THE

BOOK OF THE FARM

DIVISION III.

Wherefore come on, O young husbandman!
Learn the culture proper to each kind.

VIRGIL.

THE

BOOK OF THE FARM

DETAILING THE LABOURS OF THE

FARMER, FARM-STEWARD, PLOUGHMAN, SHEPHERD, HEDGER, FARM-LABOURER, FIELD-WORKER, AND CATTLE-MAN

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FOURTH EDITION

REVISED, AND IN GREAT PART REWRITTEN, BY

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IN SIX DIVISIONS

DIVISION III.

WILLIAM BLACKWOOD AND SONS

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MDCCCLXXXIX

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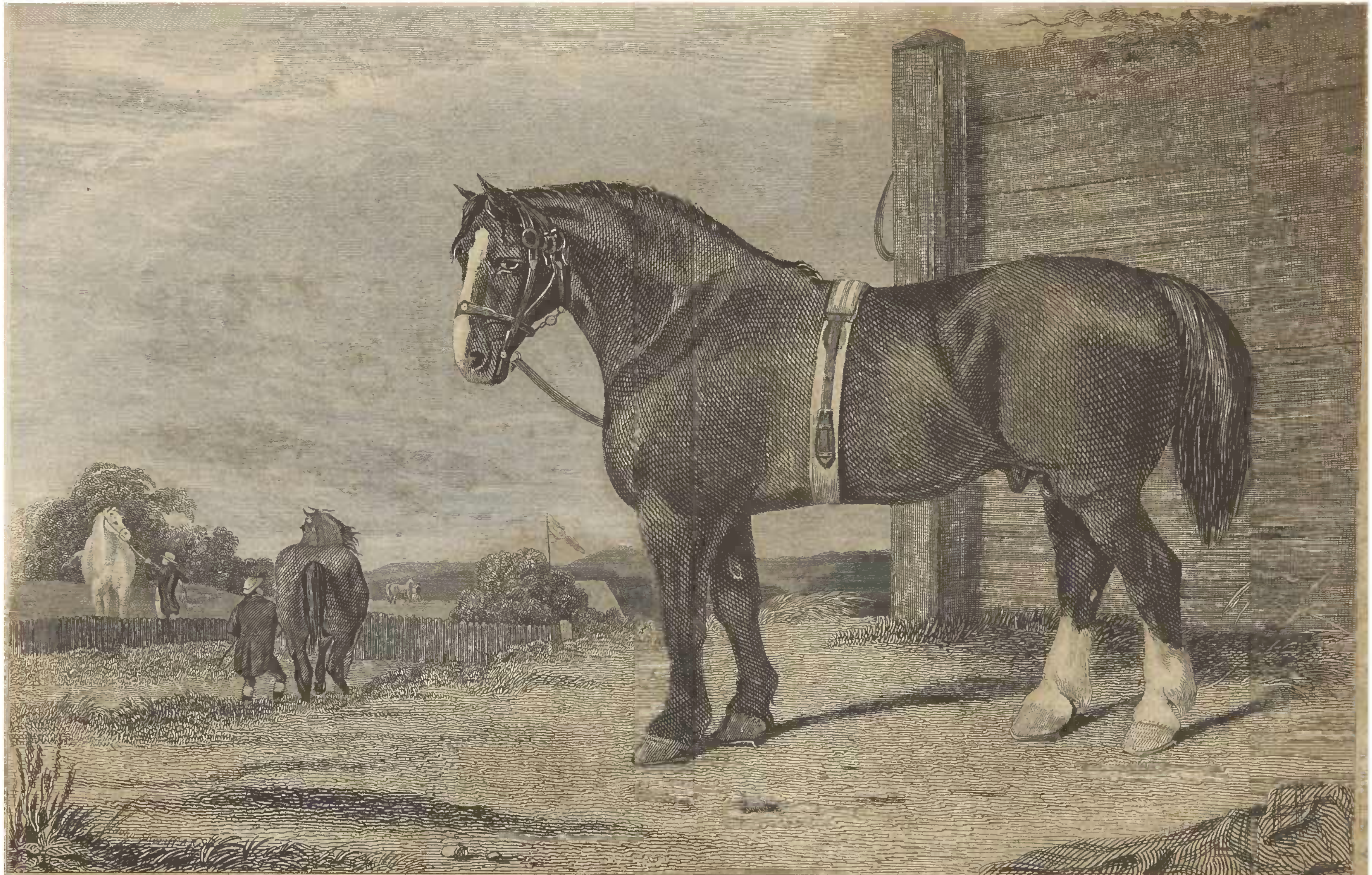

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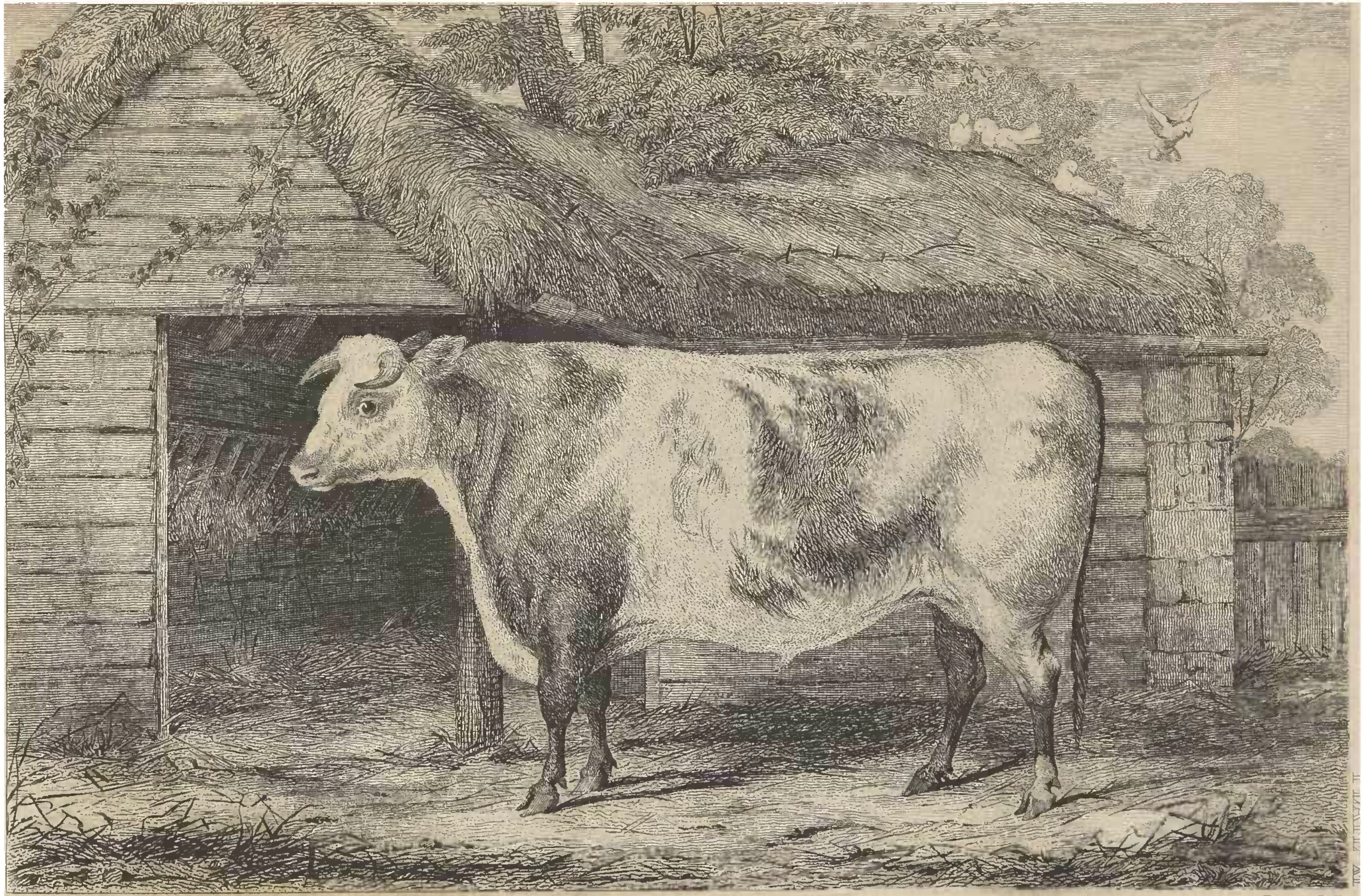

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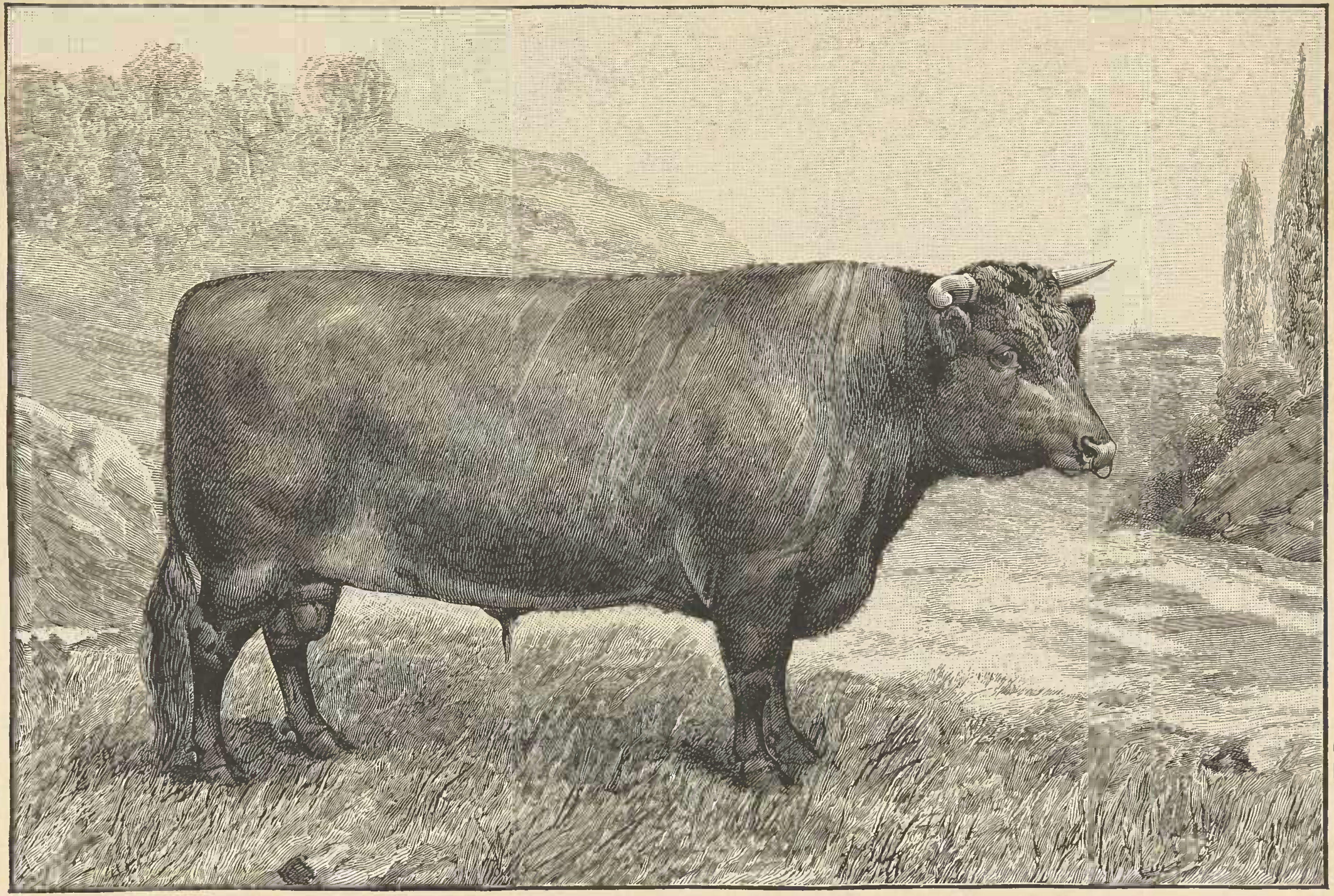

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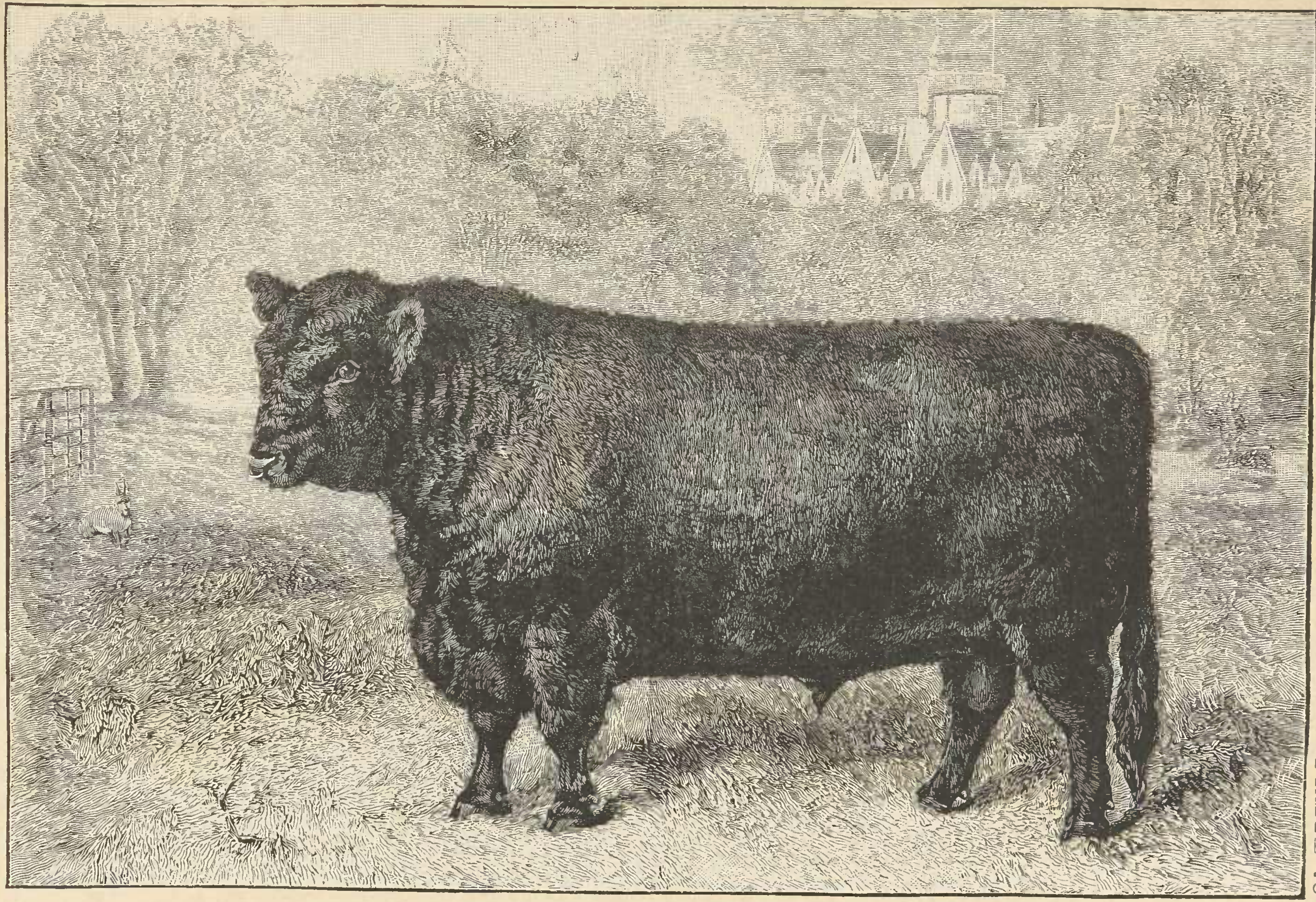

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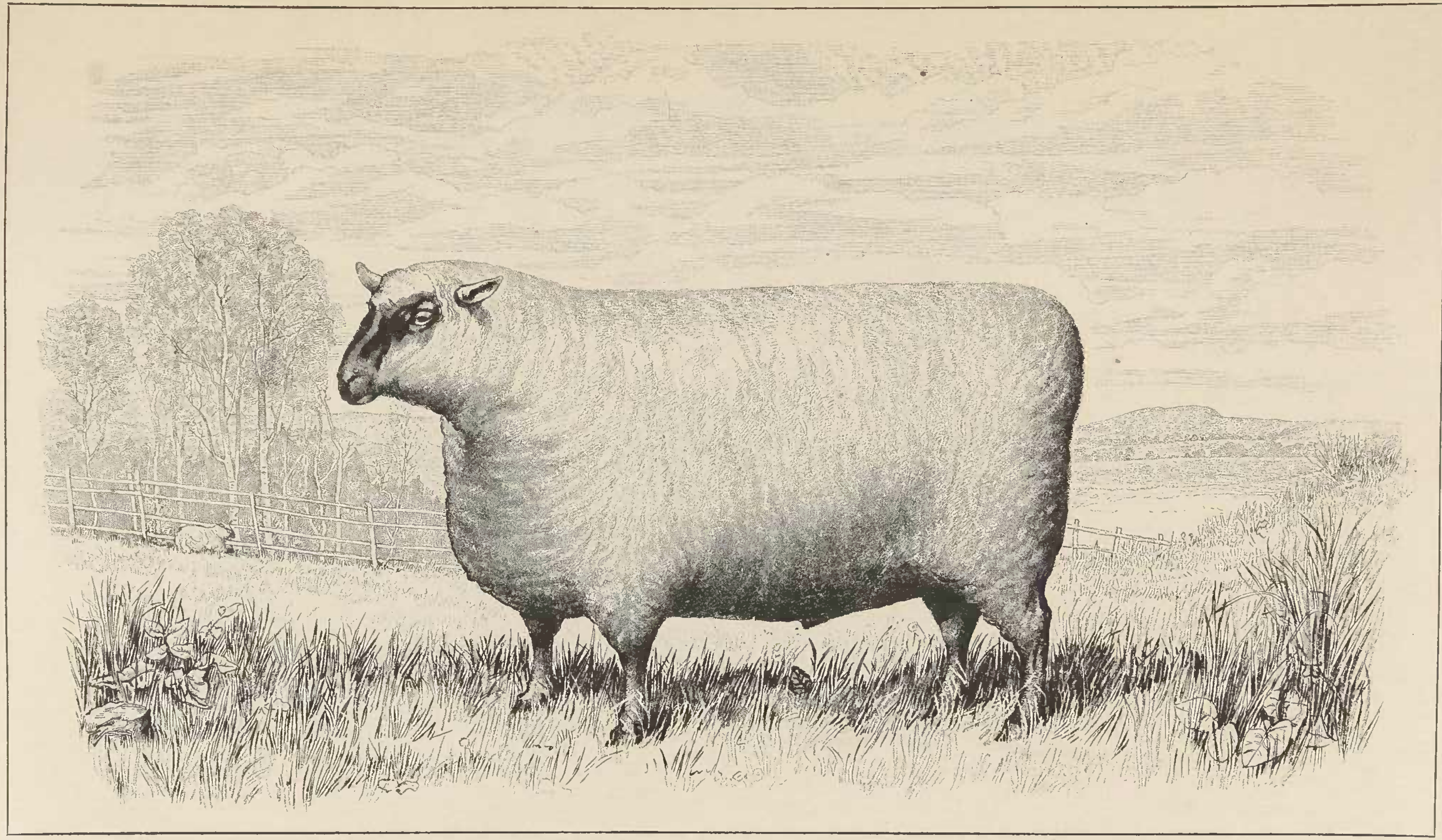

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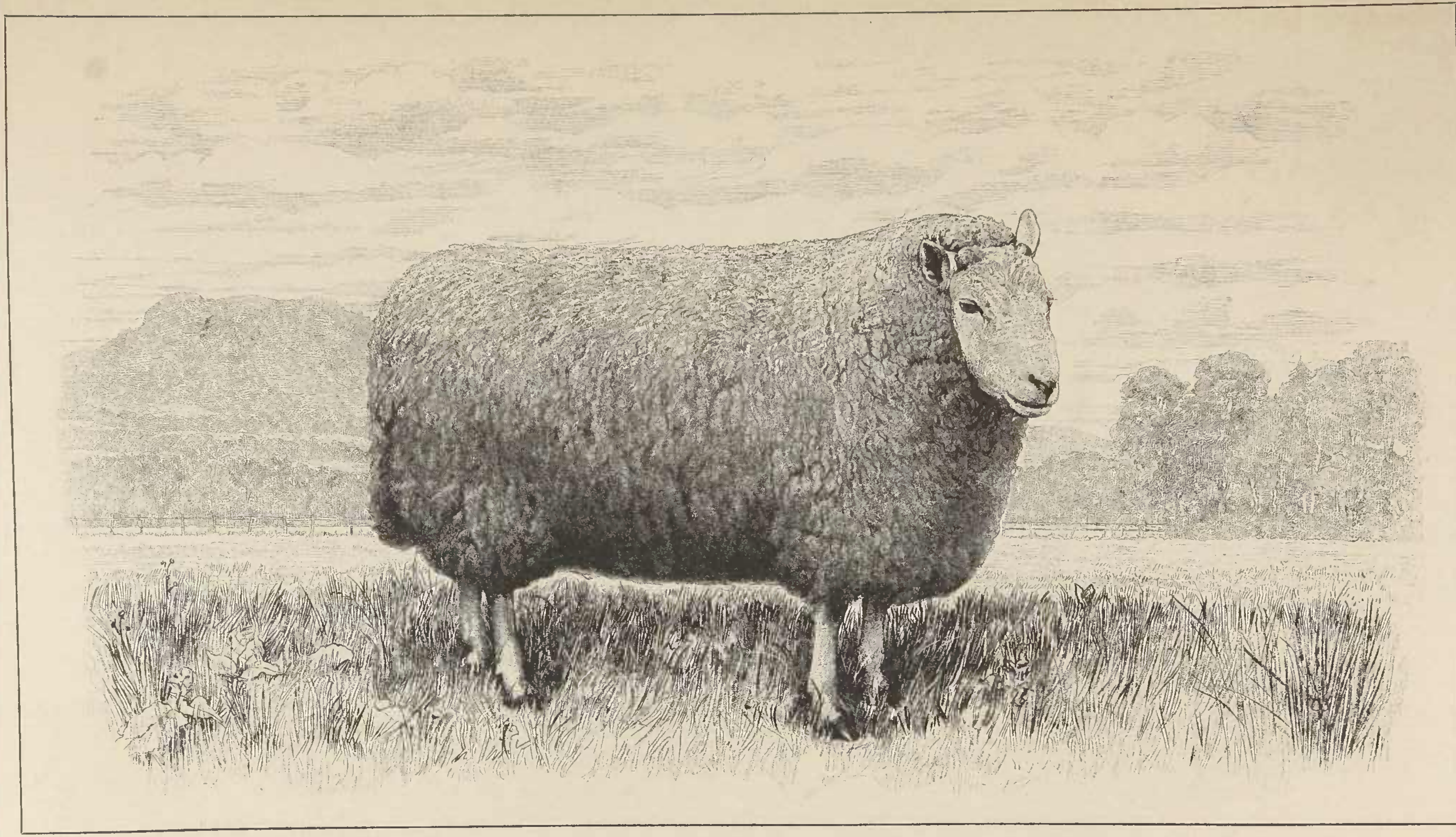

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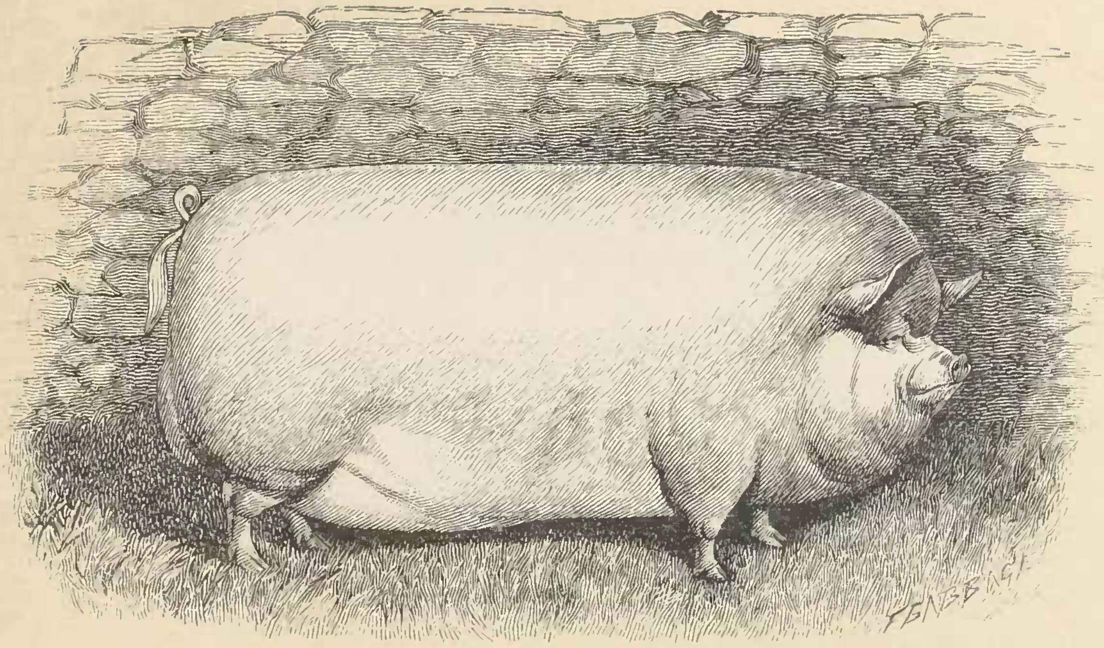

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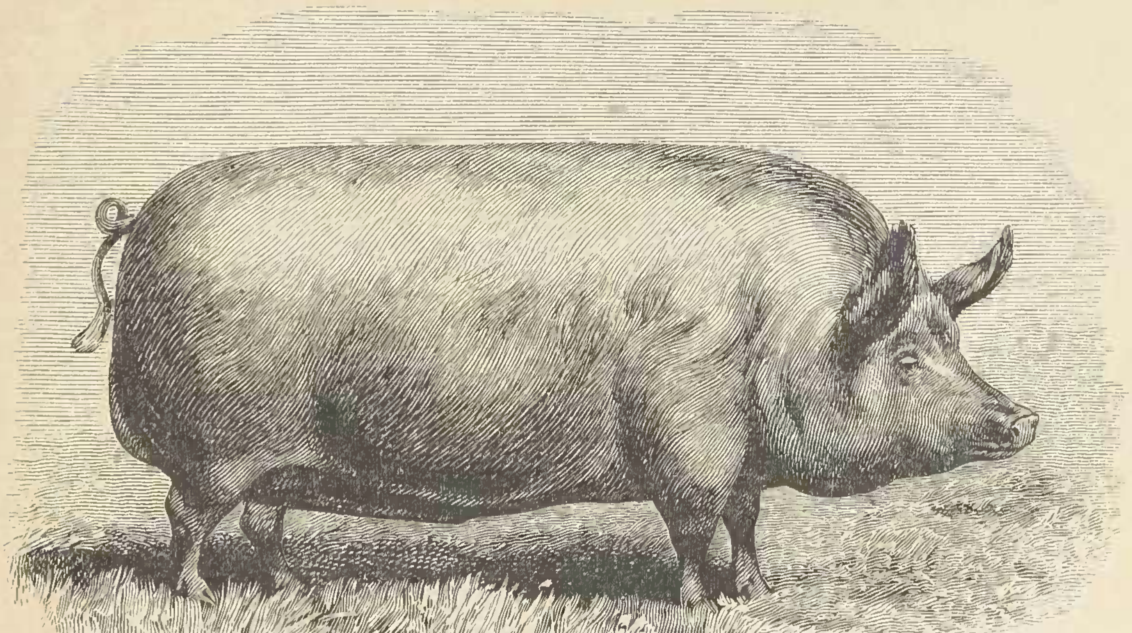

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THE

BOOK OF THE FARM.

SPRING.

FIELD OPERATIONS AND SPRING WEATHER.

In the vegetable world winter is the season of repose, of passive existence, of dormancy, though not of death. Spring, on the contrary, is the season of returning life, of passing into active exertion, of hope, and of joy; of hope, as the world of life springs into view immediately after the industrious hand has scattered the seed upon the ground—and of joy, in contemplating with confidence the reproductions of the herds and flocks. It would be vain to attempt to describe the emotions to which this delightful season gives birth. It is better that the pupil of agriculture should enjoy the pleasure for himself; for "the chosen draught, of which every lover of nature may drink, can be had, in its freshness and purity, only at the living fountain of nature; and if we attempt to fetch it away in the clay pitchers of human description, it loses all its spirit, becomes insipid, and acquires an earthy taste from the clay."

Early Rising and the Joys of Spring.—To enjoy the beauties of spring in perfection, "it is necessary to take advantage of the morning, when the beams of the newly risen sun are nearly level with the surface of the earth; and this is the time when the morning birds are in their finest song, when the earth and the air are in their greatest freshness, and when all nature mingles in one common morning hymn of gratitude. There is something peculiarly arousing and strengthening, both to the body and the mind, in the early time of the morning; and were we always wise enough to avail ourselves of it, it is almost incredible with what ease and pleasure the labours of the most diligent life might be performed. When we take the day by the beginning, we can regulate the length of it according to our necessities; and whatever may be our professional avocations, we have time to perform them, to cultivate our minds, and to worship our Maker, without the one duty interfering with the other."

The Morning of Life.—"The dayspring of the morning leads us, by an easy and very natural transition, to the dayspring of human life, the morning of our sojourn upon earth; and the parallels between the commencement of life itself, and of those successive days by which it is numbered, is a parallel the most striking. There is a freshness in young life which no experience can acquire for us at any future time; and there is a newness in every object, which is not felt after years have passed over our heads. Our bodies are light, flexible, easily moved, and not liable to be injured. Our minds, too, never become wearied or listless; and although the occupation and the thought are necessarily different from those of persons of mature age, they are far more energetic, and what is learned or done takes a more permanent hold of the memory.

"There are many circumstances which render the morning of life of far more importance than the morning of an individual day. It is a morning to which no to-morrow morning can follow; and therefore, if it is neglected, all is inevitably and utterly lost. We cannot exactly make up the loss of even one morning, though we can repair it a little by our diligence in future mornings. We must bear in mind, however, that the means of doing this are a mercy to us, and not a privilege that we can command as our own. We never 'know what a day may bring forth;' and as there daily occur around us instances in which the young and the strong are at once levelled to the dust, we never can be certain that the demand shall not be made on ourselves—'this night is thy soul required of thee.' But if it is thus perilous to neglect one morning out of many, how much more perilous to neglect the one morning of a life—a life granted by a beneficent God, in a world full of the wonders of His power, capable of enjoyment, and deny Him service while it lasts, and in the fulness of time entering, through the atonement of the eternal Son, a life of bliss which shall have no end!" [1]

Cares of Stock-owners in Spring.—Spring is the busiest of all seasons on the farm. The cattle-man, besides continuing his attendance on the feeding cattle, has now the more delicate task of waiting on the cows at calving, and providing comfortable lairs for new-dropped calves. The dairymaid commences her labours, not in the peculiar avocations of the dairy, but in rearing calves—the support of a future herd. The farrows of pigs also claim a share of attention. The shepherd, too, has his painful watchings, day and night, on the lambing ewes; and his care of the tender lambs, until they are able to gambol upon the new grass, is a task of peculiar interest, and naturally leads to higher thoughts—"we cannot refrain from thinking of the unspeakable condescension and kindness of Him who 'feeds His flock like a shepherd, gathers the lambs into His arms, and carries them in His bosom, and gently leads those that are with young.'"

Field-work in Spring.—The condition of the fields demands attention as well as the reproduction of the stock. The day now affords as many hours for labour as are usually bestowed at any season in the field. The ploughmen, therefore, know no rest for at least ten hours every day, from the time the harrows are yoked for the spring wheat until the turnips are sown. The turnip land, bared as the turnips are consumed by sheep, or removed to the steading, is now ploughed and prepared for spring wheat, barley, or oats—that is, should the weather be mild and the soil dry enough. The first sowing is the spring wheat; then the beans, the oats, and the barley. The fields intended for the root crops then receive a cross-furrow, in the order of the fallow crops—the potatoes first, then turnips, and lastly the bare fallow, if there should be any, which is now very exceptional.

This is the course followed with the root-land in many cases, but where the stubbles are ploughed with a strong loose furrow in early winter, the soil is so pulverised by the influences of winter, that spring ploughing may be unnecessary, grubbing and harrowing being sufficient to bring it into the required condition. This will, of course, much depend upon the nature and condition of the land. Stiff, dirty land will most likely have to be cross-ploughed in spring, and grubbed once or even twice as well.

Grass seeds are then sown amongst the young autumnal wheat, as well as amongst the spring wheat and the barley or oats. The field-workers devote their busy hours to carrying seed to the sower, turning dunghills in preparation of the manure for the potato and turnip crops, continuing the barn-work to supply litter for the

[1] Mudie's *Spring*, 12-15.

stock yet confined in the steading, and to prepare the seed-corn for the fields. The hedger resumes his work of water-tabling and scouring ditches, cutting down and breasting old hedges, and taking care to fence with paling the young quicks upon the hedge-bank, which he may have planted at the commencement and during fresh weather in winter, as also to make gaw-cuts in the sowed fields.

The steward is now on the alert, urges the progress of every operation, and intrusts the sowing of the crops to none but himself, or a tried hand, as the skilful hedger, or ploughman experienced in the management of an approved corn-sowing machine. Thus every class of labourers have their work appropriated for them at this busy season; and as the work of every one is individually defined, it is scarcely possible for so great a mistake to be committed as that any piece of work should be neglected by all.

The Farmer's Duties in Spring.—The farmer himself now feels that he must be "up and doing." His mind becomes stored with plans for future execution; and in order to see them executed at the proper time and in the best manner, he must now forego all visits, and remain at home for the season; or at most undertake an occasional and hasty journey to the market town to dispose of surplus corn and transact other pressing business. The work of the fields now requiring constant attendance, his mind as well as body becomes fatigued, and, on taking the fireside after the labours of the day are over, the farmer seeks for rest and relaxation rather than mental toil. He should at this season pay particular attention to the state of the weather, by observing the barometric and thermometric changes, and make it a point to observe every external phenomenon that has a bearing upon the changes of the atmosphere, and be guided accordingly in giving his instructions to his people.

