·795	·685	·324	1·524	100·000
Green Globe (not manured) ...	7	3·44	...	·933	91·730	4·726	·321	·881	·680	·416	1·246	100·000
,, (Belfast guano) ...	7	4·44	...	·896	91·330	4·896	·238	·884	·710	·398	1·544	100·000
,, (Odams's super.) ...	7	3·97	...	·864	90·700	5·053	·332	1·157	·760	·346	1·652	100·000
Fosterton Hybrid	27	3·82	...	·934	90·295	4·948	·336	·928	·625	·496	2·372	100·000

The high proportion of water in the turnip renders it a poor feeding-material, the amount of dry matter being generally only about 8 or 9 per cent. In the samples under consideration the limits were 10·01 to 8·27, with a mean of 9·11 per cent. The substances of which the dry matter is composed, when considered

as constituents of food, are divisible into flesh-formers and heat-givers, the former embracing albuminoids, and the latter the carbohydrates—sugar, &c. It is on the relative amount of these two classes of food that the feeding-value depends.

All the turnips examined were lighter than water. It has been frequently stated that the specific gravity can be taken as an indication of the feeding-value; and that this is the case is well shown in the following table, in which the specific gravities, the albuminoids calculated on the dry matter, and the albuminoid ratios are compared:—

TABLE II.—COMPARISON OF SPECIFIC GRAVITIES, ALBUMINOIDS, AND ALBUMINOID RATIOS IN TURNIPS.

	Specific Gravity.	Albuminoids.	Albuminoid Ratio.
Fosterton Hybrid (manured, 1885)	·934	5·11	1–16
Green Globe (not manured, 1885)	·933	5·03	1–16
Aberdeen (manured, 1884)	·913	4·91	1–16
Green Globe (manured, Belfast guano, 1885) ..	·896	4·59	1–18
Green Globe (manured, 1884)	·868	4·50	1–19
Devonshire (not manured, 1885)	·874	3·72	1–22
Green Globe (manured, 40 per cent. soluble phosphate, 1885)	·864	3·71	1–22
Devonshire (manured, 1885)	·873	3·69	1–23
Lincolnshire (manured, 1885)	·841	3·34	1–25
Lincolnshire (manured, 1884)	·837	2·71	1–31
Devonshire (manured, 1884)	·936	2·70	1–31

The albuminoid ratios are obtained by adding together the carbohydrates or their equivalents, which are digestible—the sugar, extractive matter, and fat, the latter calculated to its equivalent in starch—and then dividing the product by the number representing the albuminoids. It will be seen that, with only two or three exceptions, a high specific gravity is accompanied by a high percentage of albuminoids and a high albuminoid ratio, and *vice versâ*.

Sugar.—Fully one-half of the dry matter contained in turnips is composed of sugar. This is of the same kind as that contained in sugar-beet and sugarcane, and forms one of the most valuable of the heat-giving ingredients of feeding-stuffs. The numbers under the heading of "Fat, &c.," besides fat, include chlorophyll, wax, and other substances soluble in ether.

Extractive Matter includes various substances which have not been determined individually, but which are assumed to possess a feeding-value equivalent to starch, sugar, and other carbohydrates. Amongst such might be mentioned digestible fibre, bodies of the pectose group, and also certain nitrogenous bodies (amides, &c.), which will be considered later.

Cellulose.—This substance is not included in the number showing the albuminoid ratio, since it is assumed to be indigestible. It consists of that portion of the turnip which resists the action of 5-per-cent. solutions of acid and alkali. This treatment is intended to represent the solvent action of the natural digestive fluids. The results, of course, are not absolutely correct for all kinds of animals: still, the determinations are of value for comparative purposes.

Nitrogenous Substances.—The most important results, perhaps, obtained in the present investigations are those showing the several conditions in which nitrogen exists in turnips. During the past few years the attention of chemists and agriculturists has been drawn to the fact that nitrogen exists in certain fodders and feeding-stuffs in more than one condition, and that the nitrogen existing in some of these forms does not possess the same nutritive value as in others. That existing in albuminoids has been shown to be probably the only nitrogen which acts as a true flesh-former, whilst that contained in amides and allied bodies, in nitrates, and in ammonia salts, is found to possess a less value, these substances being about equivalent to the carbohydrates. The nitrogen in

these several forms was estimated in the analyses of last year; the results then obtained have been augmented and confirmed by those made this season. The results of last year were calculated on the entire turnip, but those obtained this year, in order to be better realised, have been calculated on the dry matter of the turnip only. It has been necessary, therefore, to recalculate the former, in order that they may be compared. The following table shows the combined results obtained:—

TABLE III.—SHOWING THE SEVERAL CONDITIONS IN WHICH NITROGEN EXISTS IN THE DRY MATTER OF TURNIPS.