Weather in Spring.—The weather in spring, in the zone we inhabit, is exceedingly variable, alternating, at short intervals, from frost to thaw, from rain to snow, from sunshine to cloud—very different from the steady character of the arctic spring, in which the snow melts without rain, and the meads are covered with vernal flowers ere the last traces of winter have disappeared. Possessing this variability in its atmospherical phenomena, spring presents few having peculiarities of their own, unless we except the cold unwholesome east wind which prevails from March to May, and the very heavy falls of snow which occasionally occur in February.

East Wind.—So invariable is the phenomenon of the *east wind* in spring, that every person who dwells on the east coast of Great Britain is quite familiar with it, having felt its keenness and known its aptitude to produce catarrhal, pulmonary, and rheumatic affections. In its dread, many migrate to a milder climate until summer shall have set in. An explanation of this remarkable phenomenon has been given by Mr Samuel Marshall. "In Sweden and Norway," he observes, "the face of the country is covered with snow to the middle of May or longer. This frozen covering, which has been formed during winter, grows gradually shallower to the 15th or 16th of May, or until the sun has acquired 17° or 18° N. declination; while, on the other hand, the valleys and mountains of England have received an accession of 24° or 25° On this account, when the temperature of Sweden and Narway is cooled down by snow to 32°, that of Britain is 24° or 25° higher than that of the preceding countries. Because, while the ground is covered with snow, the rays of the sun are incapable of heating the air above 32°, the freezing-point. For this reason the air of England is 24° or 25° more heated than that of the before-mentioned countries. The air of Sweden and Norway will then, of course, by the law of comparative specific gravity, displace that of England, and, from the relative situation of those countries with this country, will produce a N.E. wind. The current is in common stronger by day than by night, because the variation of temperature is at that time the greatest, being frequently from 50° to 60° about noon, and sinking to 32° in the night."[1]

Spring Winds.—All the seasons have their peculiar influence on the winds.

[1] Brewster's *Jour. Sci.*, viii. 39.

"In *spring*," says Schouw, "E. winds are common; at certain places in March, at others in April. They diminish the force of the W. current, which in many countries is at that time weaker than during the rest of the year. The relation of N. to S. winds is not constant, and varies according to the localities. In some the direction is more N., in others more S., than the mean direction of the year." "When winds come from distant countries, they possess a part of the properties by which those countries are characterised," is an observation of Kaemtz. "Thus the W. winds, that blow from the sea, are much more moist than the E., which traverse continents. The latter, particularly when they are N.E., are very cold, especially in spring; and they give rise to a great number of rheumatic affections. The very opposite sensations, produced by violent S. or N. winds, are much more marked in countries whose inhabitants live in the open air."

Kaemtz further explains the cause of the very variable nature of the wind in our countries. After having mentioned that the two great leading currents of wind on the globe are the N.E. and S.W., he observes that "meteorological registers present to us the indication of a great number of winds which blow from all parts of the horizon. When we compare corresponding observations made in many localities in Europe, we are not slow in recognising that those winds involve no other causes than difference of temperature. Suppose, for instance, that a general S.W. wind occupies the upper regions, but that the W. part of Europe is very hot, whilst the E. regions remain very cold, with a clouded sky, the difference of temperature will immediately give rise to an E. wind; and when this wind meets that from the S.W. there will be a S.E. wind, which may be transformed into a true S. wind.

"These differences of temperature explain the existence of almost all winds. Now, suppose that a region is unusually heated, and that there is no prevailing wind, then the cold air will flow in on all sides; and according as the observer is in the N., the E., the S., or the W., he will feel a different wind blowing from the corresponding points of the horizon. However, to put the fact beyond doubt, we need corresponding observations, embracing a great number of localities,"[1] an advantage now very efficiently provided by the Royal Meteorological Society and the Scottish Meteorological Society.

The character of the winds in spring is, that they are very sharp when coming from the N. or N.E. direction; and they are also frequent, blowing strongly sometimes from the E. and sometimes from the W. In the E. they are piercing, even though not inclining to frost; in the W. they are strong, boisterous, squally, and rising at times into tremendous hurricanes, in which trees escape being uprooted only in consequence of their leafless state, but by which many a hapless mariner is overtaken and consigned to a watery grave, or dashed without mercy on a rocky shore.

Snow in Spring.—Very frequently snow covers the ground for a time in spring. The severest snow storms and falls usually occur in February. Truly awful is a storm of snow in spring amongst the hills.

It is a serious affliction to the sheep-farmer when a severe and protracted snowstorm occurs in spring. The losses caused by the storm are often very great, especially in breeding flocks, where lambs are sometimes lost in hundreds daily. Then by providing extra food for sheep in spring storms, the sheep-farmer's outlays are frequently increased to a serious extent.

Clouds in Spring.—The prevailing *clouds* in spring are the same as in winter—namely, the *cirro-stratus*, which more frequently gathers itself into the *cumulo-stratus*, and hovers about the horizon, and either subsides entirely below it on the approach of frost at night, or veils the zenith in the daytime in the form of *cirro-stratus*; but the *cumulo-stratus* of spring presents a very different aspect to what it does in summer, having generally a well-defined though ragged margin, and a peculiar look of transparency or clearness, which is preserved even when the clouds become purple or nearly black.

Rain in Spring.—The character of rain in spring is sudden, violent, and

[1] Kaemtz's *Cour. Meteoro.*, 50-54.

cold, not unfrequently attended with hail.

Evaporation in Spring.—Evaporation is quick in spring, especially with an E. wind, the surface of the ground being as easily dried as wetted. Thus two or three days of drought will raise the dust in March, and hence the cold felt on such occasions.

Prognostics of Spring.—The weather in spring may be regarded as the keystone to that of the ensuing seasons. Its indications are analogous to those of *cirri*, which make the first movement in the upper regions of the sky when a change is about to take place in the state of the atmosphere. The *prognostics* of spring are therefore worthy of attention, and the enumeration of a few of them may point to that class of phenomena which deserves the greatest attention at this season.

Dalton says that the *barometer* is at the lowest of all during a thaw following a long frost, and is often brought down by a S.W. wind. When the barometer is near the high extreme for the season of the year, there is very little probability of immediate rain; when the barometer is low for the season, there is seldom a great weight of rain, though a fair day in such a case is rare; the general tenor of the weather at such times is short, heavy, and sudden showers, with squalls of wind from the S.W., W., or N.W. When the appearance of the sky is very promising for fair weather, and the barometer at the same time low, it may be depended upon that the appearances will not long continue so; the face of the sky changes very suddenly on such occasions. Very dark and dense clouds pass over without rain when the barometer is high; whereas, when the barometer is low, it sometimes rains almost without any appearance of clouds. A sudden and extreme change in *temperature*, either from heat to cold, or from cold to heat, is generally followed by rain within 24 hours.

Weather Proverbs.—Many prognostics of the weather have been received as proverbs by the country people; and as these have become current only after mature experience, we may rely on their accuracy. These are a few relating to spring:—

February.

February fill dyke, be it black or be it white:
But if it be white, it's the better to like.

The hind has as leif see his wife on the bier,
As that Candlemas day should be pleasant and clear.

If Candlemas day be fair and clear,
The half o' winter is to gang and mair;
But if Candlemas day be foul,
The half o' winter is gane at Yule.

March.

March hack ham, comes in like a lion, goes out like a lamb.

A bushel of March dust is worth a king's ransom.

March grass never did good.

A windy March, and a showery April, make a beautiful May.

March wind and May sun
Make clothes white and maids dun.

So many frosts in March, so many in May.

March many weathers.

March birds are best.

April.

April showers bring forth May flowers.

When that Aprilis with her showery soote
The droughte of March had pierced to the roote.

When April blows his horn,
It's good both for hay and corn.

A cold April the barn will fill.

The *borrowing days*—the last days of March and the first days of April—are proverbially stormy. This well-known rhyme is regarding them:—

March said to Averil,
Do you see thae hoggs on yonder hill?
If ye lend me days three,
I'll do my best to gaur them dee.
The first day was wind and weet,
The second day was snaw and sleet,
The third day was sic a freeze
As festen'd the birdies to the trees;
But when the three days war come and gane,
A' the wee hoggies gaed hirplin' hame.

Birds in Spring Storms.—During a snowstorm in spring, wild birds, becoming almost famished, resort to the haunts of man. The robin is a constant visitor, and helps himself with confidence to the crumbs placed for his use. The male partridge calls in the evening within sight of the house, in hopes of obtaining some support before collecting his covey together for the night to rest upon the snow.

Hares have been known to come to the door in the evening, and through the night in the moonlight, to receive the food set down for them. Rooks now make desperate attacks upon the stacks, and will soon make their way through the thatch. Beginning their attacks at the top, they seem to be aware of the exact place where the corn can be most easily reached. Sparrows burrow in the thatch; and even the diminutive tomtit, with a strength and perseverance one should suppose beyond its ability, pulls out whole straws from the side of the stacks, to procure the grain in the ear.

Further on in spring, the insect world come into active life in myriads, to serve as food for the feathered tribes. Rooks, with sturdy walk and independent gait, diligently search the ground for them, in the wake of the plough, and feed their young therewith. Tomtits clamber round every branch of trees which indicate an opening of their floret buds. A stream of migration to the north, of wild geese and other water-fowl, betokens the approach of genial weather.

Cottage Gardening.—"By the time the season is fairly confirmed, the leisure hours of the cottagers," and of the ploughmen, who are cottagers of the best description, are spent, in the evening, "in the pleasing labour, not unaccompanied with amusement, of trimming their little gardens, and getting in their early crops. There is no sort of village occupation which men, women, and children set about with greater glee and animation than this; for, independently of the hope of the produce, there is a pleasure to the simple and unsophisticated heart in 'seeing things grow,' which, perhaps, they who feel the most are least able to explain.

"Certain it is, however, that it would be highly desirable that not only every country labourer, but every artisan in towns, where these are not so large as to prevent the possibility of it, should have a little bit of garden, and should fulfil the duty which devolved on man in a state of innocence, 'to keep it and to dress it.' It is impossible for any one who has not carefully attended to the subject, to be at all aware how strong the tie is which binds man even to a little spot of his native earth, if so be that he can consider it as his own, and that he himself, and those on whom he loves to bestow it, are to enjoy the fruit.

"This is the very strongest natural hold which binds a poor man to his country, and to all those institutions established for the wellbeing of society. Show me the cottage, the roses and the honeysuckles on which are neatly trimmed and trained, and the garden behind is well stocked with culinary herbs and a few choice flowers, and I will speedily find you a cottager who never wastes his time or money, or debases his mind, and learns 'the broad road which leadeth to destruction,' in the contamination of an alehouse. If the garden is neat, one may rest assured that the cottage, however humble it is, is the abode of contentment and happiness; and that, however simple the fare may be, it is wealth and luxury in full store to the inmates, because they are satisfied with it, and grateful for the possession of it." [1] The contentment of the married ploughmen—in districts where comfortable cottages and little garden-plots are provided—and the attachment to the farm upon which they serve, may be traced to the feelings expressed in these remarks.

The Farmer's Garden.—Farmers, as a rule, are bad gardeners. Not unfrequently the garden, or where the garden should be, is one of the most thoroughly neglected spots on the farm. This is much to be regretted, for the value of a good, well-stocked kitchen-garden to a household is very great. There should be a garden on every farm, and it may be kept in good order at trifling expense. The hedger, stableman, or some other of the farm-servants, should know as much of the art of gardening as to be able to keep the farmer's garden in decent order in the absence of a gardener, whose assistance may with advantage be called in to crop the ground in the respective seasons. A field-worker now and then could keep the weeds in subjection, and allow both sun and air free access to the growing plants. Besides carelessness about the garden, the

[1] Mudie's *Spring*, 274-275.

same feeling is evinced by too many farmers in the slovenly state in which the shrubbery and little avenue attached to their dwelling are kept.

Fat Cattle.—In spring the farmer thinks of disposing of the remainder of his fat cattle. Should he not be offered the price he considers them worth, he may keep them on for a time—a few of them perhaps for a month or two on grass—for beef is usually plentiful and cheap in spring, and scarce and dear early in summer.

Grass Parks.—Spring is the season for letting grass parks. In the majority of cases the parks are held by landed proprietors. The ready demand for old grass induces the retention of pleasure-grounds in permanent pasture, and removes temptation from a landlord to speculate in cattle. It is not customary for farmers to let grass parks, except in the neighbourhood of large towns, where cowfeeders and butchers find them so convenient as to induce them to tempt farmers with high prices. Facility of obtaining grass parks in the country is useful to the farmer who raises grazing stock, when he can give them a better bite or warmer shelter than he can offer them himself, on the division of the farm which happens to be in grass at the time.

Selling Wood.—The landed proprietor has also to seek a market in spring for his *timber*, which he annually fells in thinning his plantations. Such sales afford convenient supplies to farmers in want of paling for fencing new hedges, wood for sheep-flakes or stobs, or timber for the erection of shedding for animals, or for implements. They are also serviceable to country joiners and implement-makers, in affording them necessary materials nigh at hand. The timber is felled by the owner, and assorted into lots of sizes and kinds best suited to the local demand. Prunings and thinnings are sold as firewood.

ADVANTAGES OF HAVING FIELD-WORK WELL ADVANCED.

The season—*early spring*—having arrived when the labouring and sowing of the land for the various crops cultivated on a farm of mixed husbandry are about to occupy all hands for several months to come, the injunction of old Tusser to undertake them in time, so that each may be finished in its proper season, should be regarded as sound advice. When field-labour is advanced ever so little at every opportunity of weather and leisure, no premature approach of the ensuing season can come unawares; and no delay beyond the usual period will find the farmer unprepared to proceed with the work. When work proceeds by degrees, there is time to do it effectually. If it is not so done, the farmer has himself to blame for not looking after it. When work is advancing by degrees, it should not be allowed to be done in a careless manner, but with due care and method, so as to impress the work-people with the importance of what they are doing. The advantage of doing even a little effectually is not to have it to do over again afterwards; and a small piece of work may be done as *well*, and in as short a time, in proportion, as a greater operation.

Keep the Plough going.—Even if only one man is kept constantly at the plough, he would turn over, in the course of a time considered short when looked back upon, an extent of ground almost incredible. He will turn over an imperial acre a-day—that is, 6 acres a-week, 24 acres in a month, and 72 acres in the course of the dark and short days of the winter quarter. All this he will accomplish on the supposition that he has been enabled to go at the plough every working day; but as that cannot probably happen in the winter quarter, suppose he turns over 50 acres in that time, these will still comprehend the whole extent of ground allotted to be worked by every pair of horses in the year. Thus a large proportion of a whole year's work is done in a single, and that the shortest, quarter of the year. Now, a week or two may quickly pass, in winter, in doing things which, in fact, amount to time being thrown away.

Instances of misdirected labour are too apt to be regarded as trifles *in winter;* but they occupy as much time as the most important work—and at a season, too, when every operation of the field is directly preparatory to others to be executed in a more busy season.

Neglected Work inefficiently done.—The state of the work should be a subject for the farmer's frequent consideration, whether or not it is as far advanced as it should be; and should he find the work to be backward, he consoles his unsatisfied mind that when the season for active work really arrives, the people will make up for the lost time. Mere delusion—for if work can be made up, so can *time*, the two being inseparable; and yet, how can lost time be made up, when it requires every moment of the year to fulfil its duties, and which is usually found too short in which to do everything as it *ought to be done?* The result will always be that the neglected work is done in an inefficient manner.

Subdivision of Farm work.—*Field*-labour should be perseveringly advanced in winter, whenever practicable; and some consider it a good plan, for this purpose, to apportion certain ploughmen to different departments of labour—some to work constantly on the farm, some constantly at the plough, others frequently at the cart. When the elder men and old horses, or mares in foal, are appointed especially to plough, that most important of all operations will be well and perseveringly executed, while the young men and horses are best suited for carting when not at the plough. Thus the benefits of the subdivision of labour may be extended to farm operations.

Advancing Field-work.—It is right to give familiar examples of what is meant by the advantage of having field-labour advanced whenever practicable. The chief work in spring is to sow the ensuing crops. It should therefore be the study of the farmer in winter to advance the work for spring sowing. When the weather is favourable for sowing spring wheat, a portion of the land, cleared of turnips by the sheep, may perhaps be ploughed for wheat instead of barley. If beans are cultivated, let the ploughing suited to their growth be executed; and in whatever mode beans are cultivated, care should be taken in winter to have the land particularly dry, by a few additional gaw-cuts where necessary, or clearing out those already existing. Where common oats are to be sown, they being sown earlier than the other sorts, the lea intended for them should be ploughed first, and the land kept dry; so that the worst weather in spring may not find the land in an unprepared state. The land intended for potatoes, for turnips, or tares, or bare fallow, should be prepared in their respective order; and when every one of all these objects has been prepared for, and little to do till the burst of spring work arrives, both horses and men may enjoy a day's rest now and then, without any risk of throwing work back.

Spring Preliminaries.—But besides field operations, other matters require attention ere spring work come. The implements required for spring work, great and small, have to be repaired—the plough-irons new laid; the harrow-tines new laid, sharpened, and firmly fastened; the harness tight and strong; the sacks patched and darned, that no seed-corn be spilt upon the road; the seed-corn threshed, measured up, and sacked, and what may be last wanted put into the granary; the horses new shod, that no casting or breaking of a single shoe may throw a pair of horses out of work for even a single hour;—in short, to have everything ready to start for the work whenever the first notice of spring shall be heralded in the sky.

Evils of Procrastination.—But suppose all these things have been neglected until they are wanted—that the plough-irons and harrow-tines have to be laid and sharpened, when perhaps to-morrow they may be wanted in the field—a stack to be threshed for seed-corn or for horse's corn when the sowing of a field should be proceeded with; suppose that only a week's work has been lost, in winter, of a single pair of horses, 6 acres of land will have to be ploughed when they should have been sown,—that instead of having turnips in store for the cattle when the oat-seed is begun, the farmer is obliged to send part of the draughts to fetch turnips—which cannot then be stored—and the cattle will have to be supplied with them from the field during all the busy season.

In short, suppose that the season of incessant labour arrives and finds every one unprepared to go along with it, what must be the consequences? Every creature, man, woman, and beast, will then be toiled beyond endurance every day, not to *keep up* work, which is a lightsome task, but to *make up* work, which is a toilsome burden. Time was lost and idled away at a season considered of little value; thus exemplifying the maxim, that "procrastination is the thief of time"—and after all, the toil will be bestowed in vain, as it will be impossible to sow the crop *in due season.* Those implicated in procrastination may fancy this to be a highly coloured picture; but it is drawn from life.

CATTLE IN SPRING.

To the stock-owner the spring months are full of hopes and anxieties. At the opening of the season calving will most probably be in full swing; and in breeding stocks this is the most critical period in the whole year. Naturally, therefore, the treatment of cows and their young produce demands our first consideration at this time.

THE CALVING SEASON.

The calving of cows is one of the chief events of the spring upon stock farms. Not that calving does not occur until spring—for most breeders of farm-stock are anxious to have calves early, particularly bull-calves, and for that purpose calves are born as early as the month of December. Besides, those in the new-milk trade require to have the animals dropping their young at intervals during the whole year. Still by far the largest proportion of cows do not calve until January, February, and March, and the season of calving continues good till the middle of April. After that date the calves are accounted late.

An early calf possesses the advantage of having passed through its period of milk-drinking in time to be supported upon grass, as soon as it affords sufficiency of food. *A late calf* somehow seems never to fully regain the lost time.

Risks of the Calving Season.—From eight to ten weeks at this season is a period of great anxiety for the state of the cows. Every care, therefore, that can conduce to her passing in safety over this critical period ought to be cheerfully bestowed. When the cow first shows heavy in calf, which is after the sixth month, the litter in the court should not be too deep, as over-exertion in wading through soft litter may cause such an excited action of the cow's system as to make her slip calf. The litter in a court constantly trampled by cattle at freedom becomes firm, and affords a good footing, and the cattle-man should spread every barrowful thinly.

Cows, as they calve, and after it is safe for them to go into the air, should not go into the court at the same time with those yet to calve; as calved cows soon *come into season*—that is, desire the bull—and when in this state, the other cows ride upon them, and this propensity is strongest in those cows yet uncalved. Such violent action, upon soft litter, is likely to prove injurious to uncalved cows. The time of day in which cows in different states may go out, should be left to the discretion of the cattle-man, who knows that cows, after calving, become more tender in their habit than before, and should have the best part of the day—from 12 to 2 o'clock.

Symptoms of Pregnancy.—Cows may be ascertained to be in calf between the fifth and sixth months of their gestation. The calf quickens at between four and five months. The calf may be felt by thrusting the points of the fingers against the right flank of the cow, when a hard lump will bound against the abdomen, and be felt by the fingers. Or when a pailful of *cold* water is drunk by the cow, the calf kicks, when a convulsive sort of motion may be observed in the flank, by looking at it from behind, and if the open hand is then laid upon the space between the flank and udder, this motion may be most distinctly felt. It is not in every case that the calf can be felt at so early a period of its existence; for lying then in its natural position in the interior of the womb, it cannot be felt at all; and when it lies near the left side of the cow, it is not so easily felt as on the opposite one. So that, although the calf cannot be *felt* at that early stage, it is no proof that the cow is not in calf.

When a resinous-looking substance can be drawn from the teats by stripping them firmly, the cow is sure to be pregnant. After five or six months, the flank in the right side fills up, and the general enlargement of the under part of the abdomen affords an unequivocal symptom of pregnancy.

But there is seldom any necessity for thus trying whether a cow is in calf, for if she has not sought the bull for some months, it is almost certain to be because she is pregnant.

Youatt's Method of Testing Pregnancy.—These are the common modes of ascertaining the pregnant state of the cow; but Youatt has afforded us more scientific means of ascertaining the fact. He says he would not give, nor suffer any one else to give, those terrible punches on the right flank, which he had no doubt were the cause of much unsuspected injury, and occasionally, at least, were connected with, or were the origin of, difficult or fatal parturition. At a very early stage of the gestation, he says, by introducing the hand gently and cautiously into the vagina, the state of the womb may be ascertained. If it is in its natural state, the mouth of the womb or *os uteri* will be closed, though not tightly so; but if it is impregnated, the entrance of the uterus will be more firmly closed, and the protrusion will be towards the vagina. He adds a caution, however, in using this mode of exploration: "When half, or more than half, of the period of pregnancy is passed, it is not at all unlikely that so much irritation of the parts will ensue as to cause the expulsion of the fœtus." He would rather introduce his hand into the rectum, and as the fœtus of two months is still in the pelvic cavity, he would feel the little substance under his hand. He adds: "I am certain that I am pressing upon the uterus and its contents. I cannot, perhaps, detect the pulsation of the embryo; but if I had delayed my examination until the fœtus was three months old, I should have assurance that it was there by its now increased bulk, while the pulsation of its heart would tell me that it was living."

When still older, the pulsation of the heart may be distinctly heard on applying the ear closely to the flank here and there, and upwards and downwards, while the cow is held quietly and steadily.

Cow's Womb.—The womb of the cow is a bag of irregular form, having a chamber or division attached to each side, called the horns of the womb; and so called, perhaps, because of the horn-like form they present in an unimpregnated state. The womb consists almost entirely of muscular fibres, with a large proportion of blood-vessels and of vascular matter, which admits of contraction and extension. Its ordinary size in a large cow is about 2½ feet in length, but, when containing a full-grown fœtus, it is 7 feet in length. This is an extraordinary adaptation to circumstances which the womb possesses, to bear an expansion of 7 feet, from about a third of that length, and yet be capable of performing all its functions.

The Fœtus.—"The fœtus of the cow is huddled up in the right side of the belly," says Youatt. "There its motions are best seen, and the beatings of its heart best heard. The enormous paunch, lying principally in the left side, presses every other viscus, and the uterus among the rest, into the right flank.

Indication of Twins.—"This also explains a circumstance familiar to every breeder. If the cow should happen to carry twins they are crowded together in the right flank, and one seems absolutely to lie upon the other. Whenever the farmer notices the kicking of the fœtus high up in the flank, he at once calculates on twins." [1]

Reckoning Time of Calving.—The exact time of a cow's calving should be known by the cattle-man as well as by the farmer himself, for the time when she was served by the bull should be registered. Although this last circum-

[1] *Jour. Agric. Soc. Eng.*, i. 172.

stance is not a certain proof that the cow is in calf, yet if she has passed the period when she should have taken the bull again without showing symptoms of season, it may safely be inferred that she became in calf at the last serving, from which date should be calculated the period of gestation, or of *reckoning*, as it is called.

A cow is reckoned to go just over 9 months with calf, although the calving is not certain to a day. The experiments of the late Earl Spencer afford useful information on this point. After keeping the record of the calving of 764 cows, he came to this conclusion: "It will be seen that the shortest period of gestation, when a live calf was produced, was 220 days, and the longest 313 days; but I have not been able to rear any calf at an earlier period than 242 days. Any calf produced at an earlier period than 260 days must be considered decidedly premature; and any period of gestation exceeding 300 days must also be considered irregular: but in this latter case the health of the produce is not affected. It will also be seen that 314 cows calved before the 284th day, and 310 calved after the 285th; so that the probable period of gestation ought to be considered 284 or 285 days, and not 270, as generally believed."

Indication of Bull-calves.—It is also a popular belief that when a cow exceeds the calculated period of gestation, she will give birth to a bull-calf. The belief accords so far with experience. Lord Spencer observes, "In order fairly to try this, the cows that calved before the 260th day, and those that calved after the 300th, ought to be omitted as being anomalous cases, as well as the cases in which twins are produced; and it will then appear that from the cows whose period of gestation did not exceed 286 days, the number of cow-calves produced was 233, and the number of bull-calves 234; while of those whose period exceeded 286 days, the number of cow-calves was only 90, while the number of bull-calves was 152."[1]

Calf-bed coming Down.—Cows are most liable to the complaint of the coming down of the calf-bed, when near the period of calving, between the eighth and ninth months, and, from whatever cause it may originate, the position of the cow, as she lies in her stall, should be amended by raising her hind quarters as high as the fore by means of the litter. The immediate cause of the protrusion of a part of the womb is, the pressure of the calf's fore feet and head against that part of it which is opposite to the vaginal passage, and the protrusion mostly occurs when the calf is in its natural position; so that, although no great danger need be apprehended from the protrusion, it is better to use means to prevent its recurrence than to incur bad consequences by indifference or neglect.

Feeding In-calf Cows.—Much more care should be bestowed in administering food to cows near the time of their reckoning than is generally done. The care should be proportioned to the state of the animal's condition. When in high condition, there is great risk of inflammatory action at the time of parturition. It is therefore the farmer's interest to check every tendency to obesity in time. This may partly be effected by giving fewer turnips and more fodder than the usual quantity; but some cows when in calf, and have been long dry, will fatten on a very small quantity of turnips; and there is a tendency in dry food to aggravate inflammatory action.

Medical Treatment of In-calf Cows.—Other means should therefore be used, along with a limited allowance of food. In as far as medical treatment can be applied to the case, there is perhaps nothing safer than bleeding and laxatives. "Every domestic animal like the cow," observes Skellett, "is to be considered as by no means living in a state of nature. Like man himself, she partakes of civilised life, and of course is subjected to similar infirmities with the human race. The time of gestation is with her a state of indisposition, and every manager of cattle should be aware of this, and treat her with every attention and care during this time. The actual diseases of gestation are not indeed numerous, but they are frequently very severe, and they occasion always a tendency to slinking, or the cow slipping her calf. As the weight of the calf begins to increase, it will then be necessary to take some precautions—and

[1] *Jour. Agric. Soc. Eng.*, i. 167, 168.

these precautions will consist in an attention to her diet, air, and exercise." [1]

Critical Period in Pregnancy.—The eighth and ninth months constitute the most critical period of a cow in calf. The bulk and weight of the fœtus cause disagreeable sensations in the cow, and frequently produce feverish symptoms, the consequence of which is costiveness. The treatment is laxative medicine and emollient drinks, such as a dose of 1 lb. of Epsom salts with some cordial admixture of ginger and caraway-seed and treacle, in a quart each of warm gruel and sound ale. Turnips may be given in moderate quantities, as they have a laxative tendency, especially the white varieties. Potatoes are inadmissible, because of their great tendency to produce hoven. If hoven were to overtake a cow far advanced in pregnancy, the calf would either be killed in the womb, or it would likely cause the cow to abort.

Oilcake for Calving Cows.—Oilcake as a laxative along with swedes is very satisfactory. The cake is given to the cows for two months, one month before and one after calving, and its valuable property of keeping them in a fine laxative state, and at the same time in good health, will be amply demonstrated. The quantity given to each cow daily is usually 2 to 4 lb. at any intermediate time between the feeds of turnips. When a little oilcake is given to cows before and after their calving, less apprehension need be entertained of their safety as far as regards their calving, in whatever condition they may happen to be, as it proves a laxative to the fat, and nourishing food to the lean, cow.

Over-leanness to be avoided.—But the state of over-leanness is also to be avoided in cows in calf. The cow should have nourishing food, such as mashes of boiled barley, turnips, and oilcake, not given in large quantities at a time, but frequently, with a view to laying on flesh in a gradual manner, and at the same time of avoiding the fatal tendency to plethora.

Abortion.

Slinking, abortion, or slipping of the calf, is a vexatious occurrence, and a great loss to the breeder of stock. It is not only a loss of perhaps a valuable calf, but its want makes a blank in the number of the lot to be brought up in the season, which can be filled only by purchase, perhaps not even in that way. Another vexation is that the cow can never again be fully depended upon to bear a living calf, as there will be considerable danger of her slipping in after-years. Why this result should ensue has never been satisfactorily explained. The only safe remedy for the farmer is to take the milk from the cow as long as she gives it, and then fatten her for the butcher.

Causes of Abortion.—The direct causes of this troublesome complaint are various,—chiefly violent exercise, frights, bruises, knocks, bad attendance, diseased bulls, bad food—particularly musty fodder—impure water, bad smells, sympathy, and hay affected with ergot.

Fig. 240.—*Head of timothy with numerous ergots.*

Ergot and Abortion.—There has from time to time been much discussion as to whether or not abortion in cows is due in any large measure to their eating grasses affected with ergot. Ergot is a fungus which attacks the ear or panicle of grasses and cereals, rye particularly, takes the place of the seed, and is recognised there as a black spur. See fig. 240, which represents a head of timothy grass with numerous ergotised ears. Ergot is a strong irritant, and the idea is, that the irritation which ergot consumed in the food by cows sets up in the womb results in the premature expulsion of the fœtus. It is in ergotised hay that the greatest danger exists, for in hay ergot is sometimes present in considerable quantities.

But there is good reason to doubt the contention that ergot is one of the chief causes of abortion amongst cows. It is rarely present in farm crops in such large

[1] Skellett's *Partur. Cow*, 41.

quantities as to be likely to cause abortion. Farmers should certainly regard ergot as a dangerous enemy, and should burn any portions of hay in which it is seen to exist extensively. We suspect, however, that the great majority of the many cases of abortion which occur every year amongst cows must be attributed to other causes.

Bad Smells and Abortion.—Skellett observes: "The cow is remarked to possess a very nice and delicate sense of smelling, to that degree, that the slinking of one cow is apt, from this circumstance, to be communicated to a great number of the same herd; it has been often known to spread like an infectious disease, and great losses have been suffered by the cowfeeders from the same."[1] There is unquestionably much truth in these remarks, and it is therefore desirable that everything in a byre occupied by breeding cows should be kept in a clean and wholesome state. Every particle of filth should be removed daily from the feeding-troughs in front, and the urine-gutters behind the cows, and the byre should be thoroughly ventilated when the cows go out to the courts.

These circumstances also show the propriety of preventing pigs being slaughtered in the court in which cows walk, and any animal being bled near the byre.

Symptoms of Abortion.—The first symptoms of abortion are a sudden filling of the udder before the time of reckoning would warrant, a looseness, flabbiness, and redness of, and a yellow glairy discharge from, the vagina, and a giving way of the ligaments on both sides of the rump.

Preventing Abortion.—Whenever a cow shows symptoms of slinking, which may be observed in the byre, but not easily in the grass field, she should be immediately removed from her companions. She should be narrowly watched, and means of preventing slinking instantly adopted. These consist in keeping her perfectly quiet, giving laxative food, such as oilcake and mashes, and if there is straining, frequent doses of opium, belladonna, or antispasmodics.

But these means will prove ineffectual if the symptoms make their appearance suddenly, and go through their course rapidly.

Mr C. Stephenson on Preventive Means. — Mr Clement Stephenson, M.R.C.V.S., Newcastle-on-Tyne, in a suggestive paper in the *Royal Agricultural Society of England's Journal* (1885), says: "All breeding animals should be kept in as natural a condition as possible. The food should be good in quality, and apportioned according to the breeding state they are in; remember that the fœtus as well as the cow is to be kept in a growing healthy condition. Avoid the practice of giving inferior and refuse food to in-calf cows. Be very particular respecting the purity of the water-supply; neglect of this is a fruitful cause of abortion. See to general sanitary arrangements, ventilation, pure air, and good drainage; use disinfectants freely. In the fields keep a sharp look-out for decomposing putrid matter, which eventually destroy. Exercise is most important; even in winter cows should be let out for a short time every day. Before service be sure that the generative organs of both animals are healthy. Where possible, split up the herd into small lots, cows with bull-calves, cows with heifer-calves, cows and heifers to serve, cows and heifers settled in calf, and doubtful breeders by themselves, which do not serve with a valuable bull, or unless they are regular."

Hemp-seed as a Preventive.—Many American breeders have strong belief in hemp-seed as a safe preventive of repeated abortion in cows that had previously aborted—common hemp-seed, half a pint morning and night about the time of pregnancy at which the cow formerly aborted. Fluid extract of Indian hemp is also commended—a table-spoonful every second day in wet bran, from the time corresponding to former abortion up to within a month of calving. This fluid in excess would itself cause abortion, but in small doses it has a beneficial effect by allaying irritation.

After-risks from Abortion.—The risk which the cow runs, after slinking, is *in not getting quit of the cleansing, afterbirth,* or *placenta,* it not being in a state to separate from the womb. Should it remain, it will soon corrupt, and send

[1] Skellett's *Partur. Cow*, 62.

forth a very nauseous smell, to the detriment of the other cows. If it does not come away in the course of a few hours, or at most a day, the assistance of the veterinary surgeon should be obtained. But in ordinary cases a dose of laxative medicine—such as 1 lb. Epsom salts, 1 oz. powdered ginger, and 1 oz. caraway-seeds—will be quite sufficient.

The cow should have plenty of warm drinks, such as warm water, thin gruel, and mashes made of malt, with bran, so as to keep the body gently open—which should be attended to at all times. Should the regimen not be sufficient to keep the body open, and feverish symptoms appear, recourse must be had to stronger remedies, such as Epsom salts, 1 lb.; nitre, 2 oz.; anise-seed in powder, 1 oz.; cumin-seed in powder, 1 oz.; ginger, ½ oz.;—mixed together for one dose, which is to be given in 2 quarts of water-gruel with ½ lb. of treacle. This dose may be repeated, if the first dose has not had the desired effect, in ten or twelve hours.

Preventing recurrence of Abortion.—In regard to preventing the recurrence of this vexatious complaint, though the best thing for the farmer is not to attempt any, but milk and fatten the cow, yet a natural desire may be felt to retain a valuable and favourite cow, so that means may be used to enable her again to bear a living calf. Skellett mentions as preventive measures, that "when a cow has slipped her calf, in the next gestation she should be early bled, her body should be kept open by cooling physic; she should not be forced to take any more exercise than what is absolutely necessary for her health, and her interfering with other cattle guarded against by keeping her very much by herself. At the same time," he adds, "it must be observed, that though it is necessary to preserve a free state of the bowels, a laxity of them will often produce this accident; cows *fed very much upon potatoes*, and such other watery food, *are very apt to slink*, from their laxative effects. In the food of the cow, at this time, a proper medium should be observed, and it should consist of a due proportion of other vegetable matter mixed with the fodder, so as the bowels may be kept regularly open, and no more."

If the cow is in high condition, she should be reduced in condition; if in very low, she ought to get nourishing food and strengthening medicines; and if she is much annoyed by nauseous smells, these should either be counteracted, or the cow withdrawn from them.

Disinfecting powders and fluids must be sprinkled about the byres—such as Jeyes's fluid, or some preparation of carbolic acid—while washing the backs of the animals themselves with a weak solution of sheep dip or "smear" will tend to counteract any smell or contagion about the animals themselves.

Coarse Pasture causing Abortion.—It is understood that cows which are fed in the neighbourhood of, and in woods, and that live on coarse rank pasture in autumn, are most liable to this complaint. In Switzerland the complaint increases after the cows are put on rank pastures in autumn. Similar experience has been had in this country, where in-calf cows have grazed pastures on which there was a rank growth of coarse herbage, especially after wet sunless years such as 1879. We know of some cases where good has been done by having coarse herbage of this kind cut by a mower in the autumn and gathered into the dung-pit or burned.

Is Abortion Infectious?—Although slinking is spoken of as an infectious complaint, it has no property in common with any contagious disease; and sympathetic influence being a main cause of it, the result is as fatal as if direct contagion had occasioned it.

Calving.

Symptoms of Calving.—About a fortnight before the time of reckoning, symptoms of calving indicate themselves in the cow. The loose skinny space between the vagina and udder becomes florid; the vagina becomes loose and flabby; the lower part of the abdomen rather contracts; the udder becomes larger, firmer, more florid, hotter to the feel, and more tender-looking; the milk-veins along the lower part of the abdomen become larger, and the coupling on each side of the rump-bones looser; and when the couplings feel as if a separation had taken place of the parts there, the cow should be watched day and night, for at any hour afterwards the pains of calving may come upon her. From this period the animal becomes easily excited, and on that account should not be allowed to go out, or be disturbed in the house. In some cases these premonitory symptoms succeed each other rapidly, in others they follow slowly. With heifers in first calf these symptoms are slow.

Attendance at Calving.—Different practices exist in attending on cows at calving. In the southern counties the cattle-man attends on the occasion, assisted sometimes by the shepherd, and other men if required. In some parts of the northern counties, as also in the south-western counties of Scotland, the calving is left to women to manage. This difference in practice may have arisen from the *degree of assistance* required at the operation. The large and valuable breeds of cows almost always require assistance in calving, the neglect of which might cause the cow to sink from exhaustion, and the calf to be strangled or drowned at its birth. Powerful assistance is sometimes required, and can be afforded only by men, the strength of women being unequal to the task.

The cows of the smaller varieties more frequently calve without assistance, and with these women may manage the calving without difficulty.

On large farms there should be a skilled cattle-man to take the charge, the farmer himself in all cases giving his sanction to the means about to be employed—it being but fair that he himself should bear the heaviest part of the responsibility connected with the process of calving.

Preparation for Calving.—A few preparatory requisites should be at hand when a cow is about to calve. Flat *soft* ropes should be provided on purpose to tie to the calf. The cattle-man should have the calf's crib well littered, and pare the nails of his hands close, in case he should have occasion to introduce his arm into the cow to adjust the calf; and he should have goose-fat or hog's lard with which to smear his hands and arm, although the glairy discharge from the vagina will usually be sufficient for this purpose. Goose-fat makes the skin smoothest. It may be necessary to have a sackful or two of straw to put under the cow to elevate her hind-quarters, and even to have block and tackle to hoist up the hind-legs in order to adjust the calf in the womb. These last articles should be ready at hand if wanted. Straw should be spread thickly on the floor of the byre, to place the new-dropped calf upon. All being prepared, and the byre-door closed for quietness, the cow should be attended every moment.

Progress of Calving.—The proximate symptoms of calving are thus exactly described by Skellett as they occur in an ordinary case. "When the operation of calving actually begins," he says, "then signs of uneasiness and pain appear: a little elevation of the tail is the first mark; the animal shifts about from place to place, frequently getting up and lying down, not knowing what to do with herself. She continues some time in this state, till the natural throes or pains come on; and as these succeed each other in regular progress, the neck of the womb, or *os uteri*, gives way to the action of its bottom and of its other parts. By this action the contents of the womb are pushed forward at every throe; the water-bladder begins to show itself beyond the shape, and to extend itself till it becomes the size of a large bladder, containing several gallons; it then bursts, and its contents are discharged, consisting of the *liquor amnii*, in which, during gestation, the calf floats, and which now serves to lubricate the parts, and renders the passage of the calf easier. After the discharge of the water, the body of the womb contracts rapidly upon the calf; in a few succeeding throes or pains the head and feet of it, the presenting parts, are protruded externally beyond the shape. The body next descends, and in a few pains the delivery of the calf is complete."[1]

Assistance in Calving.—The easy calving here described is usually over in 2 hours, though sometimes it is protracted to 5 or 6, and even to 12 hours, particularly when the water-bladder has broken before being protruded beyond the vagina, and then the calf is in danger of being drowned in the passage. But although the calf may present itself in the natural position, with both its fore-feet projecting, its chin lying on both the fore-legs, and

[1] Skellett's *Partur. Cow*, 105.

the point of the tongue appearing out of the side of the mouth, it may not be calved without assistance. To render this, the feet of the calf being too slippery to be held firmly by the bare hands, the soft flat rope, with a folding loop at the double, is placed above each fetlock joint, and the double rope from each leg is held by the assistants. A pull of the ropes should only be given at each time the cow strains to get quit of the calf. It should be a steady and firm pull, in a direction rather downwards from the back of the cow, and sufficiently strong to retain whatever advance the calf may have made. The assistance given is rather to ease the cow in her exertions in the throes, than to extract the calf from her by force. Meantime the cowman endeavours to relax the skin of the vagina round the calf's head by manipulation, as well as by anointing with goose-fat, his object being to slip the skin over the crown of the calf's head; and when this is accomplished, the whole body may be gently drawn out. In obstinate cases of this simple kind, a looped rope passed across in the mouth round the under jaw of the calf, and pulled steadily, will help the passage of the head; but this expedient should not be resorted to until the cowman cannot effect it with his hands, the cord being apt to injure the tender mouth of the calf.

The Calf.—On the extrusion of the calf, it should be laid on its side upon the clean straw on the floor. The first symptom of life is a few gasps which set the lungs in play, and then it opens its eyes, shakes its head, and sniffs with its nose. The breathing is assisted if the viscid fluid is removed by the hand from the mouth and nostrils. The calf is then carried by two men, suspended by the legs, with the back downwards, and the head held up between the fore-legs, to its comfortably littered crib, where we shall leave it for the present.

Reverse Presentation.—The presentation is sometimes made with the *hind-feet foremost*. At first the hind-feet are not easily distinguished from the fore; but if a hind presentation is made in the natural position of the body, with the back uppermost, the hind-feet will be in an inverted position, with the soles uppermost. There is no difficulty in a hind presentation, only the tail should be put straight, and not folded up, before the legs are pulled out. The first obstructing point in this presentation is the rump, and then the thickest part of the shoulder. On drawing out the head, which comes last, it should be pulled away quickly, in case the calf should give a gasp for air at the moment of leaving the cow, when it might inhale water instead of air, and run the risk of drowning. The mouth and nose should, in this case, be wiped immediately on the calf being laid down upon the straw on the floor.

Restless Cows in Calving.—All as yet has been easily managed, and so will be as long as the cow lies still on her side in the stall, with plenty of straw around and behind her hind-quarter. But some cows have a restless disposition, and, whenever the pains of labour come on, start to their feet, and will only lie down again when the pain ceases. It is thus scarcely possible to ascertain the true position of the calf, especially when not presented in a natural position. It is now necessary to extract the calf energetically, and remove the uneasiness of the cow quickly; for until she gets quit of the calf, she will not settle in any one position. When the calf is so near the external air as to enable the operator to get the ropes round its legs, whether fore or hind, they should be fastened on immediately after the discharge of the water, and, on gently pulling them, her attention will be occupied, and she will strain with great vigour, the standing position giving her additional power, so that the extraction of the calf is expeditious.

As the calf will fall a considerable height, the ground should be well littered, so as to receive the body of the calf upon it. Active means should be used after the symptoms of actual calving have begun. If such are neglected, the calf may be found killed, or injured for life.

Reviving Calves.—Some calves, though extracted with apparent ease, appear as if dead when laid upon the straw. Besides removing the viscid fluid from the mouth and nose, the hand should be placed against the side of the breast, to ascertain if the heart beats. If it does so, all that is wanted is to inflate the lungs. To do this the mouth should be opened, and if no breathing is yet felt, some one should blow steadily into the mouth, a device which seems to answer the purpose; and also a hearty slap of the open hand upon the buttock of the calf will cause it to start, as it were, into being. Perhaps bellows might be usefully employed in inflating the lungs. Should no beating of the heart be felt, and yet consciousness of life seem to exist, the calf should be carried without delay to its crib, and covered up with the litter, leaving the mouth free to breathe, and it may survive. But even after a few gasps it may die—most probably the cause of death arising from injury received in calving, such as too long detention in the vaginal passage, or a too severe squeeze of the womb on the thorax, or by the rashness of the operator.

Dead Calf.—When a calf is thus lost, its body should be skinned while warm, cut in pieces, and buried in a compost for manure, and the skin sold or made into "wechts" or baskets for the corn-barn.

Difficult Presentations.—The difficult cases of presentation which usually occur are with one foot and the head, and the other foot drawn back, either with the leg folded back altogether, or the knee doubled and projecting forward. In all these states the missing leg should be brought forward. To effect this, it is necessary to put round the presented foot a cord to retain it within the power of the operator, and the head is then pushed back into the womb to make room to get at the missing foot, to search for which the greased arm of the operator should be introduced, and the foot gently brought beside the other. The rope which was attached to the first foot now serves to pull the entire body into the passage, when the throes may again be expected to be renewed.

The presentation may be of the head alone without the feet, which may be knuckled forward at the knees, or folded back along both sides. In the knuckled case both legs should be brought forward by first pushing the head back, and, in case of losing hold of the calf, a loop of rope should be put in the calf's mouth: in the folded case, both should be brought forward.

A worse case than either is, when one or both legs are presented and the head folded back upon the side. In this case the calf will most likely be dead. The legs should be pushed back, retaining hold of them by ropes, and the head brought forward between the legs if possible. It may be beyond the strength of the operator to bring forward the head; if so, he should put a loop into the calf's mouth, and his assistants pull forward the head by it.

Still more difficult cases may occur, such as a presentation of the shoulder, with the head lying into the side; a presentation of the buttock, with both the hind-legs stretched inwards; or the calf may be on its back, with one of the worst presentations now enumerated,

In whichever of these positions the calf may present itself, no extraction can safely take place until the head, and one of the legs at least, are secured, or both the hind-legs, with the back turned uppermost, are presented. In no case should a fore or hind leg be so neglected, as to either obstruct the body on passing through, or tear the womb of the cow. The *safest* practice is, to secure both legs as well as the head. This may cause the operator considerable trouble, but by retaining hold of what parts he can with the cords, and dexterously handling the part amissing, so as to bring it forward to the passage whilst the assistants pull as he desires, his object will in most cases be attained. But it should be borne in mind that none of these objects will be attained without the powerful assistance of the throes of the cow herself. If this precaution is not attended to and watched for by the operator, the muscular grasp of the womb will render his arm powerless.

One circumstance should here be considered by the operator. When the hind-quarters of the cow have an inclination downwards, she has the power to strain the stronger, and to counteract his efforts the more easily. On finding her position so, he should raise the hind-quarters of the cow with sackfuls of straw higher than the fore-quarters, until he has got the calf in the position he desires, and then, on letting the cow down again, and watching her strainings, assist her at that time and only at that time, and the extraction may be successful.

But the power of the womb may

have been exhausted. When it can no longer render assistance by its strainings, the operator must continue his exertion with the greater force until the calf is brought away. When the head only of the calf is presented, and cannot protrude itself through the vagina, an inspection should be made of the position of the calf, by thrusting the head back with a loop in the mouth, and on finding the fore-legs bent backward, to bring them forward. When this inspection has been too long delayed, and the head kept confined in the passage, the violent throes of the cow will most likely strangle the calf, and the head will swell to an inordinate degree. The swelling will prevent the calf's head from being pushed back to get at the legs, then the head must be cut off, the legs brought forward, and the body extracted.

One of the most difficult cases is, when the fore-feet are presented naturally, and the head is thrust down upon the brisket between the legs. The feet must first be pushed back, and the head brought up and forward, when the extraction will become natural.

Extracting a Dead Calf.—When the symptoms of calving have continued for a time, and no appearance of a presentation by the calf, the operator should introduce his arm to ascertain the cause, and the probability will be that the calf has been dead in the womb some time. A dead calf is easily recognised by the hand of an experienced cowman. It should be extracted in the easiest manner; but should the body be in a state of decay, it will not bear being pulled out whole, and must be taken away piecemeal.

Twin Calves.—As regards the extraction of twin calves, before rendering the cow any assistance it is necessary to ascertain whether there are twins, and that the calves have made a proper presentation; that they are free of each other; that one member of the one is not interlaced, or presented at the same time with any member of the other. When quite separated, each calf may be treated according to its own case.

Desperate Cases.—The block and tackle should never be resorted to but to save the life of the cow. If this might be done by turning the calf, the attempt should be made in the best manner. If this is not likely to succeed, it will be better to destroy the calf by cutting it away than lose the cow. Should the cow die, the live calf can easily be extracted by the Cæsarean operation.

Veterinary Advice in Calving.—A skilful cowman may be able to manage all these difficult cases within a reasonable time; but unless he is particularly dexterous at cases of calving, it is much safer to work under the advice of a veterinary surgeon, who may or may not operate himself. In the case of extracting monstrosities, his actual assistance is indispensable.

Isolation in Difficult Cases.—Calving in a byre does not seem to produce any disagreeable sensations in the other cows, as they express no surprise or uneasiness in regard to what is going on beside them. When the cow gives vent to painful cries, which rarely happens, the others express a sympathetic sound; and when the calf is carried away, they exhibit some restlessness, but the emotion arising therefrom soon subsides. But if difficult and protracted labour is apprehended, it is better for the other cows, and also for the particular cow herself, that she be removed to another well-littered apartment, where the operator and his assistants can have free action around her.

Mistaken Idea.—A notion exists in some parts of England that a cow, when seized with the pains of labour, should be made to move about, and not allowed to lie still, although inclined to be quiet. "This proceeds from an erroneous idea," Skellett well remarks, "that she will calve much easier, and with less danger; but so far from this being the case, the author has known a great many instances where the driving has proved the death of the animal by overheating her, and thus producing inflammation and all its bad consequences. Every rational man will agree in opinion with the author, that the above practice is both cruel and inconsistent in the extreme; and this is confirmed by what he has noticed, that the animal herself, as soon as the pains of calving come on, immediately leaves the rest of the herd, and retires to some corner of the field, or under a hedge, in order to prevent the other cows, or anything else, coming near, that may disturb her in bringing forward her young."[1]

Quietness for Cows at Calving.—In short, too much gentleness cannot be shown to cows when calving, and they cannot be too strictly guarded against every species of disturbance.

Afterbirth.—The afterbirth, or placenta, does not come away with the calf, a portion of it being suspended from the cow. It is got quit of by the cow on straining, and when the calving has been natural and easy, it seldom remains longer than from one to seven hours. In bad cases of labour it may remain longer, and may only come away in pieces; but when it remains too long and is sound, its separation will be assisted by attaching a small weight to it, say of 2 lb., with the occasional straining of the cow.

A draught in gruel, containing Epsom salts 8 ounces, powdered ergot 1 ounce, and carbonate of ammonia 4 drachms, given daily, will facilitate the cleansing. If the afterbirth should remain till decomposition actually commences, the hand should be introduced and the placenta removed as gently as possible.

The common custom is to throw the afterbirth upon the dunghill, or to cover it up with the litter; but it should not be put there to be accessible to every dog and pig that may choose to dig it up—pigs have been known almost to choke themselves with it. Let the substance be buried in a compost-heap; and if there be none such, in the earth. The umbilical cord or *navel-string* of the calf breaks in the act of calving.

Refreshing the Cow.—When a cow seems *exhausted* in a protracted case of calving, she should be supported with a warm drink of gruel, containing a bottle of sound ale. Should she be too sick to drink it herself, it should be given her with the drinking-horn.

After the byre has been cleansed of the impurities of calving, and fresh litter strewed, the cow naturally feels thirsty after the exertion, and should receive a warm drink. There is nothing better than warm water, with a few handfuls of oatmeal stirred in it for a time, and seasoned with a handful of salt. This she will drink up greedily. A pailful is enough at a time, and it may be renewed when she expresses a desire for more. This drink should be given to her for two or three days after calving in lieu of cold water, and mashes of boiled barley and gruel in lieu of cold turnips; but the oil-cake should never be forgotten, as it acts at this critical period as an excellent laxative and febrifuge.

Barley for newly Calved Cows.—A common practice with some is to give the cow barley in the sheaf to eat, and even raw barley, when there is no barley in the straw. Sometimes a few sheaves are kept for the purpose; and barley-chaff is given where people grudge to part with good barley in this way. The practice, however, is objectionable, for nothing causes indigestion more readily than raw barley or barley-chaff at the time of calving, when the tone of the stomach is impaired by excitement or fever. *Boiled* barley, with a mucilaginous drink, is quite safe.

Nothing should be given at this time of an astringent nature. The food should rather have a laxative tendency.

Immediate Milking.—It is desirable to milk the new-calved cow as soon as convenient for her, the withdrawal of milk affording relief. It frequently happens that an uneasiness is felt in the udder before calving; and should it increase while the symptoms of calving are yet delayed, the cow will experience much inconvenience, especially if the flush of milk has come suddenly.

The Udder.—The cause of uneasiness is unequal hardness of the udder, accompanied with heat, floridness, and tenderness. Fomentation with warm water twice or thrice a-day, continued for half an hour at a time, followed by gentle rubbing with a soft hand and anointing with goose-fat, will tend to allay irritation. In the case of heifers with the first calf, the uneasiness is sometimes so great during the protracted symptoms of calving, as to warrant the withdrawal of milk before calving.

Should the above remedial measures fail to give relief, the great heat may cause direct inflammation and consequent suppuration in the udder. To avert such an issue, the uneasiness should be attend-

[1] Skellett's *Partur. Cow,* 113.

ed to the first moment it is observed, neglect permitting the complaint to proceed so far as to injure the structure of the udder. Prevention of the congestion of the udder may be secured by refraining to give rich food until after the ninth day, when the womb has discharged its contents attendant on calving.

Attention to the Cow.—In ordinary cases of calving, little apprehension need be felt for the safety of the cow; but she must be carefully attended to for at least a fortnight after calving. No cold drinks, no cold turnips, should be given her, and no cold draughts of air allowed to blow upon her. The hind-quarters, raised up by litter for a few days, will recover the tone of the relaxed parts.

Flooding.—In cases of severe and protracted labour the cow may be overtaken by several casualties, such as flooding or loss of blood, which is caused by the vessels of the womb being prevented collapsing as they should do; but it is not often a fatal complaint, and may be removed by the application of a lotion, consisting of a quart of strong vinegar mixed in one gallon of spring-water, in which cloths should be dipped, and applied frequently to the loins, rump, and vagina. A drink of two quarts of cold water and a pint of ale will much relieve her and assist the efforts of nature.

Protruding Womb. — Should the womb protrude when the placenta remains too long after delivery, in consequence of long and severe straining of the cow, the womb should be washed perfectly clean with a mixture of milk and warm water, and replaced with care, taking hold of it only by the upper side. The hind-quarter of the cow should be well elevated with straw, and a saline dose of laxative medicine administered, with some opium, to allay pain and prevent straining.

Inflammation in the Womb.—After severe calving, draughts of cold air may cause inflammation in the womb. Large drinks of cold water will produce the same effect, as well as the irritation arising from retention of the cleansing. A purge is the safest remedy, consisting of 1 lb. of Epsom salts, 8 drachms powdered aloes, and ½ ounce ginger in a quart of warm water or gruel.

But in all cases of severe calving the veterinary surgeon should witness the process, and afterwards administer the requisite medicines and prescribe the proper treatment and regimen.

Uterine Discharge. — About nine days after calving, should no uterine discharge come from the cow, means should be used to promote it, otherwise severe costiveness and puerperal fever may ensue. Oilcake for a fortnight before and after calving has been found an excellent expedient for promoting the discharge—which discharge has the effect of thoroughly cleansing the womb.

Coming in "Season."—A cow will desire the bull in four or five weeks after calving. The symptoms of a cow being in season are thus well described by Skellett: "She will suddenly abate of her milk, and be very restless; when in the field with other cows she will be frequently riding on them, and if in the cow-house she will be constantly shifting about the stall; her tail will be in constant motion; she will be frequently dunging, staling, and blaring; will lose her appetite; her external parts will appear red and inflamed, and a transparent liquor will be discharged from the vagina. In old cows these symptoms are known to continue 4 or 5 days, but in general not more than 24 hours, and at other times not more than 5 or 6 hours. Therefore, if a cow is intended for procreation, the earliest opportunity should be taken to let her have the bull; for if it be neglected then, it will often be 2 or 3 weeks before the above symptoms will return. These instructions," adds Skellett, "are necessary to be given only to the proprietor of a small number of cows, where a bull is not always kept with them. If a cow, after calving, shows symptoms of season sooner than 4 or 5 weeks, which is sometimes the case, she should *not be permitted to have the bull sooner than 4 or 5 weeks from that period*—for the womb before that time is, in general, in so relaxed a state, as not to be capable of retaining the seed, consequently she seldom proves with calf if she is suffered to take him sooner." [1]

Too Early Bulling Unwise.—This last remark is of great value, for there is

[1] Skellett's *Partur. Cow*, 11-13.

good reason to believe that many cases of cows not holding in calf with the first serving after calving arises from the want of consideration on the part of breeders as to whether the cow is in that recovered state from the effects of calving which may be expected to afford a reasonable hope that she shall conceive. And this is a point more to be considered than the mere lapse of time after calving; for a cow, after a severe labour, may be in a much worse state for conception, even at double the length of time, than another which has calved with ease, although she may have come as regularly into season as her more fortunate neighbour. The state of the body, as well as the length of time, should be taken into consideration in determining whether or not the cow should receive the bull.

Fatigue affecting Pregnation.—A common practice in places where there is no bull, is to take the cow to the bull at a convenient time for the cattle-man to take her; and should she have passed the bloom of the season before her arrival at the bull, the issue will be doubtful. The cow may have travelled a long distance and become weary, and no rest has been allowed her, although she has to undergo the still farther fatigue of walking home. Fatigue renders impregnation doubtful. Many are not satisfied with the service of their cows until both bull and cow are wearied out. Others force cow or bull, holding her by the nose, and goading him with a stick against the inclination of either. Such treatment renders impregnation doubtful. There is, beside, the chance that the bull is worn out for the day.

None of these mischances can happen when a bull is at home. Even then a discretion is requisite to serve the cow at the proper time, and this can only be known by observing her state.

Cow's Record of Character.—It is desirable that the farmer should keep or have kept a record of the character of each cow, in regard to her state of season, and of her reckoning to calve—a desirability all the greater because of the great difference of character evinced by cows under the same treatment. For example, one arrives soon at mature season after the symptoms are exhibited, and as soon it disappears; a second requires some hours to arrive at the same point, and the season continues for a time in a languid state: a third runs through the course of season in a few hours, while a fourth is only prepared to receive the bull at the last period of her season; a fifth may exhibit great fire in her desire, which induces her keeper to have her served at once, when too soon; whilst a sixth shows comparative indifference, and, in waiting for an exhibition of increased desire, the season is allowed to pass away; and in this last case, cattlemen, conscious of neglect, and afraid of detection, will persist in the bull serving her, though she may be very much disinclined, and does everything in her power to avoid him.

Attention in Serving.—There is no way so natural for a bull to serve a cow, as when both are in the field together. The most proper time is chosen by both, and failure of conception then rarely happens. But it is possible that the bull cannot serve the cow in the field by disparity of height. The cow should then be taken to a part of the ground which will favour his purpose. One *thorough* skip is quite sufficient for securing conception, but two or three skips are mostly insisted upon. The cow should be kept quiet in the byre after being served until the desire leave her, and she should have no food or water for some hours after, as any encouragement of discharges from the body, by food and drink, is inimical to the retention of the semen.

Conception Completed. — "When nature is satisfied," says Skellett, "or the symptoms of season disappear in the animal, conception has taken place. The neck of the womb becomes then completely closed by a glutinous substance which nature has provided for that purpose, being perfectly transparent, and with difficulty separated from the parts. This matter is for the purpose of excluding all external air from the mouth of the womb during gestation, which, if admitted to the fœtus, would corrupt the membranes and the pellucid liquor in which the fœtus floats, and would undoubtedly cause the cow to slink. This glutinous substance also prevents the lips of the mouth of the womb from growing together; and when the cow comes into season it becomes fluid—the act of copulation serving to lubricate the parts and prevent inflammation." [1]

In-Calf Heifers.—The heifers in calf that are to be transferred to the cow-stock should be taken from their hammels, in which they have been all winter, into the byre, into the stalls they are to occupy, about three weeks or a fortnight before their reckoning. If they had been accustomed to be tied by the neck when calves, they will not feel much reluctance in going into a stall; but if not, they will require some coaxing to do it. When taking them to the byre at first, it should be remembered that a fright received at this juncture may not be forgotten by them for a long time to come. To avoid every chance of that, let them go in quietly of their own accord; let them snuff and look at everything they wish; and having assistants to prevent their breaking away, let the cattle-man allow them to move step by step, until they arrive at the stalls. Here may be some difficulty: some favourite food should be put in the manger to entice them to go up. Another difficulty will be putting the seal, fig. 104, round the neck. It should be hung, when not in use, upon a nail on the stake, from which it should be quietly taken down, without clanking the chain; and while the heifer is eating, let the cattle-man slip one hand below the neck with the chain, while the other is passed over it, to bring the loose end of the seal round the neck, and hook it into whatever link he first finds. The moment the heifer feels she is bound, she will hang back, or attempt to turn round in the stall to get away, which she should be prevented doing by gentle means; and after remaining in that state for some time, and feeling herself well used and kindly spoken to, she will yield; but although she may appear to submit, she must not be left alone for some time—till the assurance she will not attempt to turn in the stall is certain.

Reckoning Table.—The following table, containing the dates at which cows should calve from those at which they were bulled, is founded upon the data afforded by Lord Spencer—namely, 285 days as the average period of gestation. It is unnecessary to fill up the table with marking down every day of the year, as in the short period between each fortnight can easily be calculated the particular reckoning of each cow:—

A RECKONING TABLE FOR THE CALVING OF COWS.

When Bulled.	When will Calve.	When Bulled.	When will Calve.
Jan. 1.	Oct. 13.	July 16.	April 27.
" 15.	" 27.	" 30.	May 11.
" 29.	Nov. 10.	Aug. 13.	" 25.
Feb. 12.	" 24.	" 27.	June 8.
" 26.	Dec. 8.	Sept. 10.	" 22.
March 12.	" 22.	". 24.	July 6.
" 26.	Jan. 5.	Oct. 8.	" 20.
April 9.	" 19.	" 22.	Aug. 3.
" 23.	Feb. 2.	Nov. 5.	' 17.
May 7.	" 16.	" 19.	" 31.
" 21.	March 2.	Dec. 3.	Sept. 14.
June 4.	16.	17.	" 28.
" 18.	" 30.	" 31.	Oct. 12.
July 2.	April 13.		

Leading Cows.—A cow is generally easily led to the bull at a distance by a halter round the head. If she is known to have a fractious temper, it is better to put a holder in her nose than to allow her to run on the road and have to stop or turn her every short distance. A simple form of holder is in fig. 241, which has a joint that allows the two parts of the holder to meet, and to open so far asunder as to embrace the nostril of the animal. A screw-nut brings the two knobbed points as close as to embrace firmly the septum of the nose. In using this nut it should not be so tightly screwed as to squeeze the septum. The leading-rein is fastened to the under ring.

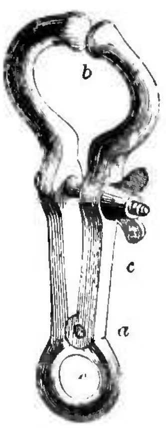


Fig. 241.—*Bullock-holder.*
a Joint.
b Knobbed points, meeting.
c Screw-nut.
e Ring for rein-rope.

In Africa "an unruly cow is never tied by the head: a man walks behind it, having hold of a rope tied tightly round its hock; this plan seems to *Rareyfy* the animal most completely." [2]

Detecting Pregnancy.—The usual mode of determining whether a cow is in calf is deceptive. She may not have held when bulled; she may

[1] Skellett's *Partur. Cow*, 17.

[2] Grant's *Walk across Africa*, 52.

have taken the bull again in a few days, and she may not show evident symptoms of calving until only a few days before she actually calves. The application of the ear to the flank of the cow is a simpler and more certain mode of ascertaining the pulsation of the calf, and the unerring *stethoscope* renders the mode truly philosophical. The existence of pregnancy may be detected by it at as early a stage as six or eight weeks, by which time the beating of the heart of the calf may be distinctly heard, and its singular double beating cannot be mistaken.

Milk-fever.—"Although parturition is a natural process," as is well observed by Youatt, "it is accompanied by a great deal of febrile excitement. The sudden transferring of powerful and accumulated action from one organ to another—from the womb to the udder—must cause a great deal of constitutional disturbance, as well as liability to local inflammation."[1] One consequence of this constitutional disturbance of the system is *milk-fever* or puerperal fever. Cows in high condition are more subject than others to this complaint, and especially if they have been kept up for some weeks before calving. The complaint may seize the cow only a few hours after calving, or it may be days. Its first attack is probably not observed by those who have the charge of the cows, or even by the farmer himself, who is rather chary in looking after the condition of cows, in case he should offend his female friends, to whose special care that portion of his stock is consigned.

The *symptoms* are first known by the cow shifting about in the stall, or from place to place if loose, lifting one leg and then another, being easily startled, and looking wildly about her as if she had lost her calf, and lowing for it. Then the flanks begin to heave, the mouth to open and issue clear water, she staggers in her walk, and at length loses the use of her limbs, lies down and places her head upon her side. The body then swells, the extremities feel cold and clammy. Shivering and cold sweats follow, the animal is at first wild and excited, throwing her head about, and afterwards comatose; the pulse becomes irregular, and death ensues.

The promptest *remedy* to be used, after the first symptom has been observed, is to bleed to the extent of 3 or 4 quarts, but not after the earliest stages. The next is to open the bowels, which will be found to have a strong tendency to constipation. From 1 lb. to 1½ lb. of Epsom salts, according to the strength of the cow, with a little ginger and caraway, should be given as a purge. The spine should be stimulated by the application of ammonia liniment, and the head kept cool by cloths wet with cold water. The animal should be bolstered up into the natural position with bundles of straw, and hoven prevented by the use of the trocar and canula. Perspiration must be induced by covering with cloths, and the animal must be prevented from injuring herself when she begins to throw her head wildly about. It must be confessed, however, that the disease is nearly always fatal. Treatment rarely effects a cure, and practical experience has shown that, in the majority of cases, it is much better to kill the animal at once, as she is sure to die at any rate.

Prevention of Milk-fever.—But it is a preventable disease. It is due to overfeeding and having the body in a too plethoric state from the use of concentrated foods. Regular physicking and moderate feeding for a month or so before calving, so as to reduce any "fulness" of body, will almost always ensure safety.

Red-water.—The ninth day after a cow has calved, a uterine discharge should take place, and continue for a day or two, after which the cow will have all the symptoms of good health. It has been observed that when this discharge does not take place, the cow will soon after show symptoms of *red-water*. She will evacuate urine with difficulty, which will come away in small streams, and be highly tinged with blood, and at length appear like dark grounds of coffee. "The nature and cause of the disease are here evident enough," as Youatt well observes. "During the period of pregnancy there had been considerable determination of blood to the womb. A degree of susceptibility, a tendency to inflammatory action had been set up, and this had been increased as the period of parturi-

[1] Youatt's *Cattle*, 546.

tion approached, and was aggravated by the state and general fulness of blood to which she had incautiously been raised. The neighbouring organs necessarily participated in this, and the kidneys, to which so much blood is sent for the proper discharge of their function, either quickly shared in the inflammation of the womb, or first took an inflammation, and suffered most by means of it."[1]

The *prevention* of this disease is recommended in using purgative medicine after calving; but as purging never fails to lessen the quantity of milk given by the cow for some time after, a better plan is to give such food as will also operate as a laxative for some time before as well as after calving. One substance which possesses these properties is *oilcake.*

MILKING COWS.

Structure of the Udder.—The structure of a cow's udder is remarkable. It consists of two glands, disconnected with each other, but contained within one bag or cellular membrane; these glands being uniform in structure. Each consists of three parts, the *glandular* or secreting, the *tubular* or conducting, and the *teats* or receptacle or receiving part. The division is longitudinal, and each half is provided with three teats, one of which, however, is abortive, so that milk is only yielded by four altogether, and thus each teat with its adjacent portion of the udder is called a "quarter." The glandular forms much the largest portion of the udder. It appears to the naked eye composed of a mass of yellowish grains, but under the microscope these are found to consist entirely of minute blood-vessels forming a compact plexus, which secrete the milk from the blood.