—	Fosterton Hybrid, 1885.	Aberdeen, 1884.	Green Globe, 1884.	Green Globe not manured, 1885.	Green Globe, Belfast guano, 1885.	Green Globe, Odams's super., 1885.	Devonshire, 1884.	Devonshire manured, 1885.	Devonshire not manured, 1885.	Lincolnshire, 1884.	Lincolnshire, 1885.
Total nitrogen ...	1·324	1·417	1·419	1·448	1·881	1·317	1·279	1·022	1·171	1·433	1·061
Albuminoid nitrogen ..	·808	·779	·708	·796	·723	·585	·425	·584	·585	·429	·530
Nitrogen as ammonia salts	·017	·017	·014	·018	·017	·018	·024	·018	·020	·011	·021
Ditto as nitrates ...	·023	·015	·009	·021	·029	·017	·002	·003	·001	·005	·013
Ditto as amides, &c. ...	·476	·606	·688	·613	1·112	·697	·827	·417	·565	·988	·497
Percentage of nitrogen as albuminoids	61·01	54·98	49·91	55·00	38·42	44·44	33·30	57·13	49·96	29·94	49·95
Nitrogen as ammonia salts	1·29	1·20	·97	1·23	·93	1·34	1·88	1·77	1·71	·77	1·98
Ditto as nitrates ...	1·75	1·05	·62	1·43	1·57	1·27	·16	·31	·08	·35	1·23
Ditto as amides, &c. ...	35·95	42·77	48·50	42·34	59·08	52·95	64·66	40·79	48·25	68·94	46·84
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

These results show that, in the samples analysed, at most only 61 per cent. of nitrogen existed as albuminoids, and that in some cases only about 30 per cent. was in this form. Taking the mean of the eleven samples the amount would be 48 per cent.

One or two points are noticeable in the results, which bear on the influence of manures as affecting the composition of the crop, and, although it might be urged with reason that isolated cases are not to be depended on, still the points about to be noticed are not without significance.

The Green Globe turnip, manured with Belfast manure, will be seen to be richer in total nitrogen than any other turnip, even the Fosterton Hybrid and Aberdeen. This must clearly be due to the nitrogen supplied in the guano. This manure is an animal guano made from the refuse of the freezing works, and had the following composition:—

	Per cent.
Moisture	9·80
*Organic matter and combined water ..	68·37
†Monocalcic phosphate	4·61
Tricalcic phosphate	nil
Ferric and aluminic phosphates	3·25
Calcic sulphate	5·97
Silica and insoluble matter	7·67
Alkalies, loss, and undetermined	·33
	100·00

* Containing nitrogen, 4·27; equal to ammonia, 5·18.
† Equivalent to tricalcic phosphate rendered soluble, 6·08.

Although the total percentage of nitrogen is high it will be observed that the proportion of nitrogen existing as albuminoids is not so; in fact it is below that of the same kind of turnip grown without manure, but with other conditions precisely the same. Since it has been already stated that it is only the nitrogen existing as albuminoids which is of service as a flesh-former, it must be inferred that the feeding value of turnips is not increased by the use of nitrogenous manures.

Whilst it must be admitted that phosphates, especially those in a soluble form, have a considerable influence on the growth of the turnip plant, yet both in the case of the Devonshire Greystone and the Green Globe turnips, which were grown without manure, the percentage of albuminoids is above that of the same turnips grown with superphosphate. This does not prove that phosphates are not generally required, for this is beyond doubt, but that the use of this manure tends to diminish the percentage of albuminoids, and that an excess should be guarded against. This point has been already noticed by Dr. Aitkin, chemist to the Highland Agricultural Society of Scotland, and the present results are only confirmatory.

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