The udder should be capacious, though not too large for the size of the cow. It should be nearly spherical in form, though rather fuller in front, and dependent behind. The skin should be thin, loose, and free from lumps, filled up in the forepart of the udder, but hanging in folds in the hind part. Each quarter should contain about equal quantities of milk, though sometimes the hind ones yield the most.

[1] Youatt's *Cattle*, 504.

The teats should be at equal distances every way, neither too long nor too short, but of moderate size, and equal thickness from the udder to the point, which should be smaller. They should not be too large at the udder, to permit the milk to flow down too freely from the bag and lodge in them; nor too small at that place, to allow the coagulation of the milk to *cord up* or fill the orifice; nor too broad at the point, to have the orifice so large that the cow cannot retain her milk after the bag becomes full and heavy. They should be smooth, and feel like velvet, firm and soft to handle, not hard and leathery. They should yield the milk freely, and not require to be forcibly pulled.

When the milk is first to be taken from the cow after calving, the points of the teats will be found plugged up with a resinous substance, which, in some instances, requires some force to be exerted on them before it will yield.

First Milk.—The milk that is obtained for the first four days has a thick consistence, and is of a yellow colour. It is known as the "colostrum," and has obtained the name of *biestings* in Scotland. It possesses the coagulable properties of the white of an egg, and will boil into a thick substance called biesting cheese. But it is seldom used for such a purpose, and is given to the calf, because in many parts the people have a notion that it is not wholesome to use the biestings.

Theory of Milking.—"Thus, then," says a writer, "we perceive that the milk is abstracted from the blood in the glandular part of the udder; the tubes receive and deposit it in the reservoir or receptacle; and the contractile tissue at the end of the teat retains it there till it is wanted for use. But we must not be understood to mean, that all the milk drawn from the udder at one milking, or *meal*, as it is termed, is contained in the receptacle. The milk, as it is secreted, is conveyed to the receptacle, and when this is full, the larger tubes begin to be filled, and next the smaller ones, until the whole become gorged. When this takes place, the secretion of the milk ceases, and absorption of the thinner or more watery part commences. Now, as this absorption takes place more readily in the smaller or more distant tubes, we invariably find that the milk from these, which comes the last into the receptacle, is much thicker and richer than what was first drawn off. This milk has been significantly styled *afterings;* and should this gorged state of the tubes be permitted to continue beyond a certain time, serious mischief will sometimes occur: the milk becomes too thick to flow through the tubes, and soon produces, first irritation, then inflammation, and lastly suppuration, and the function of the gland is materially impaired or altogether destroyed. Hence the great importance of emptying the smaller tubes regularly and thoroughly, not merely to prevent the occurrence of disease, but actually to increase the quantity of milk; for so long as the smaller tubes are kept free, milk is constantly forming; but whenever, as we have already mentioned, they become gorged, the secretion of milk ceases until they are emptied. The cow herself has no power over the tissues at the end of the teat, so as to open and relieve the overcharged udder: neither has she any power of retaining the milk collected in the reservoirs when the spasm of these is overcome."[1]

Thus the necessity of drawing away the last drop of milk at every milking; and the greater milker the cow is, this is the more necessary.

Hefting.—Thus also the impropriety of *hefting* or holding the milk in cows until the udder is distended much beyond its ordinary size, for the sake of showing its utmost capacity for holding milk, a device which all cow-dealers, and indeed every one who has a cow for sale in a market, scrupulously adopts. It is remarkable that so hackneyed a practice should deceive any one into its being a measure of the milking power of the cow; for every farmer is surely aware that, when he purchases a hefted cow, he gains nothing by the device. Why, then, encourage so cruel and injurious a practice in dealers? Were purchasers to insist on a reduction in price of the cow that is hefted, the dealers would be obliged to relinquish the bad practice.

Indications of Milking Properties.—The milking properties of a cow are to a certain extent indicated by what is called a large *milk-vein* below the belly. This vein is the subcutaneous vein, and drains a part of the udder of its blood, and when large, certainly indicates a strongly developed vascular system, which is favourable to secretion generally, and no doubt that of milk in particular.

Milk-pails.—The vessel used for receiving the milk from the cow is simple, as in fig. 242, which is one of the most convenient form. The size may be made to suit the dairymaid's taste. It is made of thin oak staves bound together with three thin galvanised hoops. Pails similar in shape are now made of tinned iron, and are preferable for cleanliness and lightness. Pitchers of tin are mostly used for milking in the dairies of towns.

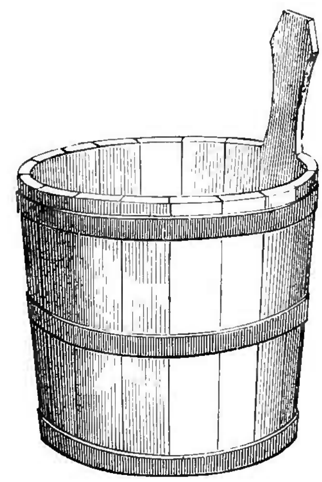


Fig. 242.—*Milk-pail.*

In Holland the milking-pails are made of brass, and must be kept quite bright, otherwise they would injure the milk. The Dutch dairymaids have a great deal of trouble in keeping these vessels in proper order. A pail, as fig. 242, is of a convenient size when 9 inches in diameter at the bottom, 11 inches at the top, and 10 inches deep, with a handle 5 inches high; which dimensions will give a mouth capacious enough to receive the milk as it descends, and of a sufficient height to rest on the edge of its bottom when held firmly between the knees of the milker, as he or she sits upon the three-legged stool. The pail should not be milked quite full for fear of spilling, and should be large enough to contain all the milk that a cow will give at a milking, as it is undesirable to annoy the cow by rising from her before the milking is finished, or by exchanging one pail for another.

The milking-stool, as in fig. 243, is made of ash, to stand 9 inches in height, or any other height to suit the convenience of the milker, with the top 9 inches in diameter, and the legs a little spread

[1] Blurton's *Prac. Ess. Milk.*, 6, 7.

out below to give the stool stability. Some milkers do not care to have a stool, and prefer sitting on their haunches; but a stool keeps the body steady, and the

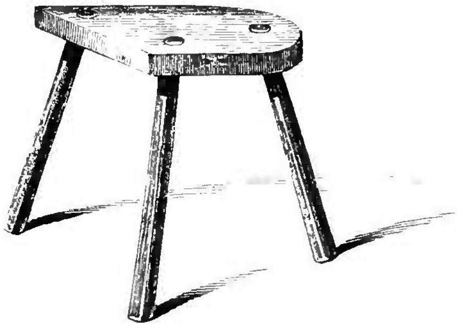


Fig. 243.—*Milking-stool.*

arms have more freedom to act, and ready to prevent accidents to the milk in case of disturbance by the cow.

Cows holding back Milk.—The cow, being a sensitive and capricious creature, is so easily offended that, if the milker rise from her before the milk is all withdrawn, the chances are she will not again stand quietly at that milking; or if the vessel used in milking is taken away before the milking is finished, and another substituted in its place, the probability is that she will *hold* back her milk—that is, not allow it to flow. This is a curious property which cows possess, and how it is effected is not very well understood; but there is no doubt of the fact occurring when a cow becomes irritated or frightened by any cause.

All cows are not affected to the same degree; but, as a proof of their extreme sensitiveness in this respect, it may be mentioned that very few can be milked so freely by a stranger the first time as by one to whom they have been accustomed.

The Milking Side.—Usually, the near side of the cow is taken for milking, and it is called the *milking side;* but whichever side is adopted, that should always be used with the same cow. The near or left side of the cow may have been adopted for two reasons; because we are accustomed to approach all the larger domesticated animals by the *near side*—the animal's left side—as being the most convenient for ourselves; and because most people are right-handed, and thereby the right hand being the stronger, it is most conveniently employed in milking the hinder teats of the cow, which are most difficult to reach, because of the position of the hind part of the udder between the hind-legs. The near side is most common in Scotland, while in England the other side is preferred. It is rare to see a cow milked in Scotland by any other than a woman, though men commonly do it in England.

The Operation of Milking.—Milking is performed in two ways, stripping and nievling. *Stripping* consists of seizing the teat firmly near the root between the front of the thumb and the side of the forefinger, the length of the teat lying along the other fingers, and of pressing the finger and thumb while passing them down the entire length of the teat, and causing the milk to flow out of its point in a forcible stream. The action is renewed by again quickly elevating the hand to the root of the teat. Both hands are employed at the operation, each having hold of a different teat, and moving alternately. The two nearest teats, the fore and hind, are first milked, and then the two farthest.

Nievling is done by grasping the teat with the whole hand, or *fist*, making the sides of the forefinger and thumb press upon the teat more strongly than the other fingers, when the milk flows by the pressure. Both hands are employed, and are made to press alternately, but so quickly in succession that the alternate streams of milk sound on the ear like one forcibly continued stream; and although stripping also causes a continued flow, the nievling, not requiring the hands to change their position, as stripping does, draws away the larger quantity of milk in the same time.

Stripping is thus performed by pressing and passing certain fingers along the teat; nievling by the doubled *fist* pressing the teat steadily at one place.

Of the two modes we prefer the *nievling*, because it is more like the sucking of a calf. When a calf takes a teat into its mouth, it seizes it with the tongue against the palate, causing them to play upon the teat by alternate pressures or pulsations, while retaining it in the same position. Nievling does this; but the action of stripping is quite different.

It is said that stripping is good for agitating the udder, and agitation is conducive to the withdrawal of a large quantity of milk; but there is nothing to prevent the milker agitating the udder while holding the teats in nievling —indeed, a more constant agitation is really kept up by the vibrations of the arms, than by pulling the teat constantly down as in stripping.

Stripping, by using a strong pressure upon two sides of the teat, is more likely to press it unequally than by grasping the whole teat in the palm of the hand; while the *friction* occasioned by passing the finger and thumb firmly over the skin of the teat, is also more likely to excite heat and irritation in it than a grasp of the hand. This friction causes an unpleasant feeling even to the milker, who is obliged to lubricate the teat frequently with milk, and to wet it at first with water, whereas nievling requires no such expedients; and as it gives pain to the cow, it cannot be employed when the teats are chapped, or affected with cow-pox, while nievling can be used with impunity.

Milking should be done *fast*, to draw away the milk as quickly as possible; and it should be continued as long as there is a drop of milk to bring away. This is an issue which the dairymaid cannot too particularly attend to herself, and see it in her assistants. Old milk left in the receptacle of the teat soon changes into a curdy state; and the caseous matter, not being at once broken and removed by the next milking, is apt to irritate the lining membrane of the teat during the operation, especially when the teat is forcibly rubbed down between the finger and thumb in stripping. The consequence of this irritation being repeated is a thickening of a part of the lining membrane, which at length becomes so hardened as to constitute a stricture which at length closes up the orifice of the teat. The stricture may easily be felt from the outside of the teat, and the teat is then said to be *corded*. After this the teat becomes "deaf" or "blind," and no more milk can afterwards be drawn from the quarter of the udder with which the corded teat communicates.

Cows troublesome at Milking.— Cows are often troublesome on being milked; and the kicks and knocks which they receive for their restlessness only render them the more fretful. If they cannot be overcome by kindness, thumps will never make them better. But the fact is, restless habits were engendered in them by the treatment they received when first taken into the byre, when, most probably, they were dragooned into submission. Udders and teats are very tender immediately after calving, and especially after the first calving; and when unfeeling horny hands tug the teats in *stripping*, as if they had been accustomed to the operation for years, no wonder that the young and inexperienced cow should wince under the infliction, and attempt by kicking to get quit of her tormentor. Can the creature be otherwise than uneasy? and how can she escape the pain but by striking out a heel? The hobbles are then placed on the hind-legs, to keep the heels down. The tail is next employed by her as an instrument of annoyance, which is then held by some one while the milking is going on, or is tied to the creature's leg by the hair of the tuft. Add to these the many threats and scolds uttered by the milker, and a faint idea of how a young heifer is broken in into milking may be conceived. Some cows are naturally unaccommodating and provoking; but, nevertheless, nothing but gentleness towards them will ever render them less so. Some cows are only troublesome to milk for a few times after calving, and soon become quiet; others kick pertinaciously at the first milking. In the last case, the surest plan is for the milker, while standing on his or her feet, to place the head against the flank of the cow, stretch the hands forward, get hold of the teats the best way possible, and let the milk fall to the ground. In this position it is out of the power of the cow to hurt the milker. Such ebullitions of feeling, at the first milking after calving, arise either from feeling pain in a tender state of the teat—most probably from inflammation in the lining membrane of the receptacle; or simply from titillation of the skin of the udder and teat, which becomes the more sensitive as the heat increases; or the udder, being still hard, gives pain when first touched. Should the udder be difficult to soften, the advice of Youatt may be tried, by allowing the calf to suck at least three times a-day until the udder becomes soft.

This will doubtless cure the udder, but may cause another species of restlessness in the cow when the calf is taken from her. Still, rather let the milker suffer inconvenience than the udder of the cow be injured. Be the cause of irritation what it may, one thing is certain, that gentle and persevering discipline will overcome the most turbulent temper in a cow. Milking affords different degrees of pleasure to different cows. One yields its milk with a copious flow, with the gentlest handling; another requires great exertion to draw the milk in streams no larger than threads. The udder of the gentle one has a soft skin, and short teats like velvet; that of the hardened one, a thick skin, and the teats long and tough like tanned leather.

Artificial Means of Milking.—A plan of drawing milk from the cow was recommended by Mr Blurton, Field Hall, Staffordshire, by introducing tubes into two teats, and milking the other teats at the same time. He was once of opinion that a tube in each teat would draw away all the available milk from the udder; but, finding his mistake in this, he adopted the following method of milking. The tubes are called *siphons*, though they have none of the properties of the true siphons. His improved plan of milking is this: "The milker sits down as in the common method, fixing the siphon can (pail) firmly between his knees: he then takes hold of the near-hand teat with a slight pressure of his right hand, and with his left introduces the *small* tube of the siphon an inch or more into the teat, putting the thumb on the large tube, to prevent the milk from running out till completely introduced—and so on with the near fore-teat, reserving the two furthest teats to be milked by hand. By this method three teats can be milked with the right hand, assisted by the siphons, in the time one can be milked with the left, and this with ease and comfort. It may be here observed that the action of milking one or two teats by hand, is quite sufficient to induce the cow to give her milk down freely from those milked by the siphons; as the cow does not possess the power of retaining her milk in any one quarter of the udder while it flows freely from the others."

These tubes, containing a small and larger end, beyond which they cannot pass into the teat, may be made of ivory, bone, or metal. They should be thrown into the pail and milked on before being used, and when taken out of the teat, let fall into the can. On being used they should be dipped in boiling water and blown through. They do not seem to possess any advantage over the hand; on the contrary, the hand must be employed to complete what they cannot accomplish, in drawing off the last drop of milk, and must be in use when they are employed.

Milking-tubes.—Milking-tubes have been invented by Cooper & Co., Sheffield. They consist of 4 india-rubber smooth tubes about the thickness of a goose-quill, 6 inches in length, as in fig. 244. To one end of them is attached an electro-plated tube, 2 inches in length, closed at the upper end, and perforated there with 3 opposite holes in each side, and at the other end is inserted a short open similar metal tube of about ¾ inch in length; the 4 tubes being held together with an indiarubber band. In using these tubes they are thrown into the milking-pail, and a small quantity of milk is milked upon them by the hand from each teat. Each tube is then inserted into the hole of the teat with the right hand, while drawing down the teat with the left hand, until the milk flows freely through it. The pail is placed on the ground under the combined orifices of the tubes, and remains there until the milk ceases to flow, when the tubes are removed.

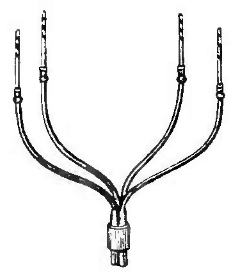


Fig. 244.—*Milking-tubes.*

About 1862 an apparatus for milking cows was presented to public notice, in which the *air-pump* was used to extract the air out of tubes which were connected by finger-pieces to the teats of the cows, and the pressure of the atmosphere on the udder expelled the milk out of it. It was not easy to fit the finger-pieces air-tight upon the teats; a restive cow could easily throw the whole apparatus out of gear; and the apparatus did not milk clean. This invention made a sort of sensation at the time, which soon subsided.

In 1864 Barland's "pocket self-milking apparatus" was brought out. It simply consists of the insertion of a tube, with a flange upon it, into each teat, and the milk flows through it from the udder.

Mr Blurton very properly advocates clean milking, and describes a good plan of drawing away all the milk from an udder. No implement can draw away the milk clean from the udder; the hand alone can do that. "In aftering," he says, "I have adopted the plan of using the *left hand to press down the thick milk* into the receptacle and teat, at the same time *milking with the right hand;* then, in a similar manner, discharging the whole from the remaining quarters of the udder." He adds what is very true, that "it must not be supposed that this method is distressing to the animal; on the contrary, her quietness during the process is a satisfactory indication that it occasions no pain, but rather an agreeable sensation." [1]

Sore Udder.—The udder, in cases of heifers, becomes not only uneasy before calving, but is subject to inflammation afterwards. "The new or increased function which is now set up," says Youatt, "and the sudden distension of the bag with milk, produce tenderness and irritability of the udder, and particularly of the teats. This in some cases shows itself in the form of excoriations or sores, or small cracks or chaps on the teats; and very troublesome they are. The discharge, likewise, from these cracks, mingles with the milk. The cow suffers much pain in the act of milking, and is often unmanageable. Many a cow has been ruined, both as a quiet and a plentiful milker, by bad management when her teats have been sore. She will also form a habit of retaining her milk, which very speedily and very materially reduces its quantity. The teats should be fomented with warm water in order to clean them, and get rid of a portion of the hardened scabbiness about them, the continuance of which is the greatest pain in the act of milking; and, after the milking, the teats should be dressed with the following ointment: Take 1 oz. of yellow wax and 3 oz. of lard, and melt them together, and when they begin to get cool, rub well in ¼ oz. of sugar-of-lead and 1 drachm of alum finely powdered." [2]

Milking Period.—Cows differ much in the time they continue to milk, some not continuing to yield it more than 9 months, others for years. The usual time for cows that bear calves to give milk is 10 months. Many remarkable instances of cows giving milk for a long time are on record. "The immense length of time for which some cows will continue to give milk," says a veterinary writer, "if favourably treated, is truly astonishing; so much so as to appear absolutely incredible. My own observation on this subject extends to four most remarkable cases: 1. A cow purchased by Mr Ball, who resided near Hampstead, that continued to give milk for 7 years subsequently to having her first and only calf. 2. A large dun Suffolk cow, shown to me as a curiosity by a Yorkshire farmer. This animal, when I saw her, had been giving milk for the preceding 5 years, during which period she had not any calf. The 5 years' milking was the result of her second calving. During that period attempts had been made to breed from her, but ineffectually. 3. A small aged cow, belonging to a *fermier* near Paris, that gave milk for 3 years subsequent to her last calf. 4. A cow in the possession of Mr Nichols, postmaster, Lower Merrion Street, Dublin. This animal was in Mr Nichols's possession 4 years, during the entire of which time she continued to give an uninterrupted supply of milk, which did not diminish in quantity more than 3 pints *per diem*, and that only in the winter months. He disposed of her for butchers' meat, she being in excellent condition. The morning of the day on which she was killed, she gave her usual quantity of milk."

Spaying Cows.—The same writer proves fully the possibility of securing permanency of milk in the cow. This is

[1] Blurton's *Pract. Ess. Milk.*, 10-12.

[2] Youatt's *Cattle*, 552.

effected by simply *spaying* the cow at a proper time after calving. The operation consists in cutting into the flank of the cow, and, by the introduction of the hand, destroying the ovaries of the womb. The cow must have acquired her full stature, so that it may be performed at any age after 4 years. She should be at the flush of her milk, as the future quantity yielded depends on that which is afforded by her at the time of the operation. The operation may be performed in ten days after calving, but the most proper time appears to be 3 or 4 weeks after. The cow should be in high health, otherwise the operation may kill her or dry up the milk. The only preparation required for safety in the operation is, that the cow should fast 12 or 14 hours, and the milk be taken away immediately before the operation. The wound heals in a fortnight or three weeks. For two or three days after the operation the milk may diminish in quantity; but it regains its measure in about a week, and continues at that mark for the remainder of the animal's life, or as long as the age of the animal permits the secretion of the fluid; unless, from some accidental circumstance—such as attack of a severe disease—it is stopped. But even then the animal may easily be fattened.

Advantages of Spaying.—The advantages of spaying are: "1. Rendering permanent the secretion of milk, and having a much greater quantity within the given time of every year. 2. The quality of the milk being improved. 3. The uncertainty of, and the dangers incidental to, breeding, being to a great extent avoided. 4. The increased disposition to fatten, even when giving milk, or when, from excess of age, or from accidental circumstances, the secretion of milk is checked; also the very short time required for the attainment of marketable condition. 5. The meat of spayed cattle being of a quality superior to that of ordinary cattle."[1] With these advantages breeders of stock can have nothing to do; but since the operation is said to be quite safe in its results, it may attract the notice of cowfeeders in town.

Preventing Udders from Running.—From some cause, the tissues of the teat may lose the power of retaining the milk in it. To prevent the running out of the milk from the cow's udder, this expedient may be adopted with a chance of success: Place an india-rubber band round the teats of the cow, and, in case the band should insert itself too deeply into the teat to be easily removed at milking, wrap the teat round with a piece of linen or thin soft leather under the band, so that the under part of the linen may be easily taken hold of in removing the band.

[1] Ferguson's *Distem. among Cat.*, 29-36.

CALF-REARING.

Importance of Calf-rearing.—Calf-rearing, the root and the rise of the cattle-breeding industry, has not received from the general body of farmers such full and careful attention as it deserves, or as it is capable of repaying. It is undeniable that the live-stock resources of the United Kingdom might advantageously be developed to a much greater extent. The growing importance of live-stock interests in British agriculture is manifest to all. In this expansion calf-rearing must play a leading part. Breeding is of course the starting-point, and the rearing of the calf is the first great step in the progress of the industry.

Aversion of Farmers to Calf-rearing.—With many farmers calf-rearing finds little favour; often, we venture to say, for no better reason than that it is a troublesome business, demanding constant and careful attention. With skilful and careful management, calf-rearing, where circumstances are at all favourable, is almost invariably remunerative. This much, however, it must have, and it rarely succeeds where not well conducted. The young animals must be fed with skill and regularity, and their health and comfort carefully attended to in every way. When this responsible work is left entirely to hired servants, it may be imperfectly or irregularly performed, with the result that the calves make unsatisfactory progress, or perhaps become impaired in health. The farmer thus loses faith in the benefits of calf-rearing. He has, perhaps, at last learned that the cause of the mischief is improper treatment; but personal supervision, or supervision by some member of his family or employees in whom confidence could be placed, may be found irksome or inconvenient, and thus again the industry of calf-rearing loses in favour.

Calf-rearing on Large Farms.—This demand which calf-rearing makes upon the careful personal supervision of the farmer or some member of his family, is undeniably the main reason why upon many large farms well suited for breeding, so few calves are brought up. We lay a little of the blame for this at the door of modern social fashion. Upon a large farm the farmer himself has many other duties which draw him away from superintending the feeding and treatment of calves; and it is not the fashion for sons and daughters of large farmers to give their attention to such matters. This conception of social life upon the farm may easily be carried too far. It is not suggested that the sons and daughters of men of capital should be expected to put their hands to the manual work of calf-rearing. There is a difference between this, however, and the superintending of work done by hired servants. The daughters and sons of farmers will be none the less ladies and gentlemen if they should make themselves acquainted with certain details of their father's business, and assist him in seeing that these details are carried out with due care and regularity.

Deficiency of Store Cattle.—The growth in the breeding of cattle has not kept pace with the increase in the consumption of beef. The supply of home-bred store cattle has not been equal to the demands of the feeders. Farmers have been complaining of unsatisfactory financial results from fattening cattle, and the main difficulty has been the fact that, on account of deficient supply, store cattle have been dearer than fat animals—that feeders have had to pay more for the lean cattle than the price of beef would warrant.

Home-breeding, not Importation, the Remedy.—The proper remedy for this state of matters is the extension of home-breeding—assuredly not the importation of foreign lean cattle. Let that be resorted to only when our own resources in cattle-breeding have been developed to the fullest advantageous extent. We are far short of that limit yet; and we would fain hope that until it is reached the best efforts of our leaders of agriculture may be directed to the encouragement of home-breeding rather than to the devising or providing of means of increasing the embarrassments of home-breeders by importing foreign-bred lean stock.

Rear more Calves.—In any scheme for increasing the supply of home-bred store cattle, calf-rearing must play an important part. We must not only breed more calves, but we must also rear more. We should rear all we breed, or nearly so, and rear them well, too; for let it ever be kept in view that what an animal loses with bad treatment as a calf, it can hardly ever fully recover. But we do not mean by rearing well, any sort of extravagant treatment. In fact, we believe there is room for much greater economy in the rearing of calves. In connection with calf-rearing on dairy farms, or wherever milk can be turned to good account, this point is of special importance.

Breed longer from Cows.—We should breed longer from cows. A custom by no means uncommon is to buy a cow for a temporary supply of milk, and fatten her off when she gets dry. Now this is a serious loss. Breed from all suitable cows as long as practicable.

Breeding from Heifers.—From all heifers that are suitable, whether intended for cows or not, take one, two, or perhaps even a third calf. Keep them well all the while, letting the calves suckle; and if the heifer is not to be kept for a cow, she may be fattened off and sold as heifer-beef. The calf or two will have done her little or no harm in the butcher's eye, if only she does not show the udder of a cow. This will not often arise when the calves suckle. This question we lately put to an extensive salesman in the north of England, who replied that his experience was that two calves or so in no way spoiled the sale of the young heifer, if only there were no display of udder, and if she were plump, level, and well fattened. He added that a lot of young heifers never came before him for sale but he regretted that so much valuable material was being wasted. Premature fatting of heifers is really killing the goose that lays the golden egg. In these times farmers cannot afford such waste as that.

Are Calves Nuisances?—Unfortunately not a few dairy farmers look upon calves as little else than nuisances—as necessary evils — something which they would never wish to have if only they could without them get cows in milk. This is a great misfortune, and shows clearly that while the cry is for more store stock, there must be something radically wrong somewhere. The fact is, calf-rearing is very imperfectly understood.

We are convinced that dairy farmers, as well as other farmers in all parts suited for breeding, would find, in well-conducted calf-rearing, returns which would amply repay careful treatment and judicious and liberal feeding. The dairy farmer may dislike the calf because he has found it a greedy and bad-paying customer for its mother's milk. But if he has done so, he has had himself to blame. A good calf will well repay a moderate allowance of its mother's milk for a short time; and we would emphasise this point, that it is only for a very short time at the outset that there is any necessity to give milk—at any rate, new milk—to calves.

Milk Substitutes.—Scientific research and commercial enterprise have placed us in possession of many advantages unknown to our forefathers. In the simple matter of calf-rearing we have gained much in this way. Why, the market is teeming with cheap milk substitutes; and, without going the length of affirming that these foods are worthy of all their energetic vendors say of them, yet we unhesitatingly say that, with substantial advantage to themselves and the general public, farmers might draw upon them much more largely than they have done heretofore. Undoubtedly the use of these prepared foods is on the increase; and we think that, by a judicious use of them and other simple natural foods, calf-rearing might be increased to a very great extent, both on dairy and mixed husbandry farms.

Rearing or Selling Calves.—We do not say that all farmers should rear their calves. It may suit some better to sell the calves when one, two, or three weeks old. If the calves are of a good class they will sell readily at handsome prices. While it may suit some to breed calves and sell them young, it will undoubtedly pay others to adapt their arrangements specially for rearing. Instead of keeping large stocks of cows, they may buy in young calves, and rear them partly on milk and other suitable food. In certain cases these bought-in stock may be carried on and fattened when from two to three years old. In others they may be simply reared, and sold as lean stock when from ten to eighteen months old.

Details of Calf-rearing.

There is, of course, much variety in the systems of calf-rearing pursued throughout the country. And in this as in most other farming matters, it would be unwise to lay down hard-and-fast rules as the best for all circumstances. Various approved methods will be described, and with these in view the intelligent farmer will arrange his practice to suit his own peculiar conditions and objects.

Housing Calves.—The comfortable and economical housing of calves is a matter that demands careful attention. Calves are either suckled by their mothers, or brought up by the hand on milk and other substances. When they are suckled, if the byre be roomy enough—that is, 18 feet in width—stalls may be erected for them against the wall behind the cows, in which they are tied up; or, what is a less restrictive plan, they may be put together in large loose boxes at the ends of the byre, or in adjoining apartment, and let out at stated times to be suckled.

When brought up by the hand, they are put into a suitable apartment, preferably each in a crib to itself, where the milk is given to them. The advantage of having calves separate is, that it prevents them, after having had their allowance of milk, sucking one another, by the ears, teats, scrotum, or navel, by which malpractice ugly blemishes are at times produced. When a number of calves are kept together, they should all be muzzled to prevent this sucking.

Calf-crib.—The crib for each calf should be 4 feet square and 4 feet in height, sparred with slips of tile-lath, and have a small wooden wicket to afford access to the calf. The floor of the cribs, and the passages between them, should be paved with stone, or laid with asphalt or concrete. Abundance of light should be admitted, either by windows in the walls, or skylights in the roof; and fresh air is essential to the health of calves, so that ventilation should be carefully attended to. So also should the cleaning of the calf-cribs. The cribs should be regularly cleaned out; and it is a good plan to sprinkle the floors daily with some disinfectant, such as diluted carbolic acid—one part of acid to twenty of water. This will keep the atmosphere pure and wholesome, which is very desirable for the young animals.

If the calf compartment be separate from the cow-house, it should communicate with the latter by a close door, having upper and lower divisions, into a court with a shed, which the calves may occupy till turned out to grass.

The crib should be fitted up with a manger to contain cut turnips or carrots, and a high rack for hay, the top of which should be as much elevated above the litter as to preclude the possibility of the calf getting its feet over it.

The general fault in the construction of calves' houses is the want of light and air — both great essentials; light being cheerful to animals in confinement, and air essential to the good health of calves. When desired, both may be excluded. The walls of the calves' house should be plastered, to be neat and clean, and should be whitewashed at least once every year.

In some cases the cribs are so constructed that the calf has access, either at will or when the door of the crib is opened, to a larger enclosure in which the young animal can exercise its limbs.

The front and wicket of a calf's crib which we have seen in use, is shown in fig. 245, in which a wicket-door gives access to the crib. The hinge is of wood, simple and economical. It consists of the rails of the wicket being elongated and rounded off, and their lower face end shaped into a round pin, which fills and rotates in a round hole in a billet of wood securely screwed to the upright door-post of the crib. Another billet is screwed on immediately above the hinge, to prevent the door being thrown off the hinges by any accident.

Cross-tailed iron hinges, of the lightness suited to such doors, would soon be broken.

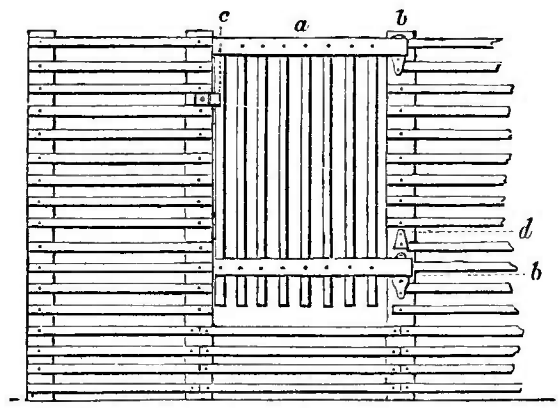


Fig. 245.—*Calf's-crib wicket.*

a Wicket to give access to the crib.
b b Its hinges of wood.
c Thumb-catch for fastening wicket.
d Billet to prevent wicket being thrown off.

More frequently the spars forming the crib are placed upright, and are of greater strength than indicated in the illustration.

Care in letting out Calves.—When the calves are fit to be put out in the open air, after it becomes mild, they should be put into a shed for some nights before being turned out to grass, and also for some nights when at grass. The shed should be fitted up with mangers for turnips, and racks for hay, and a trough of water.

Navel-string. — The state of the navel-string is the first thing that should be examined in a new-dropped calf, that no blood be dropping from it, and that it is not in too raw a state. The bleeding can be stayed by a ligature on the string, but not close to the belly. Inattention to the navel-string may overlook the cause of the navel-ill; and, insignificant as this complaint is usually regarded, it carries off more calves than most breeders are aware off.

Youatt remarks: "Possibly the spot at which the division of the cord took place may be more than usually sore. A pledget of tow, wetted with friar's-balsam, should be placed over it, confined with a bandage, and changed every morning and night; but the caustic applications that are so frequently resorted to should be avoided. Sometimes, when there has been previous bleeding, and especially if the caustic has been used to arrest the hemorrhage, and at other times when all other things seemed to have been going on well, inflammation suddenly appears about the navel between the third and eighth or tenth day. There is a little swelling of the part, but with more redness and tenderness than such a degree of enlargement could indicate. Although there may be nothing in the first appearance of this to excite alarm, the navel-ill is a far more serious business than some imagine. Fomentation in the part, in order to disperse the tumour, the opening of it with a lancet if it evidently *points*, and the administration of 2 or 3 oz. doses of castor-oil, made into an emulsion by means of an egg, will constitute the first treatment; but if, when the inflammation abates, extreme weakness should come on, as is too often the case, gentian and laudanum, with perhaps a small quantity of port wine, should be administered."

Inflammation of the navel is often caused by one calf sucking another.

Calf's First Food.—The first food the calf receives is the biestings—the first milk taken from the cow after calving. Being of the consistence of the yolk of the egg, it seems an appropriate food for a young calf. By the time it gets its first feed, the calf may have risen to its feet. If not, let it remain lying, and let the dairymaid take a little biestings in a small dish—a vessel formed like a miniature milk-pail, fig. 242, and of similar materials, is a convenient one —and let her put her left arm round the neck of the calf, support its lower jaw with the palm of the hand, keeping its mouth a little elevated, and then open the mouth by introducing the thumb of the same hand into the side of it. Then let her fill the hollow of her right hand with biestings, and pour it into the calf's mouth, introducing a finger or two with it for the calf to suck, when it will swallow the liquid. Let it get handful after handful, as much as it is inclined to take. When it refuses to take more, its mouth should be cleaned of the biesting that may have run over. Sometimes, when a calf is begun to be fed lying, it attempts to get upon its feet; and, if able, let it do so, and rather assist than prevent it.

Some are afraid to give a calf as much biestings at first as it can take, because it is said to produce the navel-ill. Let it take as much as it pleases. As to the navel-ill, it proceeds from neglect of the proper inspection and precaution after the calf is born.

Teaching Calves to Drink.—The process of feeding a new-dropped calf by hand is here minutely described, because absurd modes are practised in doing it. It is common to plunge the calf's mouth into the entire quantity of biestings, and because the liquid bubbles around its mouth with the breath from the nose, and it will not drink, its head is the more forcibly kept down into the vessel. How can it drink with its nose immersed amongst the liquid? and why should a calf be expected at first *to drink with its head down*, when its natural instinct would lead it to *suck with its head up?*

It should be borne in mind that feeding calves by the hand is an *unnatural* process; nevertheless it is convenient, practicable, and easy, provided it is done in a careful manner. The young calf must be *taught to drink*, and a good mode of teaching it is the one here given. In this way it is fed as often as the cow is milked, three times a-day.

Another Method of Teaching to Drink.—After the first two or three days, another plan should be adopted, for the calf should not be *accustomed* to suck the fingers, and it may refuse to drink without their assistance. The plan is to put a finger or two of the right hand into its mouth, and holding the pail of milk with the left under its head, bring the mouth gradually down into the pail, with the nostrils free, where the fingers induce it to take a few gluts of the milk; and while it is doing this, the fingers should be withdrawn, while the mouth is gently held down in the milk, when it will drink a little of itself. In a few days more the fingers will not be required, the head only being put down to the milk, and in a few more still, the calf will *drink* of its own accord.

Reform in Calf-feeding.—In the method of feeding calves during the first few months of their existence, there has been almost as great a revolution as in any other branch of farm practice. The old notion that at least three months of feeding upon whole milk as it comes from the cow was necessary for successful calf-rearing, has been exploded. In many cases, almost entirely in herds of pure-bred cattle, the calves still suckle their dams. But beyond these herds comparatively little new milk is now employed in rearing calves, reliance being more largely placed upon skim-milk and milk substitutes. Excellent results are obtained by the new method, and the fresh milk and cream thus saved from the calves are advantageously used for other purposes, sold to milk retailers, or made into butter and cheese.

Composition of Biestings. — The biestings or first milk after calving differs considerably in composition from ordinary milk. It contains an exceptionally large proportion of casein or cheesy matter, as the following analysis of ordinary milk and biestings will show:—

	Ordinary Milk.	Biestings.
Casein (cheese)	4.48	15.1
Butter	3.13	2.6
Milk-sugar	4.77	...
Saline matter	0.60	...
Mucus	...	2.0
Water	87.02	80.3
	100.00	100.00

The prevailing methods of feeding calves may be briefly described as follows:—

Suckling.—This is "nature's method." It is the surest and simplest means of attaining the highest development in the calf. When maximum growth in frame, flesh, and fat is the main object, and "cost of production" of little moment, suckling is the most reliable system. It is therefore pursued largely in herds of pure-bred cattle, especially by breeders who enter the showyard lists. The usual plan is to allow the calf to run with its dam, and to suck the cow at pleasure, or allow it access to her at regular intervals. The former is preferable, and will make the best calf. If the dam has not sufficient milk to raise the calf, or if her milk is desired for other purposes, the calf may be put to a nurse-cow, which the youngster will suck as readily as it would suck its own mother. A nurse-cow is sometimes averse to a strange calf, but with a little care at the outset she will gradually lose this, and will fondly welcome its attentions when her udder is in want of relief.

Suckling two or more Calves.—An average milker will yield more milk than one calf requires. A second calf may therefore be admitted, and a good, well-fed cow will easily raise two strong calves. In many cases, indeed, one cow rears two sets of calves, sometimes four in a-year, but more frequently three. After the first two calves have been weaned, a good cow should have enough milk remaining to rear at least a third calf, and if she had calved early in the season, be naturally a heavy and enduring milker, she may, with liberal feeding, be quite able to rear a second couple of youngsters. A cow that is capable of doing this will give a good account of her year's feeding.

Suckling and Milking combined.—When these additional calves cannot be advantageously obtained, or when fresh milk is desired for some other purpose than calf-rearing, the cow may be left with the one calf and her surplus milk drawn from her once, twice, or thrice a-day, according to her supply and the requirements of the calf. This method has other advantages apart from the supply of milk it provides for household or other purposes. It accustoms the cow to milking as well as to sucking, and by the operation of milking, systematically and efficiently performed, the capacity of her milk-vessels is developed, and her flow of milk stimulated; while the risk of the calf gorging itself with too much milk at any one time is obviated. Of course this supplementary process of milking the nurse-cow may be carried too far. The calf must not be robbed of its due amount of food. One objection to *partial* suckling is, that a cow suckling a calf does not allow milking afterwards with the hand in a kindly manner. Unless, therefore, cows are kept for the purpose of suckling throughout the season, they often become troublesome to milk with the hand after the calves are weaned.

Decrease in Suckling.—Suckling is not pursued nearly so extensively as formerly. Increased facilities for utilising surplus milk and cream, and the better understanding of calf-rearing by other means, have tended to curtail the practice of suckling calves. Even in pure-bred herds it has lost ground. It is a comparatively costly system, and is therefore not to be commended in ordinary farm practice. Suckling saves the trouble of milking the cows and giving the milk to the calves; but a saving of trouble may be a loss of money in the rearing of calves. An objection to suckling exists when one cow brings up two calves at a time, that the quantity of milk received by each calf is unknown, and the faster sucker will take the larger share. True, they are both brought up; but are they brought up as well as when the quantity of milk consumed is known to be sufficient for the support of each? The milk becomes scarcer, too, as the calves get older, instead of becoming more plentiful, as should be the case to satisfy the growing wants of the young animal.

Suckling with Heifers.—Reference has already been made to the plan of taking at least one crop of calves from heifers that are not intended to be added to the regular stock of cows. This is a species of "catch crop" which may often be taken with advantage. It is the usual practice to allow these calves to suck their youthful mothers. This does not—as milking would—develop the udder so as to spoil the sale of the young cow in the fat-stock market, and by liberal feeding she may be fattened while she is rearing her calf.

Hand-rearing.—Although this is an artificial, it is nevertheless the most general, as well as the most economical, system of rearing calves. It enables the farmer to use for his calves as much or as little as is thought desirable of his supply of milk, and it permits him also to avail himself of those cheaper milk substitutes which are now within his reach. He has thus, in the hand-rearing methods, much freer choice and greater scope for economical and skilful management than in the simple system of suckling.

It may be admitted that no perfect substitute for milk has as yet been discovered or devised. It by no means follows, however, that milk is the cheapest or most economical, as well as the most perfect, food for calves. The increased and still increasing demand for milk and its products for household purposes has withdrawn vast quantities of milk formerly employed in calf-rearing. This diversion is still going on, and it is to the farmer's advantage that it should be stimulated, for it practically adds another string to his bow. If he can advantageously sell or utilise his milk otherwise, he should use as little as possible of it in rearing calves. For these youngsters he has the choice of an ample assortment of other foods, the economical worth and efficiency of which have been well established. In the selection, mixing, preparation, and feeding of these foods lies the art of modern calf-rearing. It is an important item in the routine of the stock-owner's duties, and demands studious and careful attention.

Prevalent Methods.—Perhaps the most widely prevalent method of rearing calves is to feed them entirely on new milk for a short period at the outset—that period varying from two to six weeks,—and afterwards partly on new milk, skim-milk, and artificial food; or upon skim-milk and artificial food, without any of the rich milk as it comes from the cow. It is, no doubt, a good plan to let the calf have all the new milk it can readily consume for at least two or three weeks at the outset. By degrees skim-milk may be substituted for new milk, and when the new milk is wholly, or almost wholly, withdrawn, the skim-milk must be supplemented by some other richer food.

Skim-milk for Calves.—Skim-milk alone is not a well-balanced food for calves. The butter-fat has been almost wholly removed from it, and what remains is not sufficiently provided with all the elements necessary for the healthy development of the young animal. Skim-milk, left by an efficient system of creaming, will, on an average, contain the following per 100 lb.:—

Casein	3.5 lb.
Albumen	.7 "
Fat	.5 "
Sugar	4.0 "
Ash	.8 "
	9.5 lb.

The skim-milk thus retains almost all the casein and sugar in the new milk; but so effective are some of the modern processes of separating the cream from the milk, that only the merest traces of butter-fat may remain in the skim-milk. About one-sixth of the casein and albumen consists of nitrogen, and as far as it goes, skim-milk is undoubtedly a valuable food, and may be used with great advantage in conjunction with other feeding material.

Skim-milk should not be fed largely by itself to calves, for calves so fed are liable to scour, indigestion, and other bowel-complaints. It is a dangerous practice to abruptly substitute skim-milk for new milk as the main food of calves. The withdrawal of the new milk should take place gradually, and other substances should be introduced in corresponding ratio to make up for the deficiencies of the skim-milk.

Professor Stewart on Skim-milk.—"Skim-milk is much more valuable as a food than is generally supposed. It contains all the qualities of the milk except the cream. The casein, the most valuable food-constituent of the milk, and the milk-sugar, or whey, are still in it. If you feed only skim-milk to a healthy calf, it will require on an average from 15 to 20 lb. of milk to make 1 lb. of live-weight during the first ninety days, if the calf is given all it wants; and a good eater will gain 2½ lb. per day." Professor Stewart has a high opinion of boiled linseed as food for calves. He points out particularly that, given along with skim-milk, the oil of the linseed "will make good the loss of the cream in the milk." [1]

Scalding Skim-milk.—It is well to have the skim-milk scalded as soon as the cream has been taken from it, because it will thus longer remain sweet. A simple way of scalding is to insert a vessel full of the skim-milk into a larger vessel containing hot water. Some even boil the skim-milk, and are thus able to keep it sweet a whole week.

We know of one large farmer who sells his milk on the six week-days, keeps at home his Sunday's milk, has it boiled on Monday, and gives a portion of it to his calves every day. The supply of this milk often lasts the whole week. If the Sunday's milk falls short, the calves get two quarts of new milk, with one quart of water added.

[1] *Feeding Animals*, 235-237.

Artificial Food for Calves.—The other substances most largely used either in supplement of or as substitutes for milk in rearing calves, are linseed, linseed-cake, oatmeal, Indian-corn meal, palm-nut meal, malt, pea-meal, barley-meal, or some specially prepared food. The characteristics and composition of these articles are described in the chapter on "Foods," which should be referred to and consulted carefully in arranging the dietary of animals.

Preparing Foods for Calves.—All these articles of food are given to calves in the form of gruel, and they can hardly be too well steeped or boiled. It is desirable to have the linseed and linseed-cake ground into meal before boiling. Gruel from linseed-cake is often prepared by adding four parts of boiling water to one part of the meal derived by grinding the cake, and allowing the mass to remain covered up for twelve hours. Palm-nut meal may be prepared in a similar manner. In making linseed-gruel, water should be added so as to give almost a gallon and a half of gruel for every pound of linseed. If the gruel is found to purge the calf, add a little more water, and for a day or two give rather less of the gruel and more of the skim-milk. A little wheat-flour, mixed with gruel, is also a useful and simple remedy in cases of purging. Mixtures of these meals are often made into gruel for calves, and the selection of the particular articles to be used will be regulated mainly by their market prices at the time.

Quantities of Milk for Calves.—In the majority of cases where calves are raised by hand-feeding, they get about two quarts of new milk twice or three times a-day—four to five or six quarts in all—during the first two, three, four, or six weeks of their existence. At these various periods, according to custom or to the supply of new milk and the other demands for it at the time, a beginning is made with the substitution of skim-milk for new milk. A very small proportion of the latter is given at first, by degrees it is increased, and soon the new milk is wholly withdrawn. Some indeed give new milk only for about two weeks, and others continue it for six weeks or two months, perhaps even longer. The new milk and skim-milk are given together. Some feed calves three times a-day in the first few weeks, and others only twice.

Allowances of other Foods.—Supplementary foods should be begun soon, as soon perhaps as the curtailing of the new milk has commenced. The artificial food, made into gruel, is given along with the milk, and at the outset the gruel should be given in very small quantities. Sudden changes of food may inflict serious injury upon the health of the tender young animal. Some begin to give gruel to calves before they are a month old, others delay till the animal is in its sixth or seventh week. The daily allowance of gruel will of course vary with the age of the calf, and the quantity of milk it is receiving. No fixed "bill of fare" can be prescribed with safety. The appetite of the young animals must be watched closely, and special care taken to keep the bowels in good order. Feed calves liberally, but never overdo them. Let them have just as much as they can readily consume at the time; keeping on the scrimp rather than the abundant side.

Perhaps the best guide to the young farmer will be a description of methods which have been pursued with success by various breeders.

Mr W. T. Carrington's System.—The late Mr T. Carrington, Uttoxeter, Staffordshire, who kept a dairy herd of over 100 cows, reared about 40 of his earliest heifer calves as follows: "They are not allowed to suck their dams; they have from four to eight quarts of new milk *per diem*, according to age, for three or four weeks. They are then fed with skim-milk, thickened with boiled linseed or oatmeal, and are taught as soon as possible to eat hay and a small quantity of linseed cake. They are allowed to run on a grass field in May and June, and are after then generally left out altogether, with a shed to run into in very wet weather, or to avoid the heat of the sun and the teasing of the flies. The milk-feeding is altogether discontinued when they are about four months old. They are supplied with 1 lb. each per day of linseed-cake all through the year."[1]

A Common Plan with whole Milk.—Mr Wilson, late of Edington Mains, Berwickshire, describes the following system of feeding, which is common where whole milk and no skim-milk is used: Whole milk, warm from the cow, is given three times a-day for the first fortnight, and the calf is allowed to have as much of it as it will take. It may then be tempted to suck (and at length to eat) small bits of oilcake and sweet hay, and the mid-day meal of milk may be gradually reduced and ultimately discontinued; and when the calf at length takes slices of turnips and mangels freely, the milk may be brought down to five or six quarts per day, water being added to make up the necessary quantity. At seven or eight weeks the milk may be gradually reduced, and soon altogether discontinued.

A Gloucestershire Practice.—Mr Ruck, Cirencester, has reared his calves successfully upon the following food, with whole milk for the first few days, and then a little skim-milk: 7 lb. of finely ground linseed-cake dissolved in 2 gallons of hot water, to which is added 2 gallons of hay-tea, made by pouring hot water on good hay in a tub; and to this again is added 7 lb. of mixed meal, of wheat, barley, oats, and beans, in equal parts, steeped in 2 gallons of hot water. Of this mixture the calves get 2 quarts in the morning, further diluted with two quarts of warm water; and 2 quarts at night, also diluted with 2 quarts of warm water. Upon this gruel the calves thrive well, and are weaned when about 12 weeks old.

Mr Bowick's Plan.—In his useful paper on "Calf-rearing," Mr Thomas Bowick gives this account of his mode of *rearing* calves: "We manage to turn out from 25 to 30 calves annually—such as will pass muster anywhere—and never use at any time more than 6 gallons of new milk daily. For this purpose, as well as to obtain a regular supply of milk for other purposes, the calves are allowed to come at different periods extending from October to May.

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xiv. 401.

We begin with new milk from the pail, which is continued for a fortnight after leaving the cow. Then skim-milk, boiled and allowed to cool to the natural warmth, is substituted to the extent of one-third the allowance. In another week the new milk is reduced to half, and at the same time, *not before*, boiled linseed is added to the mess: 5 lb. of linseed will make about 7 gallons of gruel, and suffice for 5 good-sized calves. As soon as they take freely to this food, the new milk may be replaced with that from the dairy, and the calf is encouraged to indulge in a few sliced carrots, green hay, or linseed-meal, or finely crushed oilcake. Amongst the multitudes of substitutes for milk that have at different times been recommended, we have found nothing better than those previously referred to; or linseed, 2 parts, and wheat 1 part, ground to meal, and boiled to gruel of moderate thickness, and then mixed with an equal quantity of skimmed milk. It is true we have omitted any allusion to 'Irish moss,' which calves seem to relish well, though it does not prove of a fattening nature. For the lot of calves named (25 to 30), 2 cwt. of this article is found a desirable addition, and lasts throughout the season." [1]

General Rules.—Major M'Clintoch writes thus: "It is very difficult to lay down an exact rule for feeding calves, as far as quantity is concerned; nor can a time be fixed for weaning, the appearance of forwardness in the animals being the best rule to go by. However, as a general mode, supposing a calf to be dropped in March, I would suggest that pure 'mother milk' should be given for a fortnight, then by degrees an admixture of oilcake gruel (1 quart of cake, ground fine, to 4 quarts of boiling water) introduced, and a sufficient drink allowed at each meal, so as to remove all hollowness from the flank. In a few weeks 6 gallons will be taken by the calf, and when the weather is favourable it should be allowed to run in some well-sheltered place where the pasture is sweet. In 3 months calves have an appetite for grass, and it is then that the process of weaning should begin." [2]

Spare Dietary for Calves.—The late Mr J. Chalmers Morton described the system of feeding in a case in which "5 cows reared 50 calves, their milk having been also to some extent skimmed for butter for the household. The cows were brought to the pail one after another from February until May; and the calves, brought as they could be got, received each a share of the partly skimmed milk, more and better milk being given to the very youngest, until they began to nibble shred swedes and hay. The sole addition to this food was oatmeal gruel; half a pint of finely ground best oatmeal for each calf being put morning and evening into about 2 quarts of scalding water, which was cool enough and cooked enough, by staying there all day or night, for use at the evening or morning meal respectively, after having thus stood 12 hours. This, with care always to give food which is perfectly sweet and not too cold, with attention also to the warmth and dryness of the accommodation that is given to the calf, has reared them in health, without a single loss, during the season." [3]

Liberal Treatment desirable.—Remarking upon the scrimp character of this dietary, Mr Morton adds: "It is more and more coming to be generally acknowledged, that for the production of the best and most profitable animals, whether for the dairy or the feeding-stall, the more liberal management of the calf is in the end the better way. To stint the young beast is to diminish its quality as a good doer from the very beginning. Whether for beef or for milk, it is well that good calf-flesh should be established at the outset, and that by no stinginess or severity of after-treatment should it be lost." [4]

Mr E. Bowly's System.—In his prize essay "On the Management of Breeding Cattle," the late Mr Edward Bowly, a noted English breeder of shorthorns, thus describes his system of rearing calves: "My early calves—those which drop from December till the end of February—I allow to suck the cows for a fortnight, then take them off, and give them as much as they will drink of skim-milk and thick gruel made from boiled

[1] *Jour. Royal Agric. Soc. Eng.*, xxii. 140, 152.
[2] *Ibid.*
[3] *Ibid.*, sec. ser., xiv. 403.
[4] *Ibid.*

linseed, in equal proportions, twice a-day. As soon as they are inclined to eat, I supply them with oilcake, carrots, and hay. When three months old I reduce the milk and linseed to once a-day, and in three weeks afterwards discontinue it altogether, continuing the food till they are turned out to grass. Then I give them 2 lb. of oilcake daily, which I continue, in addition to other food, for twelve months—that is, till they go to grass the following year."

Late Calves.—Mr Bowly states that those calves which drop late in March and during the summer months he allows to run with cows, after purchasing nurses for the purpose. He considered it desirable to remove the calves from their own dams, as those cows which are being sucked by calves will not always take the bull so soon as those milked by the hand.

Devonshire Custom.—A custom long prevalent, although not universal, in Devon, was to allow the calf to suck its dam for the first eight or ten days, then take it away and give it five pints of new milk per day for the first week, after which the new milk is gradually withdrawn, and skim-milk added, until, at the end of three or four weeks, the skim-milk is entirely substituted for the new milk, and then a little other food is by degrees introduced, such as turnips, cut into finger-pieces, as for sheep, and oatmeal or other gruel. In this way the youngsters are carried on till the grazing season begins.

Daily Allowance.—The quantities of food given to calves at each meal vary according to the size, breed, and condition of the animals. For a healthy calf of any of the larger breeds the following quantities are generally allowed: in the first week, 3 pints (new milk) at once, three times a-day, making 4½ quarts per day; gradually increased till, in the fourth week, the quantity is 5 pints at once, and three meals, making up 7½ quarts per day. At one month old, when the calves eat hay, finely sliced roots and cake, two meals a-day may suffice; the quantity at two months old being 4 quarts at a meal, or 2 gallons daily.[1]

A Perthshire Example.—On a well-conducted farm in Perthshire the following system is pursued: "For the first fortnight we give nothing save new milk; the third week the quantity of new milk is lessened, and skim-milk supplies the deficiency, a little linseed and oatmeal porridge being added to it. The oatmeal is well boiled, the linseed (cake ground down very fine) steeped in boiling water an hour or two previous to use. As to the quantity that should be given, experience will prove the best guide; a supply sufficient for one animal is frequently too much or too little for its neighbour. The great 'secret of success' in calf-rearing lies in being careful not to overload the stomach; the appetite should never be quite satiated. When eight or nine weeks old, a little clover-hay and finely cut swedish turnips are given, along with a small allowance of dry linseed-cake. Some difficulty is occasionally experienced in getting them to take to the latter substance; but by putting a small bit into the youngster's mouth just after it has finished its gruel or porridge, at which time it will suck greedily at anything within its reach, it soon acquires a taste for it. The allowance of porridge should be continued until the animals are five or six months old, after which it may be gradually discontinued. We have tried various of the calf meals, or milk substitutes, in the market, but found none fit to beat the oatmeal and linseed, either as regards moderation of first cost or the satisfactory after-results."[2]

A Useful Dietary.—Mr G. H. C. Wright gives the following as a useful table of rations for a calf:—

1st week—4 quarts of new milk at three meals.
2d week—4 quarts of new milk and 2 quarts boiled skim-milk at three meals.
3d week—2 quarts of new milk and 4 quarts boiled skim-milk at two meals, and ½ lb. boiled linseed.
4th week—6 quarts boiled skim-milk and ¾ lb. boiled linseed at two meals.
5th week—6 quarts boiled skim-milk and 1 lb. boiled linseed at two meals.

1 lb. of crushed linseed (flax-seeds, not cake) will make rather more than 1 gallon of gruel.[3]

American Example.—Professor E.

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xiv. 495.

[2] *Farming World*, 1889, 23.

[3] *Ibid.*, 1889.

W. Stewart says: "We have often had calves seventy days old fed with ½ lb. flax-seed and 1½ lb. of oatmeal each, with 20 lb. of skim-milk per day, that have gained in weight 30 to 37 lb. in ten days—an average of over 3¼ lb. each per day. The flax-seed and oatmeal are boiled, and then mixed with the milk. The average weight of these calves when dropped was about 60 lb.; their average weight at seventy days was 230 lb.;—they had consequently gained 2.42 lb. per day. They were fed on new milk for one week. then half-and-half skim-milk for another week, then upon skim-milk and 4 oz. of boiled flax-seed each per day; at thirty-four days old, flax-seed increased to ½ lb., and ½ lb. oatmeal added; the latter was increased to 1 lb. in a few weeks, and afterwards another ½ lb. added."[1]

Whey for Calves.—Whey—what remains of milk after the cream and casein or cheese are taken away—is much more useful as food than is generally supposed. Often this refuse of the dairy is thrown away as of little value; but some consideration will show that in this there is great waste. Whey consists of about 93 per cent of water and 7 per cent of solids—nearly the same proportions as in common turnips. The solid matter consists of about 70 per cent of the sugar of milk, 14 per cent albuminous compounds—containing about 3.75 per cent of nitrogen, 11 per cent of ash, and nearly 5 per cent of butter or pure fat. It is probable that at least one-half of the mineral matter or ash is made up of common salt, derived from the salt used in the cheese-making. The albuminous matter makes up very nearly 1 per cent of the whole of the whey, and this, with ⅓ per cent of butter-fat and 5 per cent of milk-sugar, proves whey to be an article of food worthy of careful utilisation.

Supplementing Whey.—But while the food constituents in whey are considerable, and may be turned to good purpose in feeding calves, these must be largely supplemented by other richer commodities in order to sufficiently nourish the young animal. For the successful and economical selection and proportioning of these supplementary foods great care and no little skill are necessary. Fat-forming matter must be added to make up for that removed in the cream; and nitrogenous matter, phosphate of lime, magnesia, sulphur, soda, &c., taken away in the casein, must likewise be replaced. These elements, added in due proportion to the easily digested milk-sugar in the whey, make a very wholesome food for calves. These supplements to whey would be well supplied by linseed and linseed-cake—say ½ lb. of each well boiled and added to 2 gallons of whey for a young calf. Some might prefer oatmeal, barley-meal, or wheat-bran.

Care in use of Whey.—In utilising whey as food for stock, certain precautions are necessary. It should be used while fresh and sweet, as, if allowed to become sour, it may seriously derange the system of the animal. Then whey should not be fed alone, on account of its being so unevenly balanced—too much water and too little dry matter. To enable the animal to obtain the necessary amount of dry matter, it would have thus to swallow too much water. Therefore, give the whey in conjunction with other drier and more concentrated food.

Hay-tea for Calves.—There is considerable feeding value in hay-tea. In fact, well-made hay-tea is almost a perfect food as far as it goes. Professor E. T. Stewart says: "The soluble nutritive constituents of the hay are extracted by boiling, and this extract contains all the food elements required to grow the animal, besides being as digestible as milk. If the hay is cut early, when it has most soluble matter, and is of good quality, the tea will grow good calves; but this extract frequently has too small a proportion of albuminous and fatty matter. Yet if the hay-tea is boiled down so as not to contain too much water for the dry substance, calves will usually thrive upon it."[2]

Experiment with Hay-tea.—Professor Stewart describes an experiment which he made with hay-tea and other foods in calf-rearing. To each of five calves, thirty days old, he gave daily 2 gallons of hay-tea, in which ¼ lb. of linseed and ¼ lb. wheat middlings had been boiled. The experiment was con-

[1] *Feeding Animals*, 237.

[2] *Ibid.*, 246.

tinued for sixty days, with a gradual increase during the last thirty days of the middlings to 1 lb. The calves did remarkably well, gaining an average of a little over 2 lb. per head per day in weight. He also states that a similar experiment was tried by a dairyman who sold his milk for city consumption, yet desired to raise a number of calves. Here the results were even more satisfactory—the average daily gain in weight for sixty days being 2¼ lb.[1]

Making Hay-tea.—There is a knack in making all kinds of tea. There is a good deal in the manner in which this wholesome beverage for the calf is prepared. Some make it by merely pouring boiling water over long hay in a tub. A better plan is to cut the hay, as with a chaff-cutter, and boil it in the ordinary way for at least half an hour. Professor Stewart states that in his experiment mentioned above, he boiled hay cut ⅝ of an inch long, 3 lb. for each calf, half an hour, and then the short hay was raised upon a wire-cloth sieve over the kettle and drained, whilst the flax-seed and middlings were put into the kettle and boiled to a jelly.

It is important for tea-making that the hay should be cut young, when in full bloom, so that it may be nutritious and easily digested.

Where milk is scarce, the use of hay-tea in calf-rearing is to be commended.

Calf-rearing in Pure-bred Herds.

The methods of rearing calves in pure-bred herds does not vary quite so much as in ordinary stocks. In pure-bred herds the successful rearing of the calf is the first and main object. The utilisation of the cow's milk, apart from the upbringing of the calf, is as a rule a matter of secondary importance. The pure-bred calf, therefore, usually gets all the milk that is good for it. In the majority of cases, perhaps, it draws this directly from its dam, but the system of hand-feeding pedigree calves is also extensively pursued. In most cases the calf sucks its dam at the outset, and where hand-rearing is pursued it is taken away from the cow in ten days or two weeks—in some cases as early as its second or third day. Where the suckling method is followed, the calf is allowed to remain with the cow or have regular access to her till it is weaned at six or seven months old.

A Gloucestershire Shorthorn Herd.—In Lord Fitzhardinge's herd of shorthorns at Berkley Castle, Gloucestershire, the custom is to let the cows suckle their calves, the calves running with their dams and sucking at will for three weeks. The cows being milked between five and six in the morning, and at four o'clock in the afternoon, to take from them whatever the calves may have left. At the end of three weeks the calves are taken away and brought up by hand, the finger being given them for a day or two, if necessary, to teach them to drink out of the bucket. They are fed twice a-day, getting about a gallon of new milk each time, the quantity being slightly lessened if there is a tendency to scour. Care is taken never to gorge a calf with too much milk; the appetite and constitution of each youngster being carefully observed. Sometimes a calf three weeks old cannot beneficially take more than two quarts of new milk at each end of the day. Milk is continued till the calf is six or seven months old; but when it has been five or six weeks in this wicked world, it is allowed access to a little crushed oats, Indian meal, and barley-meal, given very sparingly at the outset, and not too finely ground, as calves do not so readily chew the cud when fed on finely ground meal.[2]

A Norfolk System.—In Mr Hugh Aylmer's large herd of shorthorns at West Dereham Abbey, Norfolk, Mr Housman tells us, "the calf at birth is allowed to remain with the dam, at least in the same box; but there is in the corner a little pen for the calf, in which it is kept, having the mother's companionship, though not unrestricted access to her, for the first fortnight. From that time the calf has a pen in some other house, sometimes in a box to itself, but oftener in a compartment in a house with other calves, and is taken to the mother twice a-day, morning and evening. If the mother is a deep milker, the herdsman takes from her as much

[1] *Feeding Animals*, 246.

[2] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xvi. 409.

milk as he finds she can spare, leaving plenty for the calf, which then comes in and clears the udder, so that the calf gets the richer 'strippings,' but does not satiate itself by taking too much after a day's (or a night's) fasting. . . There is no inflexible rule, but usually the calf, if a heifer, is suckled about six months; if a bull, sometimes rather longer. As soon as the calf can be enticed to eat a little dry food, it has in its manger a mixture of crushed oats, oilcake, and ground maize (these ingredients varied in proportion, and one or more omitted so as to tempt the appetite), and sometimes a little cut cabbage or tares with the dry food; but it does not do much more than flirt with the manger until it reaches the age of six or seven weeks, when it begins to eat in earnest, and by the time it should be weaned, it is pretty well past the necessity of having milk, so that there is no checking of growth or loss of flesh after weaning. The quantity of milk, too, can be regulated by the quantity taken from the cow before the calf is turned in with her; and the calf is thus, by easy transition, relieved of dependence upon its mother." [1]

A Northumberland Shorthorn Herd.—In almost every instance, the cows in the Duke of Northumberland's shorthorn herd at Alnwick Park are allowed to suckle their calves. This plan, Mr Housman says, is found to be a safe one for both cow and calf, and since it was fully adopted, the loss of a calf at Alnwick Park has been very rare, and no shorthorn cow has died of milk-fever for many years. The calves remain with their dams for six or seven months, when they are weaned, in order to rest the cow before she has another calf.[2]

Scotch Shorthorn Herds. — The most general plan in Scotch herds of shorthorns is to allow the cows to suckle their offspring. Describing the practice in Aberdeenshire with the Sittyton shorthorn herd specially in view, Mr Housman says: "When the cow calves, the calf is tied up beside her; and for some time, until it is well able to take all her milk, the cow is regularly milked, *the calf sucking at the same time*, so that the cow cannot retain her milk. When the calf can manage all the milk, it is allowed to go loose about at will, one stall being left for the use of cow and calf. When the cows go out to the grass, the milk generally increases, and sometimes it is again necessary to resort to hand-milking to take away the surplus. After the calf is weaned, the cow is regularly milked three times a-day. Indeed, at all times, care is taken to relieve the cow of all her milk. The calves are trained to eat oilcake and sliced turnips as soon as possible, and are weaned at from seven to eight months old." [3]

Systems in Irish Herds.—There is no part of the country where calf-rearing is better understood than in Ireland. The prevailing system in Irish pure-bred herds is to let the cow suckle the calf. In Mr T. W. Talbot-Crosbie's herd of shorthorns at Ardfert Abbey, County Kerry, all the calves are suckled, and run with cows while these are on pasture. The bull calves are taken in as soon as they begin to be troublesome, and put into boxes *in pairs*, the same two being kept together until they are sold. The cows are brought in twice a-day to suckle the calves till weaning-time. The heifer calves are usually left with their mothers till the cows are housed in the autumn, but no calf is ever allowed to be with the cow after she is six months in calf. Food is given to the bull calves as soon as they are put into the boxes, but the heifers get no extra feeding until they are weaned. The first food, other than milk, given to calves, generally consists of pulped turnips, sweet-hay, and a mixture of linseed-cake, decorticated cotton-cake, oats, and bran, in the following proportions, divided into four equal parts: Two of linseed-cake, one of cotton-cake, and one of crushed oats and bran. There is no fixed rule as to quantity, except that the bulls are fed pretty liberally according to size, and the heifer calves sparingly.[4]

In Mr Richard Welsted's old-established herd of shorthorns at Ballywalter, County Cork, the rule is to let the cow suckle the calf for one day only, and to bring up the calves by hand-feeding,

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xvi. 415.
[2] *Ibid.*, 395.
[3] *Ibid.*, 388.
[4] *Ibid.*, 422.

mainly with new milk, until they are well able to consume and live upon cut roots, hay, or grass, and roughly ground oats. To bring forward late calves, the suckling system is sometimes resorted to.

Hereford Herds.—In herds of Hereford cattle the almost universal practice is to let the calves suck their dams. The youngsters generally run with the cows on the pastures in the grazing season, and in the house they are either kept in a compartment with the cow, or in an enclosure by themselves, and brought to the cow two or three times a-day, most generally twice. If any cow gives more milk than is thought desirable for the calf, the cattle-man milks her at regular intervals. In Mr John Hill's herd at Felhampton Court, the calves, before the beginning of the grazing season, "are fed as soon as they can eat (they begin when a fortnight old to pick up a little), with hay, pulped swedes, or a few cut into finger-lengths, with a little cake and crushed oats. The allowance of cake and meal is increased as they get older, to half a pound each per day, and before the summer is over up to 2 lb. per day,"[1] the calves sucking their dams at the same time.

Polled Herds.—In the herds of polled Aberdeen-Angus cattle, suckling is the prevailing custom. The calves are trained, before being weaned, to eat other food, such as linseed-cake, hay, cut roots, bruised grain; and at the time of weaning they are fed and tended with the greatest care, so that there may be no retrogression. In some herds the calves are taken from the cows when about six weeks old, and thereafter brought up on new and skim milk, and gruel made chiefly from linseed-cake or oatmeal, or a mixture of these and other foods.[2]

General Notes.

Feeding Calves for Veal.—Large numbers of calves are slaughtered for veal, and these are of course forced with rich food from the very outset. New milk is the best of all foods for this purpose, although it may be to some extent supplemented by rich gruel, made perhaps from barley-meal or Indian-corn meal. Some give raw fresh eggs to veal-calves, which are generally allowed to suck the cow at will, or at least three times a-day. The usual period of fattening for veal is from six to ten weeks, and with the view of improving the colour of the flesh the calves are frequently bled. In fattening veal calves, most careful attention must be given to cleanliness, ventilation, and regularity of feeding.

Rearing Bull Calves.—As a rule, bull calves intended for sale for breeding purposes are fed more liberally than heifer calves. They are reared more largely upon new milk to begin with, the most general custom being to let them suck their dams for six, seven, or eight months. Then when other food is provided for them, it is usually of a richer and more forcing kind than is allowed to heifer calves. Gruel made from linseed or linseed-cake, oatmeal or barley-meal, is extensively used, and so is linseed-cake by itself or mixed with bruised grain. Malt is a favourite food with some experienced breeders in pushing on bull calves. Some breeders sweeten the food-mixture for young bull-calves with a little dissolved or diluted treacle. This should be used sparingly, however, if used at all—as food which, like treacle, is rich in sugar, is deleterious to the procreating properties of animals—that is if given in considerable quantities.

It is specially important that bull calves should have plenty of exercise and fresh air. If long shut up and highly fed on forcing food, they are liable to go wrong in the legs and feet.

Danger of gorging Calves.—Great care should be exercised in the feeding of calves in their tender days, especially during the first three weeks. At this time they should be fed sparingly rather than liberally. Many calves are lost by sucking or drinking more milk when they are quite young than their weak digestive system can readily dispose of. Whether the calf is fed by the hand or suckled by its dam, take care that it does not over-feed itself. Never let it suck or drink till it is quite satisfied—at any rate during its first three weeks. If the cow has too much milk for the calf, take away a little by the hand.

Referring to this point in his admi-

[1] *Hist. Hereford Cattle*, Macdonald & Sinclair, 274.
[2] *Polled Cattle*. Macdonald & Sinclair.

rable paper on "The Management of a Shorthorn Herd," Mr William Housman, one of our most reliable authorities on live-stock matters, says: "The theory is —and I believe it to be perfectly true—that many of the frequent and discouraging losses among young calves are caused by the allowance of too much milk at a tender age. The calves should be kept hungry—that is, never allowed to satisfy themselves—for the first three weeks of their lives. Scouring and indigestion, with consequent formation of hair-balls in the stomach, arise from too liberal or irregular feeding." [1]

Irregular feeding—long fasts followed by heavy meals of milk or other food—is quite as hurtful as, and of more frequent occurrence than, excessive feeding.

Many calves are killed by gorging with milk after a long fast—perhaps after a journey. When a purchased calf is taken to its new home it should be fed very sparingly for at least two days.

Does Suckling hinder Breeding?—By many experienced breeders it is contended that when the calf is allowed to remain with and suck the cow, there is a danger of the cow being longer in returning to the bull than if she were milked by the hand and the calf kept away from her. The subject has long been debated, and still opinion amongst leading breeders is sharply divided. The preponderance of opinion would seem to be that the danger, if such exist at all, is not serious; and this is confirmed by the fact that in pure-bred herds the suckling system is the one which prevails the most extensively. Some contend that it is the companionship of the calf, rather than the mere act of suckling, which retards the cow in breeding again; hence some who practise the suckling, systematically keep the cows and the calves separate from each other except at feeding-times.

Mr Housman made a special point of investigating experience and observation upon this subject amongst breeders of shorthorns throughout the kingdom, and he was quite unable to account for the divergence except by differences in local conditions of soil and climate, by the assumption that certain districts are more favourable than others to the breeding propensity and reproductiveness of cattle. In some herds it has been found that cows rarely return to the bull until after their calves are weaned. In others the sucked cows come round as early and as regularly as those milked by the hand.

Licking and Rubbing beneficial.—Many skilled breeders systematically let the newly dropped calf be licked by the cow. And there is more in this apparently small matter than is generally supposed. "The bloomy appearance of suckled calves is partly due to this motherly attention; and the licking along the calf's spine, which the cow, with her rasp of a tongue, gives her calf immediately after birth, has evidently an important meaning. All careful managers, when the calves are not reared by the cow, take care to imitate this process, rubbing well over the spine with a wisp of straw. This not only dries the calf and prevents its taking cold, but evidently strengthens it; and the calf, if a healthy one, responds to the rubbing by vigorous efforts, soon successful, to gain its feet." [2]

Weaning Calves.—Weaning is usually a critical event in calf-life. In dairy and ordinary stocks, where only a small portion of the milk is given to the calves, the youngsters are weaned when very young. The process may be said to begin in some cases at the end of the second week, when some skim-milk or gruel is substituted for so much of the new milk. In pure-bred herds, and wherever calves are reared largely on milk, weaning is generally completed in the sixth, seventh, or eighth month, after which the calves are fed similarly to the other animals.

Now in the weaning of calves there is scope for the exercise of the utmost skill and care. If success is to be attained, both skill and care are essential. Prepare the young animal for the weaning —the complete withdrawal of its mother's milk—by feeding it partially for some time before with such food as will form its main support after it has been weaned. Let the milk be lessened, and the other

[1] *Jour. Royal Agric. Soc. Eng.*, sec. ser., xvi. 388.

[2] *Ibid.*, 428.

food gradually increased in quantity, so that the transition may be effected almost imperceptibly. The more carefully and intelligently this is done, the more satisfactory will be the result in the calf. The amount of milk allowed to a suckled calf may be regulated by drawing away as much of the cow's milk by hand as may be desired, and at last, just before final weaning, the calf may have access to the cow only once a-day.

There is perhaps no better food for calves at weaning-time than good linseed-cake—from 1 to 2 lb. per day, and a few sliced turnips or mangels, and fresh well-made hay. If accustomed to this fare before being entirely deprived of their mother's milk, they will be found to pass through the ordeal of weaning without any loss in condition or delay in progress.

Diseases of Calves. — *Scouring* — sometimes called white skit or white scour — is the most prevalent ailment among calves. It is generally caused by improper feeding, and may as a rule be cured by giving 2 ounces of castor-oil, or an egg beaten up shell and all, followed by tablespoonful doses of *calf-cordial*, prepared of the following: prepared chalk, 2 ounces; powdered catechu, 1 ounce; ginger, ½ ounce; opium, 2 drachms; peppermint-water, 1 pint. Oatmeal or linseed gruel should be the main food for a few days.

Calves also suffer frequently from *constipation.* This will be relieved by giving 1 ounce of castor-oil beaten up in the yolk of an egg, with a very little ginger, about 1 scruple, repeating the dose if necessary.

Eggs for Calves.—An effective "pick-me-up" for a calf that is not eating or thriving as well as could be desired is a raw egg beaten up and added to the milk. Some beat up the egg shell and all, others think it preferable to withhold the shell.

Setoning.—A seton is a piece of string or tape passed through a certain part of the body, with the object of either drawing an abscess, acting as a counter-irritant, or for the purpose of inoculation. As a prevention against black-leg, or quarter-ill, it is a useful custom to insert a seton in the calf's brisket in the spring. It is considered desirable to soak the seton in some irritant such as the following embrocation—viz., hartshorn, 1 ounce; turpentine, 2 ounces; spirit of camphor, 2 ounces; laudanum, ½ ounce; olive-oil, 6 ounces.

Castrating.—The male calves can be most easily castrated when a few weeks old. They can then be cut standing, by twisting the tail around one hind leg. Stand behind the calf, cut through the bag, twist the stone several times, and scrape the cord closely through with your finger-nails or a blunt knife. When the calves are several months old they must be cast. This may be done by tying the hind-legs together with a rope, placing a halter round the neck, taking the shank end of the halter and running it through the rope that unites the hind-legs, tying it back, passing it through the portion that is around the neck, and drawing the legs tight, then fastening the rope. The fore-legs can be held by a man. The stones may then be removed by the clams and hot iron, as in the case of the horse—place the stone in the clams, and with a red-hot iron saw the cord slowly through close to the clams.

SHEEP IN SPRING.

The anxieties of the spring — the hopes and the fears — are as great to the flock-owner as to the cattle-breeder. It very often happens that the heaviest part of the winter weather has to be gone through in spring. Severe snow-storms frequently occur in February, and occasionally stretch into March, causing much anxiety, and it may be serious losses, to flock-owners, by deaths and by outlay for extra feeding and management.

Sheep in Spring Storms.—As to the treatment of sheep in stormy weather in spring, the information given under the heading of "Sheep in Winter" should be consulted. The particular kind of extra food to be given to the sheep in a spring snowstorm will depend mainly upon the supply on the farm and the sort of food cheapest and most easily obtained at the time. This one word of caution we would repeat, Do not too long delay hand-feeding if such should be necessary — do not postpone extra feeding till starvation has done its work of mischief. At such a crisis *timely* rather than liberal feeding is the essential point.

THE LAMBING SEASON.

At this season of the year lambing is the all-absorbing topic of interest with the sheep-farmer and the shepherd. No one who has not lived on a sheep-farm can conceive what the advent of the lambing-time brings to the chief actors in flock management. It arouses a depth of interest and a ceaseless anxiety not experienced at any other period of the year. It is the time in which, above all others, good or bad management *tells* —when every hour of carelessness may rob the flock of the lives of valuable animals.

And the seriousness of the lambing season is nearly allied to sentimentality; for while the faithful shepherd is toiling day and night in the lambing-pens, he is even then cheered by a foretaste of the unspeakable joys which come alike to the owner and the tender of the flock from the sight of thriving "lambs at play." It may be—we fear it is, although one is loath to believe it—that the hard utilitarianism of the present age is depriving pastoral life of much of the sentiment and poetry which gilded it in the past.

Poetry of Pastoral Life.—We are heart and soul in sympathy with Professor Wrightson when he says: "There is genuine poetry in pastoral life which it is sad to lose entirely. Nevertheless, agricultural science and literature are between them rapidly taking the romance out of it. Perhaps we should add, hard times, and the vital importance of making things pay. Still, it is a pity to lose the faculty of discerning the beauty of the dewy eve and rising moon, or listening as the amorous thrush concludes his song; or only to think of the price of mutton and of wool, or of lambs as fore and hind quarters.

"'The haunt o' Spring's the primrose brae,
The Summer's joys the flocks to follow;
How cheerie through the shortening day
Is Autumn in her weeds o' yallow!'

"The sweetness of pastoral life is going. It is disappearing under the influence of commercial enterprise, the spread of science, and the difficulties of competition. We also ourselves are victims to utilitarianism, and must plead guilty to sharing in the universal want of sentiment even when birds rejoice in leafy bowers and bees hum round the breathing flowers; or when within yon milk-white hawthorn bush, among her nestlings sits the thrush. One is sometimes inclined to wonder if steam-power and chemical manure, pedigree stock and iron fencing, weigh-bridges and milk registers, will ever compensate us for the loss of the fresh and simple country life of our forefathers. It is useless to repine, and perhaps the best thing we can do is to cherish those pleasurable feelings with which we may still view the flock spread o'er the down, or listen to the varied tones of the sheep-bell; and to cultivate more of personal interest and affection for our domesticated creatures. There is no doubt that the humble dairyman, the carter, or the shepherd, obtain more enjoyment from watching and tending their charges than do their masters; and the pleasures of farming might be greatly enhanced by devoting more personal attention to our live stock, and studying their habits. Love of animals may be cultivated, and with it comes an interest in the wild creatures which surround us."[1]

Assuredly the kindly interest here inculcated has a practical bearing upon the material wellbeing of the flock-owner, who may do much to encourage his shepherd by sympathetic countenance and intercourse by the side of the flocks. And a good shepherd is well worthy of all the encouragement that can be given to him.

[1] *Live Stock Jour.*, Jan. 1889, 42.

A Good Shepherd.—A shepherd whose unwearied attention and consummate skill become conspicuous at this critical period of the flock's existence, is an invaluable servant to a stock-farmer. His services, in fact, may be worth far more than the amount of wages he receives. Such a man will save the amount of his wages *every year*, when compared with the losses sustained by the neglect of an unskilful shepherd, especially in a precarious season, when, by treating the ewes and lambs in the most proper manner under the circumstances, the lives of many are preserved that would otherwise have been lost.

The Modern Shepherd.—As a class of men the shepherds of the present day are surpassed by none of their fellows on the farm for intelligence, efficiency, or faithfulness. They are undoubtedly, as a rule, better informed, if not more trustworthy, than the shepherds of former times. In many instances we have known, their success in treating their flocks at lambing-time has been remarkable. Yet the best of them need all their wits about them in the height of lambing, and in bad weather may sustain numerous losses in spite of their utmost efforts.

Skilful and Attentive Shepherds.—Some shepherds are as attentive as could be wished, but lacking in skill. They may have their ewes in too high condition for lambing, and may be over-anxious and over-ready to assist in difficult cases of lambing—thus, through want of skill, causing the loss of both ewes and lambs. Other shepherds, again, are sufficiently skilful, but are wanting in attentiveness. Of these two sorts of shepherds—the attentive and the skilful—the skilful is the safer, as it will usually be easier for the master to enforce attentiveness than to inculcate skill—that is, if the skilful shepherd is not a positively careless fellow, in which case he should not be in this position at all.

A Perfect Shepherd.—It is only by the union of both qualities that a perfect shepherd is constituted—preventing evils by skilful attention, and curing them by attentive skill. Even with such a perfect shepherd losses will happen, but they will be no fault of his: disease will prove mortal to sheep at lambing, which even the most skilled veterinarian cannot prevent. His acuteness will perceive a sheep affected long before any one else can detect it; but it is not to be expected of any shepherd to treat many of the diseases of sheep successfully when a veterinarian is not to be found.

Preparations for Lambing.—The cautious shepherd will have several preparations attended to before lambing begins. He will see that sufficient shelter is provided—on arable land—either in permanent or temporary lambing pens,—will have conveniently at hand supplies of extra food, such as turnips, cabbages, hay, &c., also of straw for litter, and will see that his medicine-box is replenished to meet emergencies. He will have a good lantern, such as shown in fig. 117, in readiness to guide him through the pens at night, and likewise a piece of blanket in which to wrap a weak lamb. In many cases the shepherd will have to spend the night beside the lambing-pens, and he must therefore have his own bed in order, either in his separate hut, or in a corner of the lambing-shed. There should be a fire in the shepherd's compartment, and some coffee or tea will be useful. All these essentials should be in readiness, and not have to be sought for when the active and critical work of lambing begins.

Classifying Ewes for Lambing.—Ewes are drafted into the lambing fold or ground in lots as they are expected to lamb. The tups are usually left among the ewes for six weeks. After two weeks' service the tups are marked with, say, red paint on the breast, and this, at the end of two weeks, is changed to blue paint. The marks of paint on the breast of the tup mark the served ewes on the rump, and thus their time of lambing is ascertained. The in-lamb ewes unmarked are first taken in for lambing, then those with red marks, and lastly those with blue marks. It is well to have the ewes on the lambing-ground quite a week before their lambs are due, as early parturition is frequent.

In many cases the order of marking service is the reverse of the above, the unmarked ewes being the last to lamb.

Lambing Folds or Pens.—Custom

varies greatly in the providing of shelter for lambing. On many farms there are elaborate and costly lambing sheds and pens built of stone and lime. On others the lambing-pens are merely temporary erections, formed, perhaps, of hurdles and straw; while in many cases no lambing-pens of any kind are provided. Costly erections are not necessary, and therefore undesirable, as all unnecessary outlays are. Lambing-pens of one kind or other, however, should be provided upon all farms carrying breeding-sheep, and for all kinds of sheep, whether the hardy mountain breeds or the more tender southern varieties. Let the character of the shelter be suited to the farm, the locality, and the breed of sheep. Little roofed space may suffice, but there should be a dry bed and shelter from the prevailing winds. The weather may be so favourable as to make it unnecessary to put any of the ewes and lambs under roof, yet the means of doing so should exist. The sudden occurrence of a storm without proper shelter being at hand for ewes with very young or tender lambs, might result in serious losses.

The Old-fashioned Shed.—Professor Wrightson, in the paper already quoted, says that shelter must be provided for the ewes at lambing-time. He mentions two descriptions of enclosures for lambing-ewes. One is the old-fashioned permanent shed, for which the rick-yard has often been employed. The advantages of this system are, that the flock is near home, and that the rick-yard is a protected enclosure, which, when well littered down and fenced with thatched hurdles, forms a very suitable place for the purpose. In some cases there are seen special walled enclosures, furnished with accommodation for the shepherd and shedding for the ewes. The shedding is most conveniently divided into coops by means of hurdles, and in such a shed ewes will lamb safely and comfortably. On large sheep-farms this system is objectionable on account of the distance between the flock and their food.

The Modern Fold.—The more general plan now is to construct a pen near to where the ewes and lambs are to turn out after lambing. The position of the pen, says Professor Wrightson, should have been fixed during the previous summer, and have determined the situation of certain hay and corn ricks. As threshing proceeds, the corn-ricks yield straw-ricks, which are made long, and placed so as to secure the greatest amount of shelter from the wind. A gentle slope towards the south is the best site, and in close proximity to a field of swedes or of late turnips.

The enclosure consists of a double row of hurdles, stuffed between with straw, and kept firm by means of a few posts and rails. About 2 feet from the outside wall, and on the inside, are driven 6-feet posts carrying a head rail or plate, and, resting on this plate and upon the outside hurdles, with a sufficient run or slope, thatched hurdles are fixed; thus forming a continuous narrow shed, which is again divided by hurdles into coops or cells. These coops are best open to the south and east, and backed to the north and west; and in such a position ewes and lambs lie warm even in the severest weather. Outside these cells, and inside the enclosure, the space is divided by hurdles into four or five good-sized yards, and a straw-rick ought to occupy a central position with reference to the entire space. The shepherd's portable house is drawn up at a convenient distance, and with such a fold we may look forward to the throes of lambing with a feeling of confidence and security.[1]

Fold for 300 Ewes.—In his paper on the treatment of Border Leicester ewes and lambs, Mr A. S. Alexander gives the following description of a lambing-fold for about 300 half-bred ewes: "A small field of half an acre is chosen behind the homestead. At the north side there is a high stone wall, and on the east a thorn hedge, which effectually breaks the effect of the east winds. Along the north wall are erected a row of twenty houses, 'parricks' or pens, the roofing of which is made by fixing timber from the top of the wall to the posts which form the doors and fronts of the pens. One door serves for two pens, there being in the interior a middle division which does not quite come to the same line as the walls in front. The door is closed by means of a small hurdle or 'flake,' which

[1] *Live Stock Jour.*, 1889, 65.

moves between the partition and the inside of the walls.

"The roof is thickly thatched with rye or wheat straw, tied in bundles, and on the outside or front, bunches of straw resembling sheaves are set on end, so that their tops meet the thatch; and when fixed in this position by means of 'tarry' string or old sheep-netting, a most effectual covering is made, the straw materially adding to the warmth during the cold nights so commonly prevalent in March. This row of pens forms the north side of a rectilineal figure. On the east is the hedge; and to form the other two sides west and south, a fence of larch posts, with three spruce rails, is erected of the same height as a common fence. To make this enclosure as comfortable as possible, bunches of straw are fixed all along the inside of the fence and hedge, and when fixed in position, form as it were a solid wall of straw, which is quite impervious to the strongest wind.

"The enclosure which is called the court is provided with two gates—one for driving the ewes in at the evening, at the west end, and one at the east end, where ewes and lambs are turned into a 'seed' field after a day or two. There is also a little gate formed of two bundles of straw, at which the shepherd enters at night." [1]

Permanent Lambing-shed.—A substantial permanent lambing-shed erected on the farm of Crookhouse, Lanton, Northumberland, is also described by Mr Alexander: "All the pens are erected under one roof of larch, timber, and slate, and enclosed in front and behind by substantial walls of stone. The partitions between the pens themselves are constructed of larch hurdles, fixed at each end to larch uprights, which at the same time support the roof. Each set of pens is divided by a passage communicating with the outside court, where the unlambed ewes lie at night.

"On entering a passage we have three pens on each side, provided with gates hung on hinges, and fastening by means of an eye and draw-bolt. A few pens are made six feet square, so that should the shepherd have ewes with twins, he may have ample accommodation for them, should he not require the third lamb for another ewe. There are fifty-four pens, and the reason for such a large number is that, should severe weather—as a snowstorm—come on during the season, the ewes may be penned instead of lying out.

"By having a number of doors in the lambing-shed instead of a few, the lamber is enabled to house the ewe at the point nearest the place where she lambed. To make it all the easier for him, the pens are constructed round three sides of the square court, so that at whatever part of the court a ewe lambs he has shelter at hand. A covered court enclosed is also in connection with these lambing-pens, into which on stormy nights ewes and gimmers having single lambs are placed. There is also a store-house for food under the same roof." [2]

Lambing Shelter on Hill Farms.—As a rule hill farms are deficient in lambing shelter. On these the lambing is delayed till so late a period in the season —from the middle of April till the end of May—and the mountain breeds of sheep are so hardy, that farmers are apt to trust too much to the clemency of the weather and the hardiness of the sheep. The more careful farmers have numerous small pens or "keb-houses" erected on the lambing-ground, so that there may be plenty of protection for both ewes and lambs from severe storms. On many farms, however, little attention is given to this, and as the result the losses of young lambs, and even of ewes, are often exceedingly heavy. This neglect is all the more reprehensible from the fact that comfortable lambing pens or huts might be formed at nominal expense and very little trouble. With some hurdles, or a few boards, cuttings of turf, and perhaps a little straw, temporary shelter may be provided by which the lives of many lambs might be saved. And it is equally important that the shepherd should provide himself with some extra food, such as hay, roots, and corn, with which to nourish weakly ewes confined for a time in these lambing-huts.

Lambing Hospital.—A few pens in a corner of the lambing-fold by themselves should always be set apart for hospital purposes. In these, weakly ewes

[1] *Trans. High. and Agric. Soc.*, 1882, 146.

[2] *Ibid.*, 1882, 148.

and lambs may be made specially comfortable, the ewes receiving palatable, nourishing food, or such remedial treatment as best suits their peculiar ailments. Many careful farmers have such hospitals formed at some convenient and well-sheltered spot in a field quite independent of an ordinary lambing-fold. They may be formed of hurdles and straw at very little trouble and expense, and would be of great benefit wherever a breeding flock is kept.

Accessories to the Fold.—It is often difficult to keep the floor of the lambing-fold dry. It is a good plan to have the floors of the roofed pens raised by a layer of gravel or burnt clay; and the whole should be comfortably littered with straw. The stacks of straw and hay in the centre will add greatly to the comfort of the fold. A store of roots should be at hand, and so also should be a well-filled corn-bin, with a number of small feeding-boxes which can be placed here and there for the ewes. Care should be exercised in placing the shepherd's hut, root-store, and hay and straw stacks, so as to provide the greatest possible amount of shelter.

Supplementary Shelter.—In addition to the regular lambing-fold it would be well to provide additional shelter in the form of small covered pens or huts at convenient well-sheltered parts of the farm, where weakly ewes and lambs might find comfort during a storm without having to be brought into the fold. These might be very cheap and temporary erections, constructed by the shepherd; and they would be specially useful on hilly farms, or wherever the ewes are not systematically brought into a fold for lambing. With several of these supplementary pens placed conveniently over the farm, odd ewes and lambs would be more easily provided with protection from sudden storms than if they had all to be driven to one central fold. The importance of even one night's shelter to a young lamb may be very great, often saving it from death, and setting it on its legs.

Shepherd's Hut.—This should rest on wheels, and may be made of iron or wood. It should be large enough to hold a bed for one man, a small table and chair, a cupboard for the shepherd's food, and the medicine-case or bottles for the sheep, and of course a fireplace. Fig. 246 represents a convenient portable shepherd's house made of corrugated iron by the Redcliffe Crown Galvanised Iron Co., Bristol.

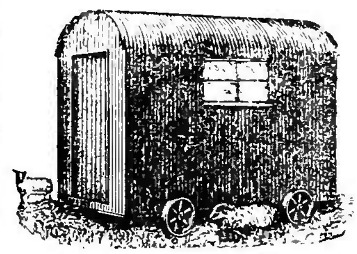


Fig. 246.—*Shepherd's house on wheels.*

Shepherd's Medicine-chest.—In many cases shepherds are now provided with medicine-chests furnished with a considerable variety of medicines and stimulants, comprising laudanum, linseed-oil, castor-oil, spirits of nitre, Epsom salts, powdered ginger, powdered chalk, tincture of aconite, carbolic acid, Gallipoli oil, and whisky or brandy, &c., &c. Excessive physicking, however, is not to be commended. Drugs should be used with caution—only when necessary, and then as promptly as possible. In the lambing-pen carbolic acid and Gallipoli oil are most valuable agents, for they are reliable preventives of inflammation after lambing.

Symptoms of Lambing.—These are, enlargement and reddening of the parts under the tail, drooping of the flanks, patting the ground with the feet, and desire for separation from their companions, stretching frequently, exhibiting restlessness by not remaining in one place for any length of time, lying down and rising up again as if dissatisfied with every place, bleating as if in quest of a lamb, and appearing fond of the lambs of other ewes. In a few hours, or shorter time, the immediate symptom of lambing is the expulsion of the bag of water from the vagina, when the pains of labour may be expected to come upon the ewe immediately. When the pains are felt, she lies down and presses with earnestness, changing one place or position for another, as if desirous of relief.

Assistance in Lambing.—Up to this time not a hand should be put upon her, nor, as a rule, until the yellow hoofs of the fore-feet of the lamb, and its mouth lying upon them, are distinctly seen to present themselves in the passage. When time has been given, and the ewe is not able to expel the lamb by her own exertions, the shepherd renders assistance before her strength fails by unavailing straining. Before giving assistance to a ewe while lambing, the shepherd should smear his hands as well as the vagina of the ewe with " carbolic oil "—that is, a mixture of 1 part of carbolic acid to 10 parts of pure olive-oil.

The exact moment for rendering assistance can be known only by experience. It is necessary to watch and wait, for a hasty parturition often superinduces inflammation, if not of the womb, of the external parts of the ewe. If the labour is unusually protracted, the ewe should be examined, and if the lamb is found to be in its natural position—with its head resting on its two fore-legs—a little more time may be given. Tedious labour often terminates in an easy birth. In nine cases out of every ten of natural presentation the ewe will lamb without assistance. But the ewe should not be allowed to thoroughly exhaust herself before receiving assistance.

When assistance must be rendered, the ewe is taken hold of as she lies, and laid gently over upon the ground on her far or right side, with her head up the hill, where the ground has an inclination. To save her being dragged on the ground when the lamb is being extracted, the shepherd places the heel of his left foot pressing against the rump of the ewe, and kneels on his right knee on the ground, pressing against the lower part of her belly, having the body of the ewe below his own body, between the heel and knee. Having his face towards the tail of the ewe, and both his hands free, he first proceeds to push out *from* him, with both hands, one leg of the lamb and then the other, as far as they will stretch; then seizing both legs firmly above the fetlock-joints *between* the fingers of his right hand, he pushes the legs from him rather downwards from the ewe's tail, with considerable force, whilst by pressing upon the space between the tail of the ewe and the head of the lamb *towards* him, with the lower edge of his left hand, he endeavours to slip the vulva of the ewe over the cantle of the lamb. The action of both hands must be made simultaneously with the strainings of the ewe, only to assist her, and keep good what is obtained at each strain, and not to tear the lamb from her prematurely by force. Whenever the lamb's head is clear, the shepherd seizes the upper part of the neck behind the head with his left hand, the right hand still holding the legs, and pulls out the body with ease. The lamb is then placed at the ewe's head, for her to lick and recognise, which she will instantly do, if her labour has not been severe. If the labour has been very severe, she will likely become sick, and be careless of the lamb as long as the sickness continues, which is evinced by quick, oppressed breathing.

If the pains have been sharp, and this her first lamb, and she is not overcome by sickness, the ewe may probably start to her feet, and run away from the lamb. The attempt at escape must be prevented, and the end of the tail of the lamb put into her mouth, to make her notice it.

The extraction of a lamb, as thus related, is done by a shepherd who has no assistant. When he has, he adopts another and more easy mode for the ewe and himself. The assistant holds the ewe upon her side, in any way the most easy for her and himself, to prevent its body being dragged along the ground while the shepherd is extracting the lamb. In doing this, the shepherd places himself behind the ewe, and, on ascertaining the position of the lamb, pulls its legs *towards* him, whilst the assistant endeavours, by the pressure of the side of his hand below the tail, to make the vaginal membrane pass over the lamb's head, which when accomplished, the shepherd seizes the back of the neck by his right hand, and, holding the legs still in his left, takes away the lamb as quickly as he can, and places it before the ewe.

There is great difference in the disposition of the ewes themselves to assist in the lambing. Some, when they find they are assisted, give themselves little trouble; others strain with vigour from first to last; and some only strain at long intervals. A ewe that strains strongly and continuously will become sooner exhausted than one that takes the matter more leisurely. In the case of the straining ewe there is greater danger in neglecting to make examination of the presentation in time, before the ewe has become exhausted.

A Second Lamb.—If she continues to lie on her side, her abdomen should be felt, to ascertain if there is another lamb to come. If there is, the pains accompanying the passage may have been the cause of her carelessness for the first lamb. If the second lamb is in a natural position, it will most probably, by this time, be showing itself in the passage. If so it be, it should be taken away at once in the same manner as the first, and the ewe, feeling the attempt, will at once assist on her part by straining.

The existence of a second lamb is worth attending to immediately on another account—some ewes become so engrossed with the first lamb, that the pains attending the second are neglected for a time. When a second lamb is found in her, she must be watched, that whenever it comes into the passage it may be taken away; but unless it actually makes its appearance there, it should not be attempted to be taken away.

Should the second lamb not make its appearance in a reasonable time, it may be suspected that the lamb is either dead or not in a natural position, and examination should be made by the fingers into the state of the case. In cases of suspected twins, some make an examination to ascertain if they are presenting themselves separately. If a complication is probable, the hand will have to be introduced to effect a separation of the twins by bringing one forward to the passage. A dead lamb is easily known by the feel, and should be extracted immediately; but should the lamb be alive, and make no appearance, it may be necessary to introduce the hand to ascertain its position. Before the hand is introduced, it should be smeared with the mixture of carbolic acid and oil.

False Presentations.—Cases of difficult lambing generally arise from the presentation of the lamb in some false or abnormal form. The natural position of the lamb in the passage is upon its belly, with its head resting upon its two fore-legs. The false or abnormal presentations are of course variations from this position. The most recent, and one of the fullest definitions of abnormal presentations, is that given as follows by Professor Wrightson, whose sound advice should be considered carefully by flock-owners and their shepherds:—

"1. One fore-leg only presented with the head lying upon it. In this case it is difficult for a ewe to lamb without help. The operator will endeavour to get hold of the missing limb, and, bringing it forward into its proper position, deliver the ewe. The best manner of doing this we shall consider after passing in review the principal abnormal presentations.

"2. Both fore-legs lying back, the head alone being presented. In this position the ewe must have assistance, as birth without it is impossible. The head must be pushed back, the legs brought forward, and the lamb extracted.

"3. The head slipped down between, or on one side of, the fore-legs. This must be set right by bringing the head into its natural position above the fore-legs, and extracting the lamb.

"4. A broadside presentation, in which case the broad side of the lamb is found within the uterus, and of course no progress can be made until the hand and forearm of the operator are introduced and the fœtus is turned and brought into position.

"5. The fœtus on its back, in which case a similar manipulation must be employed as in the last case.

"6. A breech presentation. If the hocks are doubled, the breech of the lamb must be pushed forward, and the hind feet brought up. The lamb is then pulled away backwards without turning.

"7. The fœtus too large, or the passage too small. This is a troublesome case, sometimes involving the loss of the lamb, and occasionally of the ewe. Shepherds sometimes are obliged to carefully introduce a knife and cut off the shoulders, and remove the fœtus piecemeal. More commonly by patience and by exerting a good deal of strength the lamb is safely born.

"8. Monstrosities are not uncommon, most seasons providing examples of lambs with five legs, headless lambs, fusion of two lambs into one, &c. These cases are puzzling, and require special treatment, and when such malformations are presented there need be no hesitation in employing the knife for their removal.

Assisting in Lambing.—"Having given all the possible unnatural presentations likely to be met with, I shall next explain how assistance ought to be rendered to a ewe in distress. In all cases great care and gentleness are requisite, and all roughness or hurry should be avoided. The hand should be anointed with fresh lard or oil, and the finger-nails must be short (shepherds' nails always are). The hand must be compressed into as narrow a space as possible and gently introduced. In giving assistance the operator should draw the lamb in accordance with the natural pains of the ewe, and wait for her to pain. Assistance given at that moment is useful; but if force is used during the intervals of the labour-pains, the muscles of the uterus are excited, and the result is the early exhaustion of the mother. Again, in using force the fœtus should be drawn downwards towards the hocks of the ewe, and the operator need not be afraid of using his strength when the fœtus is once brought into a proper position."[1]

One Fore-leg Presentation.—In regard to the difficulty of one fore-leg presentation, Mr George Brown, Watten Mains, Caithness, says: "If the lamb is well forward in the passage, it is much easier, and often safer, to bring the lamb away as presented, than to attempt pressing back the head to get forward the other foot."

Cæsarean Operation.—The lamb is sometimes in the Fallopian tube, from some cause or other not coming into the womb after conception. Cases of this nature can only be managed by the Cæsarean operation—taking the lamb out of the ewe's side. In cases of this kind, while the lamb may be saved, the ewe, unless a good deal of care and skill are used, is very liable to be lost.

The hardier the breed the rarer the necessity for assistance in lambing. In flocks of Blackfaced and Cheviot sheep, thousands of ewes lamb every season without the slightest assistance.

Inflammation after Lambing.—Unless the utmost care is exercised there is great risk of losing the ewe after a case of hard labour, by "bearing" or "straining"—after pains—and inflammation. Formerly the rate of mortality from inflammation after lambing was very high, but it has been abundantly proved that by timely treatment the danger may be effectually averted. It has already been pointed out that in all cases the shepherd, before assisting a ewe, should smear his hand in a mixture of carbolic acid and olive or Gallipoli oil—about 1 part of the former to 10 parts of the latter. Then, after the removal of the lamb, about two tablespoonfuls of the carbolic acid and oil should be poured into the womb, while any of the external parts which seem inflamed should be smeared with the same mixture. This treatment should be repeated every three or four hours, as may be found necessary. The strength of the carbolic mixture should be regulated—from 5 to 20 parts of Gallipoli oil to 1 of carbolic acid—according to the symptoms of the case. Where the symptoms of inflammation are serious, a strong mixture should be applied promptly and frequently. The efficacy of this simple and inexpensive treatment in preventing after-birth inflammation is remarkable—so much so indeed, that if it is applied in time, immediately after birth in hard cases of labour, and in all cases upon the faintest indication of after straining or inflammation, complete prevention may be expected in ninety-nine cases out of every hundred. It should be mentioned that the credit of discovering this invaluable preventive belongs to Mr Charles Scott, author of 'The Practice of Sheep Farming.'

Rotten Turnips causing Inflammation.—Referring to the occurrence of inflammation among ewes after lambing, Mr James A. Gordon, of Arabella, states that he had found the tendency to inflammation and mortification much greater when ewes were fed on turnips of which a good many were in a half-rotten condition. The best corrective in this case, he says, is to remove the ewes to a field where they can get plenty of young clover, and will receive only a few roots, nothing being so suitable for ewes and their young lambs as fresh young grass.

Inflammation Infectious.—Referring to the infectious character of inflammation in ewes after lambing, Mr George Brown,

[1] *Live Stock Jour.*, 1889.

Watten Mains, Caithness, says: "When a case of inflammation does occur, it is absolutely necessary to separate the ewe from the flock, and have the place she lambed at thoroughly disinfected. The disease is most infectious, and will attack all ewes which lamb after the first case if they come into contact with the contagion. The shepherd, if he has touched the affected ewe, must be very careful to wash his hands in either turpentine or carbolic oil, and even change his clothes before touching another ewe; while ewes which die of inflammation should be skinned by some one else, not by the shepherd.

"*Oats* are a fruitful cause of inflammation in ewes, as ewes fed largely on them become full and hot-blooded at a critical time. Feeding on oats should therefore be discontinued a few weeks before lambing, and cake or bran, or extra turnips, given instead."

After Lambing.—When lambing has taken place in the day, in fair weather, the ewe with her lambs are best at liberty within the enclosed area of the lambing-ground ; but in rain or snow, and at night, she should be taken into the shed, and kept there for some time until the weather proves better, or she has recovered from the effects of the lambing. In the day-time, it matters little for lambs how cold the air is, provided it be dry. It is considered a good sign of health when a lamb trembles after birth.

Cleansing.— The cleansings or placenta generally drops from the ewe in the course of a very short time, in many cases within a few minutes after lambing. It should be carried away, and not allowed to lie upon the lambing-ground.

The Lamb.—The lamb is fondly licked by the ewe at first, and during this process the youngster makes many fruitless attempts to gain its feet, and it is truly surprising how very soon after an easy birth it will stand. The moment it does so, its first effort is to find out the teat, expressing its desire for it by imitating the act of sucking with its lips and tongue, then uttering a plaintive cry, and wagging its still wet long tail. There are various obstacles to its finding the teat at first—the long wool on the ewe's flank hides it — that on the udder interferes with it—and what is still more tantalising, the intense fondness of its mother urges her to turn herself round to it, in order to lick it with her tongue, muttering affectionate regards, while her wheeling about removes the teat, the sole object of the young creature's solicitude. When at length a hold of it is obtained, it does not easily let it go until satisfied with a good drink, which is indicated by its full flanks. When a fond ewe has twin lambs, one can easily obtain the teat while she is taken up in caressing the other. This is the usual behaviour of strong lambs; and on once being filled with warm milk, they increase in strength rapidly, and are soon able to bear very rough weather.

Assisting Lambs to Suck.—But after a protracted labour, the lambs may be so weakly at first as to be unable to reach the teat by their own strength. They must then be assisted, and the assistance is given in this way: turning the ewe over upon her rump, the shepherd kneels upon the ground on his right knee, and reclines her back against his left leg, which is bent. Removing any wool from the udder by the finger and thumb if necessary, he first squeezes the wax out of the teats, and, taking a lamb in each hand by the neck, if twins, opens the mouth of each with a finger, and applies the mouth to a teat, when the sucking proceeds with vigour. A young ewe or gimmer is apt to be shy to her first lamb, but after being suckled, either in this or the natural way, she will rarely forsake her offspring.

When lambs do not succeed at once in finding the teat, the shepherd should soon give the lamb its first suck in this way, which not only saves it much trouble, and gives it strength, but affords himself a favourable opportunity of examining the state of the udder. The first good and early suck to a lamb imparts a strength to it beyond expectation.

Gimmers often have so scanty a supply of milk, that it is expedient for the shepherd to support their lambs partially on cow's milk until the requisite supply appears, which will be partly induced by suckling, and partly by nourishment of succulent food.

Hand-feeding Lambs.—When the shepherd has lambs to support for a short time, he should supply them with cow's milk at regular hours, in the morning and evening, immediately after the cows have been milked, and should see the lambs suckled by their mothers during the day, as also that the ewes have a sufficiency of milk. The dairymaid should put the cow's milk for the shepherd in bottles, when the cows are milked in the morning and evening, and he should feed the young lambs while the milk is warm from the cow. The feeding is done in this way: Sitting down, the shepherd takes a mouthful of milk from a bottle, and, holding up the mouth of the lamb open, he lets the warm milk drop into it in a small stream from his mouth, which the lamb drinks as fast as it comes; and thus mouthful after mouthful until the lamb is filled. The auxiliary supply of milk should be withheld whenever the ewe can support her lambs.

Removing Ewes and Lambs.—Ewes are kept on the lambing-ground until they have recovered from the effects of lambing, the lambs have become strong, and the ewes and lambs are well acquainted with each other. The time required for all this depends on the nature of the lambing and the state of the weather: the more severe the lambing, and the more broken the weather, they are kept the longer in ward. When quite recovered, the ewes, with their lambs, are put into a field of new grass, where the milk will flush upon the ewes, much to the advantage of the lambs.

It is generally a troublesome matter to drive ewes with young lambs to any distance to a field, the ewes turning round upon and bewildering the lambs. The dog irritates the ewes more than assists the shepherd in this task. A plan often adopted is to lead the flock, when small, instead of driving it, by carrying a single lamb, belonging to an old ewe, by the fore-legs, with its head between the legs—which is the safest way of carrying a lamb—and walking slowly with it before the ewe; she will follow bleating close at the shepherd's heels, while the rest of the ewes will follow her. If the distance to the field is considerable, the decoy lamb should be set down to suck and rest, and another taken for the purpose. When the number of ewes and lambs is considerable, they will have to be driven, and that quietly, and with plenty of time given them.

Mothering Lambs.—When ewes and lambs are turned out to pasture, or out of the lambing-fold, the shepherd ought for the first ten days to see, at least twice a-day, that every lamb is with its own mother, and especially in the case of twins, to see that they are both having regular access to the right ewe. Distinctive marks with paint on ewes and lambs are helpful in this work of *mothering*.

Risk of Over-forcing Lambs.—In putting ewes and very young lambs on to luxuriant grass, care is necessary to see that the lambs are not too hard forced with milk. Mr George Brown, Watten Mains, Caithness, says: "If the pasture is rich and the ewes very full of milk, there will be danger of lambs dying from inflammation and apoplexy. Change of diet may stop this fell epidemic, for such it may become, especially if there is an east wind at the time. Scores of the strongest lambs have been lost in a few days in this way. Careful change and moderation in feeding are the best preventive treatment."

Protecting Lambs from Foxes.—Foxes are apt to snatch away young lambs at night, even close to a lambing-house. An effectual preventive to their depredations has been found in setting a sheep-net (fig. 75, vol. i. p. 172) in front of the lambing-houses, leaving sufficient space for a few ewes with their lambs making their lair within the net. When thus guarded, with a lantern burning outside, the foxes become apprehensive of a snare, while the lantern serves the useful part of affording ample light to the shepherd to see his valuable charge. The expedient of net and lantern was tried after several lambs had been destroyed in successive years by foxes, and a lamb was never afterwards lost in this way. A fox will seldom meddle with a lamb above a month old.

It is easy to distinguish between an attack by a fox and by a dog. The fox seizes the lamb by the neck behind the head, to throw it over his shoulder, and, if he is scared at the moment, distinct bite-holes of the teeth will be found on each side of the neck; whereas a dog seizes any part of the body, and worries by tearing the under part of the neck. The fox, if not disturbed, carries off his prey bodily—he does not take time to eat it on the spot; whilst the dog leaves behind him what he does not eat. Some ewes will fight off either dog or fox, and stoutly protect a single lamb; whilst others are so afraid, that they know not whither to flee for refuge. After an attack, the bleating of the ewe in search of her lamb—an unusual occurrence at night—will acquaint the shepherd of the disaster that has happened.

Unkindly Mothers.—Much trouble is imposed upon shepherds when ewes will not take their own lambs. In every case of a ewe refusing to let her own lamb suck, the shepherd should particularly examine the state of the udder, and ascertain the cause of uneasiness. If it be inflammation, or simply hardness, remedial measures must be used to restore the udder to its natural state. If the udder be well, the ewe must be put under discipline.

The discipline consists of putting her into the shed, and confining her to a spot by a short string tied above the fetlock of one of her fore-legs, and fastened to anything. As she endeavours to avoid her lamb, the string pulls her foot off the ground, and while her attention is taken up struggling with the string, the lamb seizes the teat and sucks in the meantime; the stratagem, often repeated, makes her take with the lamb. It is surprising how soon the lamb learns to steal a suck from its mother; if it cannot approach her by the flank, it will seize the teat from between the hind-legs. When a ewe will allow but one of her twins to suck her, she should be held till both do it, and in a short time she will yield to both.

Introducing a Strange Lamb to a Ewe.—It is not surprising that a ewe should refuse to take the lamb of another; and yet, when a lamb is left an orphan, or happens to be a supernumerary, it is necessary to *mother* it upon another ewe, or to bring it up by hand as a pet; the former if at all possible. When a gimmer that has little milk has twins at a time when a ewe that has plenty of milk produces a single lamb, it is for the benefit of the gimmer and one of her lambs that the ewe should bring up two lambs. The fostering is easily accomplished while the lambs are still wet, and the two are placed before the ewe at the same time. But in the case of a ewe that does not die till two or three days after she has lambed, it will be difficult to make another ewe that lambs a single lamb, at the time of the death of the ewe, take the older lamb along with her own.

The usual plan is, to rub the body of the older lamb with the new-dropped one before the ewe had recognised her own lamb, and to place both before her at the same time. She may then take both without scruple; but the probability is, she will reject the older one. If so, she may be put into a dark corner of the shed, and confined by a board placed across the corner, giving her room only to rise up and lie down, and to eat, but not to turn round upon the stranger lamb to box it. Meanwhile, being strong, and rubbing itself against her wool, and sucking her against her inclination, the lamb will acquire the odour of her own lamb, and ingratiate itself in her favour. If she persist in refusing the lamb for some days, the discipline of tying the leg must be resorted to in the confined cell until she yield.

Another troublesome case is, when the lamb dies at birth and the ewe has plenty of milk, while another ewe with twins is unable to support them. The expedient is, to let the ewe smell her own new-born dead lamb, and then to strip the skin off it while wet, and sew it upon the body of one of the twin lambs, and present the foster-lamb to her, which she may accept when she has been sucked by it. But it is possible that the dark corner will have to be used before she gives a cordial reception to the foster-lamb. Should all these expedients fail to *mother* the lambs upon the ewes—and they *may* all fail, though with a skilful shepherd they rarely do—the lambs should be taken away and brought up as *pets* on cow's milk.

"Stocks" for Refractory Ewes.—Of the various forms of discipline administered to ewes that are unwilling to admit foster-lambs, placing in "the stocks" is perhaps the most irksome. In bad cases it is usually the most speedily effective. The stocks are formed in this way: Two small posts, such as hurdle stakes, are driven firmly into the ground about six inches apart. The head of the ewe is passed through between these posts, and a thong or shackle is passed over their tops, so as to keep the posts sufficiently close to hold the ewe by the neck. A third stake is passed horizontally under the ewe's belly, and supported at the two ends on the bottom bars of two hurdles placed on either side of the ewe, but far enough from her to enable the lamb to approach its foster-mother. In this manner the ewe is most effectually brought into subjection, for she can neither run away nor lie down, which many foster-mothers would do at first in order to prevent a strange lamb from sucking. A very short experience of this form of discipline will usually be sufficient to induce the ewe to freely accept the lamb.

Changing Ewes and Lambs.—Mr George Brown, Watten Mains, Caithness, considers that there need really be little difficulty in making a ewe take to any lamb. "When a ewe becomes careless of one of her lambs," he says, "a good plan is to lift them both away from her, and place them in a box or barrel by the side of the fence, and suckle them three or four times a-day. They thus soon become so identical in smell that the ewe is willing to admit them both. Another plan is to rub both lambs with *salt and water*, so as to make them alike in smell.

"When gimmers (or shearlings) and older ewes are lambing at the same time, we often change lambs, always putting a single lamb with the gimmer. The best plan, when a gimmer lambs twins and an older ewe a single, is to lift the twins from the former to the head of the latter, and give the gimmer the single lamb. If neither be allowed to smell her own lambs, she will readily enough adopt the other. I have seen a hundred lambs so changed in one season without any great trouble."

The Newly-born Lamb.—It is wonderful how quickly the newly-born lamb attains vitality and vigour enough to move about and seek for its mother's udder. As a rule, the lamb needs little attention after birth; but it is of course desirable that the shepherd should be at hand to see that matters progress satisfactorily. The first duty of the shepherd after the lamb is born, says Professor Wrightson, is to clear its mouth of mucus, and see it draw its first breath. Previous to birth the *fœtus* receives oxygen through the mother. It is her lungs which vivify its blood, and her digestive system which prepares its nourishment. But with the breaking of the *umbilical* cord comes the necessity for air, and after a convulsive movement of the diaphragm and intercostal muscles the young creature gasps, and generally utters its first cry. Whether the almost universal practice of shepherds, of blowing into the lamb's mouth, facilitates this action, is not certain; but it is probable that this simple expedient excites the slumbering vitality, and causes the necessary muscular contraction. A slap with the flat of the hand across the buttocks will also often cause a lamb to draw its first breath, when animation appears to be suspended for a few seconds after birth.[1]

Reviving Weak Lambs.—Various devices are resorted to in order to revive weakly lambs. "Those naturally puny need to be kept in good shelter for some days, and if their dams have plenty of milk they will soon get strong. The usual trouble with young lambs is cold and hunger. A lamb so chilled that the thumb and finger held on opposite sides of the chest can scarcely detect the heart-beats, can be restored by an immediate plunge into blood-warm water. But this should be resorted to only in desperate cases, for the water is likely to obliterate the scent, by which alone the ewe recognises her offspring. For the same reason it is equally dangerous to wrap the lamb in malodorous cloths, and allow it to lie before a fire. It will probably be a long time in recovering, and the chances are that the natural scent will be lost; then there will be trouble in establishing relations again between it and the mother. Then, too, the lamb will most likely have to be fed on cow's milk, which is the greatest evil that could happen.

"If at all possible the lamb should never be removed from its mother. Carry out soft woollen wraps, well warmed, and wrap it up, letting the head remain out where the ewe can smell and lick it when disposed; she will thus keep up her ac-

[1] *Live Stock Jour.*, 1889, 114.

quaintance with it. The sooner some warm milk is given it the better. The creature may be so chilled that it cannot suck, yet it may not be advisable to carry it to the fire. Catch the ewe gently with the crook; lay her on her left side, yourself being squatted at her back; lay the lamb on its right side; with the thumb and finger of the left hand hold the jaws apart, and milk a few drops into the mouth. Still holding the jaws apart, rub the throat with a downward stroke, and it will swallow. If it cannot swallow, it will probably have to be carried to the kitchen. But try every expedient before carrying a lamb away from the sight and touch of its mother. Never give a young lamb more than a tablespoonful of milk at a time, and a teaspoonful every ten minutes will be more effective still, when life is but a spark."[1]

Stimulants for Weak Lambs.—When a lamb has become so prostrate as to necessitate removal from the mother, it should not only be placed upon a woollen cloth near a moderate fire, but have a little stimulant administered as well. Some experienced shepherds recommend from a half to a whole teaspoonful of gin or whisky in a little warm water, sweetened with moist sugar; a very little of its mother's milk—or the milk of another newly lambed ewe, if its own mother is not alive—should also be given without delay. The ewe should be milked into a small jug or cup, and the milk at once conveyed to the lamb, which may be fed by a teaspoon. If the milk gets cold before being given to the lamb, it should be heated to the normal temperature by the addition of a few drops of hot water, or, better still, by a clean hot piece of iron inserted into it.

Pet Lambs.—Pet lambs consist of orphans or supernumeraries, and in either condition are deserted creatures which would die were they not reared by hand. When ewes die, it may be difficult to avoid having pets, on account of the improbability of ewes lambing single lambs just in time to receive those which have become orphans. Pet lambs are brought up on cow's milk, which they receive warm from the cow at each milking, and as much as they can drink. Cow's milk is not so good for lambs as their mothers' milk, though they thrive upon it.

In the intervals of meals, in bad weather, pet lambs are kept under cover, but in good weather they are put into a grass paddock during the day, and under shelter at night until the nights become warm. They are fed by hand with as much milk as each can drink. They are first taught to drink with the finger, and as soon as they can hold the finger steady in the mouth, an india-rubber teat, about 3 inches in length, is used as a substitute, through which they will easily drink their allowance of milk. The lambs soon become attached to persons who feed them. The ancient Greeks had a notion that if lambs were fed on ivy-leaves for 7 days, they would ever continue healthy.

Cow's Milk for Lambs.—Caution is required in beginning a young lamb upon cow's milk. Much difference of opinion would seem to have long existed as to the influence of cow's milk upon young lambs — some contending that it is dangerous, and others affirming that it may be used with safety. The milk of a newly calved cow is said by some high authorities to be especially risky, but others equally well entitled to confidence assert exactly the reverse. Be all this as it may, the fact is, that every year large numbers of lambs are reared upon the milk of cows newly calved and long calved; and it is well known that the pretty high rate of mortality amongst these "pet" lambs is due to irregular and excessive feeding. With intelligent care at the outset, giving small allowances and often, and taking care to have the milk at the natural temperature, and afterwards feeding in moderation and at regular intervals, the youngster will be found to thrive well upon the cow's milk.

Heating Milk for Lambs.—It is not considered a good plan to heat milk for lambs by the addition of any appreciable quantity of water. The milk should be given immediately it is drawn from the cow. But if it has been allowed to cool it may be raised to its natural heat by being placed in a cup upon the kitchen range for a moment, or by a clean hot iron being inserted in the milk.

Scour in Lambs.—Cow's milk, given too freely, is liable to cause scour or diar-

[1] *Prac. of Sheep Farm.*, 82.

rhœa in lambs. Especially when very young, lambs are subject to various forms of diarrhœa, arising from various causes, some of which are not easily removed. "Scout" is a fatal form of diarrhœa amongst lambs about two or three days old. As soon as symptoms of this ailment are seen, the ewes and lambs should be removed to a fresh lair or shed, and, as a rule, this change of scene will check the disease. A teaspoonful of castor-oil is often given with good effect to lambs suffering from diarrhœa.

Carrying Lambs. — Young lambs should be handled as little as possible. When they have to be carried, this should be done by the two fore-legs. Never seize or carry a lamb by the body.

Cleaning Ewes' Udders.—Any loose wool should always be removed from the udders of ewes at lambing, so as to prevent the lamb from swallowing pieces of wool, and forming hair-balls in the stomach. These balls often prove fatal to the lambs, and they are sometimes formed by lambs on bare and dirty pasture where pieces of wool are lying about.

Catching Ewes.—Great care should be exercised in catching ewes at all times, more especially, of course, when they are near the lambing-time. It is a common practice with shepherds when they wish to catch a ewe to give a weakly twin lamb a suck, or to examine the state of her udder, to stoop down and run in upon her from behind and seize her by a hind-leg. This is a safe mode of catching a ewe when dexterously done; but when he fails, she will start and run off, and alarm the other ewes beside her—and every alarm to a ewe, whether lambed or about to lamb, is injurious, and at any rate cannot do any good.

Shepherd's Crook.—A *crook* catches the leg quietly and securely. It consists of a round rod of iron, bent in the form shown in fig. 247, terminating at one end in a knob, and at the other end in a socket, which receives and is fixed to a wooden helve, 5 or 6 feet long, according to fancy. The hind-leg is seized from behind the sheep; and as its small bone just fills the narrowest part of the crook, the leg cannot get loose backwards, and remains in the roomy loop of the crook until the shepherd has caught hold of the sheep, and allows its foot to slip through the loop. Some caution is required in using the crook, for should the sheep give a sudden start forward to get away the moment it feels the crook touch its leg, it may forcibly draw the leg through the narrow part, and strike the fore edge of the bone with such violence against the bend of the loop as to cause the animal considerable pain, and even occasion lameness for some days. On quietly hooking the leg from behind the ewe, the crook should be quickly drawn towards you, so as to bring the bend of the loop against the leg as high up as the hock, and lift the foot off the ground, before the sheep is almost aware of the movement; and being thus secured at once, her struggles will cease the moment the hand seizes the leg. The crook is placed in the figure to catch the off hind-leg.

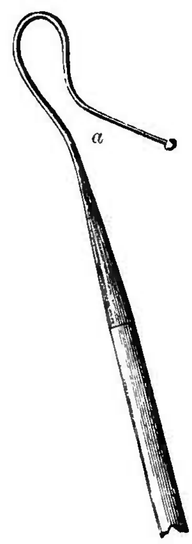


Fig. 247.—*Shepherd's Crook.*
a Narrowest part of crook.

LAMBING PERIOD—DETAILS OF MANAGEMENT.

It may at first thought seem curious that within the narrrow limits of the British Isles there should be such a length of time as there is between the dates of lambing in the earliest and the latest districts. The lambing period in this country now actually extends over six months, beginning with Dorset sheep in the extreme south of England in November, and ending with mountain sheep in the north of Scotland in the month of May. Lambing, therefore, stretches into three seasons of the year, yet it is in a special sense associated with spring, and is conveniently dealt with in this part of *The Book of the Farm.*

In detailing the different systems of management, the prevailing dates for lambing in the various districts will be noted. Climate is, of course, the chief element in determining the time of lambing, as it is desirable that there should be a plentiful supply of green food for the ewes while nourishing their young with milk. In certain cases a more highly artificial system of rearing or forcing is pursued, with the object of providing early lambs for the meat market.

Early Market Lambs.

Dorset Flocks.—The fattening of lambs for slaughter when a few months old is now pursued extensively in various parts of the country. This practice has been so skilfully carried on with Dorset sheep in the extreme south of England, that in some cases two crops of lambs are obtained in one year from the same ewes. The ewes of this breed are very prolific, and have come to possess the characteristic of turning very early to the ram. For early market lambs the Dorset ewes are usually crossed with a Down or cross-bred ram, and by feeding the ewes freely upon trifolium and cut swedes or mangels—with a run on fresh dry pasture, and perhaps half a pint each of beans daily—theyare brought to take the ram as early as May and June. When the rams are withdrawn, the ewes are changed to a dry pasture with a fold of tares or other similar forage crop, and are kept in moderate condition. The ewes walk a good deal daily, and this healthy exercise has a favourable influence on the crop of lambs.

These ewes lamb in November and December. In average seasons only the weakest of the lambs need to be taken into the shed, the climate being so mild that even in the middle of winter the young lambs thrive admirably by the side of their mothers in the open fields. When the weather is wet and stormy, the ewes and lambs have to be housed or brought into some exceptional shelter till the worst of the storm is past, but no unnecessary pampering is practised.

Preparation is made for the ewes with the early lambs by serving rye-grass on portions of the wheat stubble. This fresh young grass is peculiarly suitable for newly lambed ewes, and upon this and the run of the stubble at night, and a "bite" of young clover by day, they are able to nourish their lambs bountifully. Castration is delayed till the lambs are about a month old, it being considered that lambs left entire for a month are more fleshy when matured than lambs castrated when ten days' old, which latter plan is pursued by many.

Fattening Ewe and Lamb together.—About the end of the first month the ewes and lambs are put upon roots, and liberal fare is provided, as the intention is most likely to fatten both the ewes and the lambs at the same time. The system of feeding now pursued is thus described by Mr John A. Clark:—

"The roots are cut and given in troughs, and the lambs feed in advance of, and separate from, the ewes—a lamb-gate being provided for the purpose, having a space between the bars to allow lambs to pass, without being wide enough for the ewes. As soon as it is light in the morning, the shepherd gives hay to both lambs and ewes, and then fills the troughs with cut roots, passing the lambs' portion twice through the cutter, reducing the slices into bits the size of dice. Next he gives oilcake and peas in covered troughs, the allowance being as much as they will eat. To prevent waste the oilcake is broken fine—the size of horse-beans—so that the lambs do not take up large pieces and drop them beside the troughs. To induce the young animals to eat cake and peas, it is sometimes necessary to mix a portion of common salt. The ewes next receive their portion of oilcake, *without* peas, beginning with ¼ lb. per day—half in the morning, half before the bait of roots at night. After two or three weeks of this food, the cake is gradually increased up to 1 lb. each per day; and towards the end of the fattening process half a pint of beans is added. This renders the flesh more firm; the great objection to the ewes being fattened while suckling being that they are mostly deficient in firmness and quality of meat.

"Hay or hay-chaff also is given to the lambs twice a-day; but after eight or nine weeks old they have it three times a-day—the last feeding being not later than three o'clock, as the hay not eaten will be spoiled in case of rain. The portions of hay, after having been picked over by the lambs, go to their mothers. The lambs are ready for the butcher at ten or eleven weeks old—that is, in February and March." [1]

Lamb for Christmas Dinner.—In some instances in Dorset and the Isle of Wight lambs are dropped in September, and fattened for sale by Christmas. With this practice the system of management has to be still more artificial and forcing. This highly artificial system is no doubt remunerative to the enterprising farmers who pursue it. It is not to be assumed, however, that the rearing of fat lambs for Christmas, or even for Easter, would be either practicable or profitable in other parts of the country. "In Devon and Wilts there are numerous sunny glades and warm sheltered vales, where, assisted by the hot vapours of the Gulf Stream wafted across the Atlantic by the south-western breezes, the grass is ever green." Thus the flock-owners in these favoured parts have advantages not enjoyed to the same extent in other districts.

Hampshire Customs.

The practice of rearing and fattening early lambs has been more extensively and successfully developed with flocks of Hampshire Downs than with any other variety of sheep outside the domain of these wonderful Dorset flocks. The Hampshire Down has been skilfully cultivated with this end in view, and the whole system of farming in Hampshire has, to a large extent, been arranged to promote the rapid production of mutton.

Lambing begins with the new year in Hampshire flocks, and at this season great care has to be exercised in protecting the young lambs from stormy weather when it occurs, as it of course often does. The water-meadows in the chalk districts of the south-west of England are turned to good purpose in furnishing an early supply of fresh grass for ewes, and in addition to these, a great deal of other succulent green food, such as roots, cabbage, thousand-headed kale, rape, rye, vetches, trifolium, &c., has to be provided for the ewes and lambs in winter and spring. Where there is a considerable stretch of good water-meadows, there is less necessity for other succulent food; but in dry lands where water-meadows cannot be formed, great store is placed upon the forage crops.

It is undesirable to force ewes into high condition before lambing; but it is an essential feature in the management of early lambing flocks that as soon as the lambs are dropped the ewes should be fed liberally with succulent milk-producing food. Liberal feeding has more to do with the progress of young lambs than the mildness of the weather. It is, indeed, wonderful how even very young lambs will withstand cold and wet weather if only their mothers have plenty of good milk for them. They are, of course, all the better of shelter, and ought to have it; but above everything else, see that they are well nourished with milk. And the surest way of providing this is to feed the ewes liberally after lambing.

Lambing on the Arable Farms.—For this early lambing on the arable farms of the south-west of England, mild as the climate is, it is desirable to have a well-arranged and ample lambing yard or pen.

"The forward ewes," says Professor Wrightson, "should be brought into the pen every night and lie upon the straw. A good-sized heap of swedes should also have been provided, and hay racks or cribs should be placed around, so that the animals may receive a foddering when they come into shelter at about four o'clock in the afternoon. During the height of the lambing, the shepherd remains night and day with his flock, and provided with a good lantern, he makes periodical visits, carefully looking at every ewe. As soon as a lamb is born, it and its dam should be removed into one of the coops or cells, as already mentioned, there to remain for three or four days, until the lamb is able to follow its mother without difficulty, and until the two thoroughly know each other. When this is judged to be accomplished, the cell is vacated for other occupants, and the ewe and her lamb or lambs are transferred to one of the larger divisions of the pen.

"As lambing proceeds, the various lots of ewes are classified and separated, as follows:—

1. A yard of ewes heavy in lamb.
2. " with single lambs.
3. " " with twins.
4. " and very young lambs.

[1] *Jour. Royal Agric. Soc. Eng.*, 1878, 520.

"The older lambs, with their dams, are, when from four to seven days old, allowed to go out upon the turnips, and it is interesting to watch these young creatures learning to fend for themselves, and imitating their mothers in their eating, choosing the softer parts of the turnips, nibbling at the rape or turnip greens, or sorting out the choicer portions of the hay.

The Lambs' Corner.—"Lambs ought to be provided with a corner for themselves at an early age. A few hurdles should be placed around so as to include some small troughs in which is placed a mixture of split peas, bruised oats, and finely ground cake. Admittance is given to this enclosure by means of lamb-hurdles, which, while allowing of the ingress of the lambs, is a bar to the larger-sized ewes."[1]

Lord Northbrook's Flock.—The fine flock of Hampshires kept at Stratton, Micheldever, by Lord Northbrook, is managed similarly to the other leading Hampshire flocks. His lordship's agent, Mr T. Stirton, says: "Lambing takes place, as a rule, from the middle of January to middle of February. Ram breeders commence on the 1st of January. Generally speaking, the ewes get plenty of hay or sainfoin with a *limited supply of turnips* before lambing, and plenty of roots and hay afterwards. Ram breeders use artificial food, such as malt-dust, cake, &c. The ewes are always folded on arable land, and the roots are not cut for them. After the roots are finished, rye and winter barley follow. As a rule, the lambs are weaned about the first week in May, when the lambs have field-grass, followed by vetches during the summer—usually a fold of each a-day—or sainfoin. If not sold at the summer fairs, or sold fat at the auction sales, they then get sainfoin, rape, and turnips, till the autumn fairs, with or without cake, according to the views of the owner. The ewes live behind the lambs, for the latter have large folds. Ram breeders give their lambs at least two to three folds of different kinds of food each day, with various mixtures of artificial food. The green foods are vetches, early rape, and sainfoin."

1 *Live Stock Jour.*, 1888, 65.

The plan of having one lambing-yard near the homestead, once general, is now in most cases supplanted by temporary lambing-pens formed at some convenient spot on the fields, near the supplies of green food, and where the manure is most required.

Treatment of Ewes and Lambs.—As a rule, in fine weather the ewes go out from the pens on to the turnip-break when the lambs are two or three days old, but in some exceptional cases they are kept in shelter with their young lambs for two or three weeks. The ewes and lambs are usually kept on turnips and hay till the water-meadows are ready to receive them, perhaps about the first of April, and then they go on to the water-meadows by day, and are folded overnight on Italian rye-grass, rye, winter barley, winter oats, or trifolium, sown for the purpose—the tup and wether lambs intended to be forced being admitted in front of the hurdles to receive a little cake or corn. Where there are no water-meadows there is usually a preserved portion of clover, which forms a most useful adjunct to the turnips and forage crops.

Frequent changes of ground and food are a leading principle in Hampshire flock management, and no doubt this contributes largely to the success of the system.

Forcing Young Lambs.—For the first two, three, or four weeks the lambs subsist upon their mothers' milk, but even before they are a fortnight old they will be seen to nibble at the finer portions of the food being consumed by the ewes. The forcing of lambs may be begun in the third week, and if the object is to rear precocious ram lambs or fatten wether lambs at as early an age as possible, a separate enclosure of hurdles in advance of the ewe-fold should be formed for the lambs. The lambs get access to this enclosure through an opening in the ordinary hurdles—an opening not large enough to admit ewes—or by what is called a *lamb-hurdle*. In this lamb-fold the young lambs will pick at the fresh food before it has been spoiled by the ewes running over it, and in troughs they should receive cut roots—put twice through the cutter, so as to reduce them to small pieces—and just as much of the bruised cake and grain as they will readily consume, with a very small quantity of fresh hay. The mixtures and quantities given to lambs vary on different farms. As to quantity, the rule should be—if the lambs are to be forced—to give them as much in two or three meals per day as they will eat up at the time. A mixture of linseed-oil and peas gives excellent results. Another very good mixture may be made of equal portions of finely ground linseed and decorticated cotton-cake, bean-meal, and palm-nut meal, given perhaps with fine hay-chaff. It is not likely the lambs will eat much more than about two ounces per day of this mixture till they are weaned, after which the quantity may be doubled.

Lamb-hurdles.—The lamb-hurdle or lamb-creep, contrived to let the lambs run forward and hold back the ewes, is an important institution where breeding flocks are kept on arable land. "The lamb-hurdle," says Professor Wrightson, "is in constant requisition throughout the spring, and by its means the lambs are able to run forward and crop the choicest herbage before it is soiled or trampled by the older sheep. The best creeps are adjustable to the size of the lambs, and the upright bars through which the young animals pass are round and smooth, and revolve easily upon a central axis of iron. They are also furnished with a similar roller, which forms the top of the creep, so that the lamb passes through without rubbing the wool. The opening is hinged inwards, but is rigid when pushed outwards, and this is done to allow of lambs running quickly back into the fold if frightened, but at the same time to prevent the ewes from passing outside the fold." [1]

Various English Methods.—The foregoing details, which relate chiefly to Hampshire flocks, embrace the outstanding features of the systems of management which prevail wherever early lambing is pursued that is, lambing in January, February, and the beginning of March. The amount and character of shelter and green food provided for the ewes and lambs vary with the locality, climate, class of sheep, purposes in view, and date of lambing. Wherever the ewes are timed to lamb before the middle of March, ample shelter and green food must be furnished; for without comfort and plenty of nourishment for the young lambs, early lambing cannot possibly result in success.

The systems of management in some typical English flocks are described in Division I., pages 194 to 201.

Summersbury Southdowns. — Mr Edwin Ellis, Summersbury, Guildford, Surrey, whose fine flock of Southdowns has taken a high position in the show-yard, writes:—

"For several years I have been desirous that my lambs (Southdown) should fall in January and February, instead of from the middle of February till the beginning of April, but I have as yet been unable to obtain this result. It is true that by forcing treatment and very high feeding a few ewes would come into season in August, possibly even at the latter end of July; but this would be very expensive work at a period when we expect the flock to be kept at the smallest possible outlay. In the present year (1888), although the rams were put out on the 16th August, the first ewe was served on the 27th, and it was net till several weeks after this that any considerable numbers were tupped.

"Lambing, therefore, begins with us about the beginning of February, and we generally get half-through by the end of the month; and by the end of March the season may be said to have finished, although a few ewes will be still later than this.

Feeding of Ewes.—"When the ewes have gone half their time, we take care that they shall be well fed, having a little hay, and sometimes a few oats, but no roots if we can avoid it. After lambing we feed very liberally—good hay, swedes and swede-*tops*, if there are any, and sometimes a few mangels as well. I consider mangels better even than swedes for milk. The ewes are driven into a fold if the weather is bad, otherwise they do better in the open field.

Treatment of the Lambs.—"Directly the lambs begin to feed, they have a pen into which they can run, and sliced swedes, corn, and cake are at their disposal. If we get a large proportion of twins, a separate flock is made, and the

[1] *Live Stock Jour.*, 1888, 114.

mothers have some corn in addition to their other food. I have generally weaned when the lambs are about 12 or 14 weeks old, but I think it might be done earlier with advantage.

"When the lambs are taken away, careful attention should be given to the ewes' udders for the next few days, otherwise great pain, and possibly inflammation, may be caused by the milk. My lambs are kept on tares, trifolium, thousand-headed kale, and clover, each in their turn; and if we find it practicable to give a change of food to the ram lambs, it is beneficial. Indeed the greater variety the better.

"As for the ewes, directly the wool is off they run the commons around us, and come on to the meadows when the crop of hay has been harvested.

"Flushing" Ewes.—"I have always had a good number of twin lambs, consequent, as I believe, on 'flushing' the ewes with plenty of green food just before they come into season. The young ewes have generally one lamb, but the old ewe flock with me generally bring three lambs to two ewes, and sometimes even more than this."

Suffolk Flocks.

With the leading flocks of Suffolk sheep, which have been greatly improved in recent years, the ewes and lambs are managed with much care and intelligence. In his Prize Report to the *Farming World* in 1888, George Last, shepherd to Mr S. R. Sherwood, Hazelwood, Suffolk, says:—

"The farm consists of marshes and rough pasture and arable land, and is about two miles and a half from the sea —a cold, bleak place, but most of it good light land, with about three or four fields black and poor land even for breeding ewes.

"My flock consists of 300 Suffolk ewes, bought from the best breed of the Suffolks. Six ram lambs were used of the same breed as the ewes on October 11. One ram was put to 50 of the best ewes, and five to the other 250, which is fifty each for a ram. The 50 ewes and one ram are put on the marshes night and day for three weeks, and the 250 on the marshes during the day, and folded on coleworts at night. The rams lived as the ewes did, and were drawn from the ewes the last week in December.

Lambs Dropped.—"The ewes began to lamb on 6th March, and ended 21st of May. As for the number of lambs dropped, I do not keep strict account until I tail them, which is done when they are about a fortnight or three weeks old; and I have tailed this season 454. I have about 170 twins, 25 triplets, and the rest singles, with 3 barren ewes. I had 443 lambs living on May 29th. One lamb has died since I tailed them, with a ball of wool in its stomach, and another with sand; the others died from what we call *scoley*, caused by the cold severe weather, such as I never before experienced. We had snowstorm, and hailstorm, and frost at night all through March and part of April, and that is the cause of the lambs being scoley and stiff-jointed. They then linger and die. I should think I have lost from 40 to 50 in that way, though I had plenty of shelter.

Lambing-yard.—"My sheep-yard was made on the open common with hurdles first, then whin fagots, then straw hurdle-pens round inside and outside to the number of about 70 pens, and then thatched with straw. I keep them in the pens two or three days, then turn them on the field under the bank and battens made with whin fagots on purpose.

Feeding of Ewes.—"The general feeding of the ewes consists of maiden leys, marshes, and coleworts for the tupping season. Then follow on with white turnips and a good bait of malt-combs and chaff every morning, and a run on the whin common every day; and about a month before lambing a bushel of best oilcake to two bushels a-day mixed with the chaff and malt-combs, and from half a load to a load of mangels per day. When the ewes refuse the chaff, increase the cake to three or four bushels, and the mangels to two and three loads per day.

Feeding of Lambs.—"About the middle of April we begin to bait the lambs. I shut them from the ewes about an hour every morning for the bait, then let the lambs run forward on the clover leys for a time; the ewes then clean out what bait the lambs leave, and which is a good deal at first, but the lambs soon get hold of it and leave the ewes very little.

Losses of Lambs.—"I have lost nine ewes from the following causes: One in January from scour and inflammation; two in February from ulcer-sores; four in March—two broken down from weight, one from dead lamb's putrefaction, one wasted by ulcers; and two in April—one casted or awal'd, and one choked with mangels. There are now 443 lambs alive, reared from the 300 ewes." [1]

Shropshire Flocks.

For the following description of the prevailing system pursued during the entire year in Shropshire flocks, we are indebted to Mr Alfred Mansell, College Hill, Shrewsbury—the round of the year being commenced when the rams are admitted amongst the ewes:—

The ewes are put to the ram early in September, so as to drop their lambs early in February or March; but in high cold districts the lambs, as a rule, are all dropped in March and early in April.

Flushing the ewes is considered advisable at the tupping period, as the ewes go faster to the ram, and are generally more prolific. If so treated and for this purpose, they are put on a fresh pasture, say second year's seeds, or a permanent pasture which has been purposely saved.

To ease the rams sometimes *a teaser* is used, and the ewes as they come on are taken to the ram. This is quite necessary in the case of a very fat ram, or where it is wished to serve a larger number of ewes with a certain ram than is usually the case.

If any *show ewes* have been added to the flock, they should be treated precisely in the same way, but perhaps may be put to the ram a little earlier, as they are apt to turn several times before holding to the rams. Still, with care and patience, they can generally be got to breed.

Ram Lambs.—At the latter end of the season, should any of the ewes have turned several times, and this will probably be the case with a few of the older ewes, a ram lamb should be tried; but, as a rule, I should not commend this practice, as it is difficult for even a good judge to select a good lamb, or, in fact, any immature animal.

The *ram selected* for use should be as large as possible, combined with masculine character, perfect type, and high quality; and as a rule the size should be looked for on the side of the dam, as it is next to impossible to procure a male perfect in all the essential points, and yet with sufficient size. Rams generally will serve from thirty to fifty ewes satisfactorily, and in many cases this number is greatly exceeded. But a ram should seldom be used largely until his second year as a sire, when the breeder has had a chance of seeing his produce and of judging what they are likely to grow into.

After the ewes have all been served they run together, and for another month or so should be kept in as thriving a state as possible. They then go to old seeds or pasture and get a daily allowance (not too large) of roots and hay; the latter loose on the fields is best, as the ewes are apt to get crushed if crowded at racks.

Preparation for Lambing.—Some breeders, a short time before lambing, give the ewes boiled linseed, crushed oats, and bran mixed with pulp and cut stuff. This is a practice much to be commended, as it strengthens the ewes and greatly assists a safe and easy parturition.

As soon as the *lambing season* approaches (end of January or early in February) the ewes are folded at night. When the lambs are a few days old they go on to the seeds which have been kept up during the winter, and if the season has been moderately favourable these are usually very fresh, and a good pasture for promoting the secretion of milk. Only the ewes with twin lambs should get any assistance, as the ewes with single lambs if corn-fed are apt to get too fat and doubtful breeders. A mixture of beans, malt-dust, linseed-cake, and bran, is a capital food to sustain the ewe and increase the flow of milk.

The shepherd should, as far as possible, be encouraged to keep up the returns from the sheep by means of a bounty on each lamb alive at weaning-time (June), and also by giving him a further interest

[1] *Farming World*, 1888, 526.

in another way in the wellbeing of the flock.

Castration in ram breeders' flocks is not a general practice, and the process of selection is left until the winter, when the inferior rams are fed and sold to the butcher. In the case of ordinary flocks they are *castrated* as lambs and sold fat the following spring.

Shearing the lambs, which takes place about the last week in June, is considered to have a good effect in securing greater immunity from the fly in summer; also in preventing the clinging of the soil to the belly of the sheep when on turnips.

Weaning the lambs takes place in May or early in June. For this a good pasture is selected, as with good treatment they do not feel the change so much. No strong artificial food should be given at first, but a few common turnips may be thrown about on the ground to teach them to eat turnips. Following this, rape or cabbages are given, and as the harvest-fields are cleared the young seeds are made use of. This would carry the lamb till the end of September or so, when they are folded on common turnips till about Christmas, and then on swedes. Linseed-cakes, oats, and bran, commencing at ¼ lb. each per day, and gradually increasing, is the artificial food at this period.

As January and February come in, the *cull rams* are ready for the knife, and by the end of the latter month most of these have been despatched.

The rams intended for show and sale and the *shearling ewes* are kept on the turnips a little longer, or until the land is wanted for barley-sowing. The rams intended for show are housed early in April and shorn, but the majority are not housed until May. The rams then get mangels, hay, and a small allowance of corn, and as much green food as possible. This latter is a most necessary food. Mellowing the mangels by exposure to the sun is a good practice, as it renders them less liable to develop the water complaint amongst the rams.

The ewes after the lambs are taken from them are kept on the barest pastures, as they are apt to get gross and fat and non-breeders if they are allowed a good pasture during the summer months. Indeed many breeders, through a little carelessness on this point, annually spoil several of their best ewes.

The average *number of lambs* is 150 to 175 per cent. In small flocks it has often been much more, but, speaking generally, a lamb and half to three-quarters for each ewe is about the average.

Dipping the lambs once or even twice is very desirable, and for this purpose a non-poisonous dip is best.

To prevent *husk* or *hoose* in lambs, a most fatal complaint in the autumn, it is an excellent plan to drench the lambs either with one of the well-known patent remedies, or with the following, which costs less, and is to all intents and purposes as good: ⅛ oz. asafœtida, ⅛ oz. turpentine, ⅜ oz. linseed-oil, given in half a gill of milk or thin gruel, two days consecutively.

As a preventive against *foot-rot* it is a good plan to periodically, say two or three times a-year, carefully pare all the sheep's feet, and walk them through a trough containing a disinfecting solution (composed as described on page 198, vol. i.), after which they should be folded on a hard road or dry yard for a few hours.

Mr Carrington on the Care of Ewes and Lambs.—The late Mr W. T. Carrington, in describing the general management of sheep on light-land arable farms in England, said: "The time of putting the ram with the ewes varies with the locality, and the prospect of early spring food. In the south of England, August and September are usual months. In the midlands, October; and in the north, November. On those farms where rams are bred for annual sale, they are usually dropped early, so as to give them a good start.

Condition of Ewes at Mating-time.—"It is better that ewes going to the ram should be, though not fat, in an improving condition, a supply of succulent food at this period having also a favourable influence on the number of lambs dropped; therefore many farmers put their ewes on rape.

Ewes in Winter.—"In the autumn and early winter the ewes are run on the clover or stubbles, receiving an occasional fold of rape or early turnips, or mangel-tops, with chaff and a little cotton-cake. They often follow the feeding sheep, clearing up all their leavings on the fold. The practice formerly pursued of giving in-lamb ewes a full allowance of turnips, is generally discontinued, it being found that they are much better without such watery food before lambing.

Lambing-time.—"When about lambing, the ewes are brought in at nights, into a covered shed or yard; or a moveable lambing-shed is taken into the open field, and protection against wind and rain is provided by means of hurdles wattled with straw, or one or two old waggons, part-loaded with straw, the shepherds giving them unremitting attention both day and night.

After Lambing.—"The ewes, after lambing, are well fed, having straw, chaff, or hay, and ½ lb. to 1 lb. of cake or meal, with roots. Whatever be the destination of the lamb, the ewe should at this time be liberally fed.

"When the lambs are two or three weeks old, they begin to eat food with their dams, and lamb-hurdles are often provided, allowing them to run before the fold and eat a little dust, linseed-cake, or bruised oats. A change of food for the ewes is desirable, as soon as it can well be given. Early rye or Italian rye-grass, or the second year's clover, with a few mangels, and ½ lb. each daily of cotton-cake, proves an excellent diet.

Castration.—"Castration of all male lambs not required for stock purposes is often done by drawing at ten to twenty days' old, or is done by searing at three months old.

Weaning.—"Weaning takes place at from three to four months old; where the lambs are early taught to eat artificial food, it is not desirable to delay it too long. On those farms where fat lambs are sold to the butcher at an early age, they remain with the ewes until sold.

"The lambs, when weaned, are either taken a distance away out of the sound of their dams bleating, or a double row of hurdles at a little distance keeps them apart, when they before long become pacified. The lambs are provided with a succession of green food, much importance being attached to a frequent change of diet. It is not well for them to graze on land which has been folded with older sheep, the rank luxuriant herbage of clover or grass produced by sheep-manure being unhealthy food for lambs, and causing scour.

Dipping Lambs.—"The lambs, after weaning, are all dipped in some preparation to destroy parasites, and to prevent for a time the attacks of the maggot-fly, which in some districts, especially where much timber exists, is very troublesome, blowing up on the wool, and unless quickly eradicated, spoiling the wool, and even sometimes killing the lamb."[1]

Scotch Flocks.

In Scotland the lambing period comes on later than in England. In some exceptional cases a few lambs are dropped in February, but the general time is from the middle of March till the third week in May. In the lower-lying and better favoured districts—especially with Border, Leicester, and half-bred flocks—the majority of the lambs may be dropped in March; but in exposed hill-farms lambing does not begin till about the middle or 20th of April, and frequently extends till the closing days of May.

Early Lambing risky.—The climate, probable supply of early spring food, and amount of shelter, are the considerations which mainly determine the time of lambing. In cold late districts early lambing is very undesirable, and can hardly lead to satisfactory results. The flock-owner is truly in a pitiable condition when struggling with a big flock of ewes and newly born lambs with a deficiency of shelter and little food for them, except what may be given by the hand. Heavy outlays may be incurred, and yet the results may be very disappointing. There are few points more essential in the successful management of a breeding-flock than this—that, as soon as the lambs are dropped, the ewes should be liberally fed and protected from excessive storms. In order, therefore, to ensure this as far as possible, it is desirable that lambing should be delayed till the rigours of the winter are past and moderately genial spring weather and a speedy growth on the pastures may be reasonably calculated upon. The period of lambing will thus vary with the local-

[1] *Jour. Royal Agric. Soc. Eng.*, xiv., 1878, 713.

ity and the system of tillage farming—which latter has, of course, much to do with the supplies of such extra food as roots, grain, and hay.

South of Scotland Flocks.

In the Border Leicester flocks in the south of Scotland many lambs are dropped early in March—some even in February. As a rule, in these flocks ample provision is made for the lambing-time both in the way of food and shelter. Comfortable lambing-pens are provided; and with turnips, hay, cake, and grain, and a run upon young grass, the ewes are kept so as to ensure a full supply of milk. Keeping up the supply of milk is the chief object to have in view, for without this the crop of lambs will be disappointing.

Orchard Mains Flock.—In his Prize Report on the management of the ewes and lambs under his care in the winter of 1887-88 and following spring, Alexander Burns, shepherd to Lords Arthur and Lionel Cecil, Orchard Mains, Innerleithen, Peebles, says:—

"The sheep under my care are Cheviot ewes—part with half-bred lambs and part with Cheviot lambs.

Park Sheep.—"The Leicester rams were admitted amongst the park sheep on the 22d October, and were withdrawn on the 24th November, when two Cheviot tups were admitted in their stead. The park sheep, which numbered 205, commenced to get a run of the turnip-break a week previous to the time of admitting the rams. The latter were five in number, and consequently had each an allotment of two scores of ewes. In addition to the regular fare of turnips and grass which the ewes were getting, the rams were fed with corn and bran, while I keeled them to indicate the proceedings.

Lambing.—"Dividing them into two lots, the first commenced lambing on the 18th March. The weather was very cold—in fact too severe for old sheep, not to speak of young lambs. The ewes were, perhaps, a little to the thin side in condition. Though they did not drop a great quantity of lambs, they lambed fairly well throughout, but always grew scarcer of milk, which no doubt might be attributable to the inclement state of the weather and the wretched state of the turnips, which were simply slush.

Inflammation.—"Four deaths occurred amongst the ewes during lambing. Five dropped dead lambs, and three of these ewes rank amongst the above deaths. The other death was that of a gimmer which exhibited signs of lambing in the morning, but which went about all day without ever making any effort to lamb. I lambed her all right at night, and both ewe and lamb looked as well and comfortable in the morning as wishes could desire. The lamb was full, and the mother eating her food and tending her little offspring with motherly anxiety and care. But before mid-day the lamb was sick and grievously swollen in the belly, and died shortly. The gimmer, just as I was about to give her another lamb, gave signs of inflammation. I applied carbolic to her of the 1 to 5 strength, but to no purpose. Doses were repeated at intervals of about from two to three hours, without abating in any way the virulent nature of the inflammation. In the morning she was ready for skinning. The other three were similar in every respect, except that they dropped dead lambs. After similar treatment, they were ready for skinning also. Whether the case presents itself as hopeless or not, I always like to apply carbolic, for the simple reason that it invariably proves itself an efficient factor in keeping down infection.

Lambing in a Storm.—"Turnips, with a little rye-grass hay, was the feeding the park ewes got during the season, and as each ewe lambed, she was housed for a time—the weather being so cold that young lambs could not do to be exposed to its severity. In fact, the 28th of March was almost too much for the old sheep. Both old and young, lambed or not, I made thorough against that notorious night. The sheep lambed very slowly at the beginning, which was greatly in their favour in such weather, as it not only allowed space to accommodate, but gave time for the bestowal of special care upon each individual ewe as she lambed.

"The percentage requiring assistance was on the whole very small—perhaps something like 10 or 15 per cent."[1]

[1] *Farming World*, 1888, 526.

A Perthshire Flock.

The first of three prizes offered by the proprietor of the *Farming World* for reports "On the Management of Ewes and Lambs," was won by Mr W. Sutherland, Peel Farm, Tibbermuir, Perth, who thus describes his practice—in the winter 1887-88 and following spring:—

"Our flock (in addition to a lot of blackfaced, into the treatment of which I shall not enter) numbered 138—comprising 45 Leicester, 14 Shropshire Down, and 79 half-bred and other ewes. On the 17th September 1 Shropshire and 1 Oxford Down ram were turned in amongst the half-breds; and on the 8th October, 2 Leicester rams amongst the Leicesters, and 1 Shropshire Down among the ewes of that breed. For about five weeks previously the rams got a daily allowance of about 2 lb. each of linseed-cake and oats; but once they were admitted to the ewes they had no extra feeding whatever given them. The rams were withdrawn from the three lots on the 20th December. The first of the ewes lambed on the 17th February, and, with one or two exceptions, the whole had lambed by the 15th April. Total, 245 lambs.

"The Leicesters dropped 77 lambs—14 singles, 27 pairs, and 3 triplets—one ewe being eild. The Shropshire Downs, 28—each having a pair. The half-breeds, 140—21 singles, 52 pairs, and 5 triplets.

"Two of the ewes died from inflammation, after very severe cases of lambing, and another was suffocated by a piece of turnip sticking in her throat. Seven deaths occurred amongst the lambs. Three weakly ones only survived for a few hours. Another lingered for ten days. Two died from diarrhœa, and another from some undefinable cause.

General Management.—"In order to explain the management thoroughly, it will be advisable to start with the treatment given a month previous to the time I intend letting the rams along with the ewes. If the season has been a favourable one, the latter will, on examination, be found in good condition, and, consequently, no hand-feeding need be resorted to; but if, owing to a deficiency of pasture, any of them are in rather poor condition, I separate these from the others and give them a daily allowance of about 1 lb. each of linseed-cake and oats—this brings them rapidly into condition, and is also likely to lead to an increase in the crop of lambs.

"When the rams are admitted the hand-feeding is discontinued. During the period the rams are with the ewes each of the breeds are kept separate, and previous to the rams being turned loose the breast of each is rubbed with keel, and this is repeated daily, so that the ewes that have been tupped are readily recognised. After the rams have been out for a week all the ewes served during that period are marked with a little paint on the shoulder; at the end of the second and third weeks those served since the previous markings have other distinctive marks put on them; and any that may come in season afterwards are left unmarked. By attention to this matter a deal of trouble is saved when the lambing season arrives.

"I keep the rams with the ewes rather longer than is customary, and find by doing so we have seldom any eild ewes, and I have frequently seen a "May" lamb as far forward by the end of the season as those dropped two months earlier.

"About the beginning of November the whole of the sheep are dipped for the winter.

"When the grass begins to get scarce a daily supply of turnips are given—a cart-load to a hundred sheep—and as much hay as they can consume without waste. A week before the first are expected to lamb the first-marked lot are drawn out and kept on pasture adjoining the steading, and in addition to turnips and hay are allowed a little linseed and cotton-cake mixed with oats. When the other lots get within a week of lambing they are also separated and the same feeding supplied. It is a mistake to have the ewes too fat at this time; but a much greater one to allow them to be in poor condition—and the latter will be found to be the most frequent error.

Abortion.—"With the exception of one season we have never had any cases of abortion. When this disease appears, inquiry into the circumstances connected with the outbreak usually reveals some mismanagement in the feeding. The use of frosted turnips is a fertile source of the trouble, and the outbreak we had some years since I attributed wholly to this cause. On discontinuing the turnips and substituting an allowance of cake and corn for a time, no further cases occurred. Since then I have been careful to give only as many turnips during frosty weather as will be at once consumed without any being left lying over exposed to the frost; and in the event of the turnips getting frozen in the pits, as they occasionally do in very severe weather, I discontinue using them altogether, and give other feeding until fresh weather ensues.

Rupture.—"I have had a few cases of rupture among the ewes, caused by the weight of the lambs when near lambing. By getting a piece of strong sheet-iron curved to the shape of the ewe's back, and having a few holes pierced along both sides, and then passing a piece of sacking beneath the belly and tying it up to the plate, great relief is given.

Shelter.—"It is very important to have proper shelter available during the lambing season. More deaths occur among lambs from want of this during bad weather than from all other causes put together. I have two large open sheds, and another divided into pens about five feet square. I commence taking the ewes into the sheds a few nights before the first are likely to lamb, and after dark take a turn among them by lamp-light. By doing so they soon get accustomed to their new surroundings, and are not so apt to hurt each other through fright as they might be if this practice were deferred until lambing had actually commenced.

Lambing.—"Once they commence lambing I take a look amongst them every two hours during the night. Should any of them require assistance I rub my hands with linseed-oil before handling them, and in any case where there has been much difficulty in lambing I inject a little carbolic oil into the womb to prevent inflammation, and give five or six drops tincture of aconite in a spoonful of water, repeating the dose in two hours after if any uneasiness is shown.

"After the ewe lambs I examine the udder and clip away any wool that might interfere with the lambs sucking, and then remove them to one of the pens and keep them there for a day or two till the lambs gain a little strength; after which, if the weather is not suitable for letting them outside, I divide one of the other sheds into spaces large enough to contain six or eight of the ewes with their lambs, giving sufficient room to afford the latter space for exercise.

"I find gimmers and young ewes sometimes careless in looking after their lambs, but by confining them in one of the pens for a few days they soon take to them without much trouble. In the event of two ewes lambing about one time, the one having a single lamb and the other triplets, I take one of the lambs from the ewe having three and put it along with the one having the single. By haltering her to a corner of the pen she takes to the stranger in a very short time.

"Occasionally it is necessary to bring up some of the lambs on cow's milk. I have often heard it said that the 'bother and expense' of doing so exceeded the profit; but in most cases I have found both bother and expense amply repaid. Once the lambs are a few weeks old they will readily eat a little cake and corn, and if a piece of early well-sheltered grass is obtainable, the milk can soon be in great measure dispensed with.

"As soon as the weather is suitable, I keep the ewes and lambs out on the pasture during the daytime, but never care about leaving them outside at night until the beginning of April, when the weather is more to be depended on. Before allowing many of them outside together I put a distinctive mark on each pair of twins, so that in the event of anything going wrong, the ewe and both lambs belonging to her can be recognised without trouble.

Inflammation of the Udder.—"I find inflammation of the udder somewhat common. In such cases I give 2 oz. Epsom salts in gruel, bathe the udder with hot water, and then rub with ointment composed of 2 oz. fresh butter, 1 drachm camphor, and one spoonful spirits of wine. In severe cases poulticing is necessary, so that the lambs must be removed from the ewe altogether.

Sore Teats.—"This season, owing to the cold unseasonable weather experienced for some weeks after lambing commenced, sore teats have been more than usually prevalent among the ewes. I have found frequent applications of glycerine and olive-oil a very good remedy.

Castrating.—"When the lambs are about ten days old their tails are cut, and as soon as the weather suits, the youngest of the cross-bred tup lambs are castrated, a little turpentine being applied to the edge of the wound. The first-dropped lambs are usually too far forward in size and condition to risk castrating by the time the weather is mild enough for the operation, but as they are early sold off fat it is a matter of little consequence.

Fat Lambs.—"As soon as the grass has got a fair start, the Leicester and Shropshire ewes, with their lambs, are separated from the half-breeds—the lambs of the latter being intended for the fat market. I prefer to push them on as rapidly as possible, and therefore confine them to the young grass fields, and increase the quantity of hand-feeding, as the lambs will be taking a share of it.

Lambs for Breeding.—"The Leicester and Shrops are kept on the older pastures; their lambs being intended for breeding purposes, there is not the same necessity for forcing, and the hand-feeding is therefore discontinued.

"To keep the sheep in healthy thriving condition frequent change of pasturage is necessary.

Diarrhœa.—"A few of the lambs are sometimes attacked by diarrhœa. If it arise from the richness of the grass, a little castor-oil, sugar, and ginger (the quantity varying with the size of the lamb) will usually cure it; but should it proceed from coagulation of milk in the stomach, it is more dangerous, and frequently proves fatal. Occasionally a little hartshorn and magnesia given in water will effect a cure.

Clipping.—"The ewes are clipped about the beginning of June, and about the end of that month the whole of the ewes and lambs are dipped to prevent the attacks of maggot-fly, which is very prevalent on our land.

Weaning.—"On weaning the pure-bred lambs about the 1st of August (the crosses are all sold off fat long before then), I put the ewes to the furthest off pasture on the farm, out of sight and hearing of the lambs, which I keep confined in the fold for ten or twelve hours afterwards. By doing so they get hungry, and when allowed out at once commence eating in place of breaking away in search of their mothers, as they would otherwise be apt to do. By keeping the ewes on bare pasture for a few days, the milk rapidly dries off them; but I generally find it necessary to milk the most of them once or twice to relieve them. A week after weaning, I examine them all, and any found broken-mouthed or faulty in udders are drawn out and put on good pasture, getting also an allowance of other feeding, so as to have them early fattened. Those intended to be kept on are put on ordinary pasture.

"As soon as the lambs have got over the separation from the ewes, the ram lambs are separated from the ewe ones, and each lot put on the best grass available, a small daily ration of cake and oats being also given. The ram lambs are usually retained and sold as 'shearlings'; the best of the ewe lambs are kept to fill the vacancies caused by the drafting of the old and defective ewes; and the others are either sold in the end of the year, or kept on and disposed of the following season as 'gimmers.'"[1]

Hill Flocks.

Early Lambing Undesirable.—The lambing season, begun in the well-sheltered vales of the south-west of England, is wound up on the exposed hill-farms of the north of Scotland. On the higher sheep-ranges of Scotland, and the north of England and Ireland, vegetation is late in moving in spring, while severe snowstorms in the months of March and April are by no means rare occurrences. It is thus desirable that lambing should not take place in these parts till the spring season is well through—desirable in order that the young lambs may escape the rigours of a severe snowstorm, and that, after lambing, the ewes may not have long to wait for a bite of fresh young grass, which is so effectual in bringing on a full supply of milk.

From about the middle of April to the end of May is the most general period for lambing on hill-farms.

[1] *Farming World*, 1888, 525.

Hardiness of Hill Sheep.—Mountain sheep are not brought into lambing pens as is done with lowland breeds. They produce their young on the hillsides, and in average seasons the death-rate amongst hill lambs is wonderfully small. The vitality of these creatures when newly dropped is quite marvellous. A healthy blackfaced lamb will be on its feet and searching for the udder three or four minutes after it is born. It seems to care little for cold, and if the weather be dry and the ewe have plenty of milk the youngster will thrive rapidly, even although there should be snow and frost. Rain is more hurtful to lambs than cold with a dry temperature.

Shelter on Hill Farms.—It is therefore desirable that, even for the hardy hill sheep, some provision should be made whereby the more weakly lambs may have shelter in excessively wet cold weather. It may not be practicable to provide shed accommodation for the whole flock; but in heavy rains it would be well to have the weaker lambs drawn out with their mothers and put under a roof, where they should be left over night while the ground is wet and cold. For this purpose, it will be found useful to have some artificial shelter provided at suitable points throughout the farms. Little huts constructed perhaps of turf, hurdles, and bundles of straw or rushes, will entail little outlay or trouble in formation, and during inclement weather will be found of great benefit to the ewes and lambs. Ewes with weakly lambs can be accommodated comfortably in these scattered huts for a few days and nights, the shepherd carrying or having conveyed to them some hay and roots. It is desirable to have these huts at different points on the farm, so as to lessen the distance which ewes and weakly lambs have to be driven.

Before lambing begins the shepherd should see that the means of shelter—keb-houses, sheds, huts, or whatever name and form they may take—are in good order, and sufficient for the probable wants of the flock. If necessary, the shepherd should receive assistance in providing and repairing lambing shelter. A day or two of a man with a horse and cart may be well bestowed upon this work, to convey hurdles, posts, bundles of straw, and small supplies of roots and hay to convenient places on the farm for the formation of shelter to ewes and lambs. Forethought and carefulness in matters of this kind play a large part in the successful management of breeding flocks.

The necessity for these huts will much depend upon the amount of natural shelter on the farm. If the farm abounds in hills and hollows, with patches of rank heather, there will be little need for huts. The ewe will find a cosy bed for herself and her young by the side of a dry hillock or bush of heather. But when such natural shelter is deficient, artificial protection should be provided.

Typical Hill Flocks.—Describing the general system of management in the lambing season on average hill-farms in the north of Scotland, Mr George Brown, Watten Mains, Caithness, says:—

"On all hill farms there is more or less natural shelter, most of the ground being interspersed with knolls and valleys, and the high ground covered with heather, which forms excellent shelter for ewes and lambs. During the summer, autumn, and winter, the ewes are kept out on the hilly ground, and the straths and glens are preserved until within a fortnight of lambing. The ewe hirsels are then allowed access to these reserved pastures during the day, and are turned out again to the *mossing* or higher ground during the night. This fortnight of good feeding brings on a flush of milk as soon as lambing takes place.

"Large hirsels are divided, 500 being the usual number in each, and this number are in charge of two shepherds who work together. Before lambing begins, all the weak ewes, or those in low condition, are selected and either sent to arable land to be lambed, or taken home to a park which is usually found in connection with a pastoral farm, and there lambed, and fortified with extra feeding, being returned to their respective hirsels when they have regained sufficient strength. This park, when lambing is concluded, is preserved, so that a cutting of hay is obtained from it. On some farms there are three or four of these enclosures.

'All weakly lambs are also taken from the hill ground to be treated specially in these home enclosures. After lambing, the ewes and lambs are driven from the low ground on to the hill ground over night, where, amongst the heather and undulations, the ewes find comfortable beds for themselves and their young.

"Late in the season when, through an abundance of grass, the lambs become very big and strong before lambing, there are often serious losses both of ewes and lambs."

Hand-feeding for Ewes.—There is much difference of opinion, and as great variety of practice, amongst sheep-farmers as to the feeding of ewes during stormy weather. It is contended, on the one hand, that hand-feeding should almost, at all hazards, be avoided, for the alleged reasons that, once indulged by such treatment, the sheep will not again forage so well for themselves on the hill pasture; that hill pasture is not sufficient in quantity and quality to afterwards maintain in a thriving condition sheep that have been once artificially fed, and that on this account when artificial food is once given it has to be continued every year. In former times this was no doubt the prevailing idea; but while it is still both preached and practised by many experienced and successful farmers, yet it is certain that a more liberal and a more artificial system of management is coming into favour.

Assuredly the point is one which demands the most careful consideration. No elaborate or universal system can be laid down. Each season, and each set of circumstances, must be considered separately; and the farmer must watch carefully the condition and progress of his flock, and his existing and probable supply of food, and decide for himself to what extent, if any, his ewes should be hand-fed. In itself the hand-feeding of hill sheep is unquestionably undesirable. It should therefore be resorted to only in cases of necessity—when the available supply of other food is manifestly inadequate, and with such ewes as are too thin and weakly to furnish their lambs with a sufficiency of milk.

With this consideration in view—that hand-feeding is to be resorted to only where it is necessary in order to ensure as far as possible the full and uninterrupted progress of the young lambs—the sheep-farmer will watch carefully the daily condition of affairs, and will not hesitate to call in the aid of such extraneous food as roots and hay when the time for its use has really arrived. A high death-rate, both of ewes and lambs, occurs on many farms owing to the reluctance and delay in resorting to hand-feeding. This inhuman system cannot be commended. It cannot be profitable. To allow ewes to perish or to fall off seriously in condition and in supply of milk for the want of a handful of hay and a few roots, simply because the animals may look for similar treatment in after years, is short-sighted in the extreme. Keep up the condition and vigour of the flock at all hazards. If liberal feeding does not pay, assuredly a starvation system will not.

It is well to remember that if the ewes are brought to the lambing in good, fresh, vigorous condition, there will be the less likelihood of extensive hand-feeding being then necessary. Ewes in lamb should therefore be well wintered, and never allowed to get low in condition or weakly.

Just before lambing begins, it would be well to draft out any ewes which seem to be exceptionally thin in condition, and take these for lambing to some low, well-sheltered field, where they may have good pasture or artificial food.

For whatever extra or hand feeding may be necessary, hay and turnips are most suitable. Cake and corn may be more speedily effectual in bringing round very weakly animals, but in their pampering influence on hill sheep these concentrated foods are more injurious than hay and roots.

Shepherds' Duties at Lambing-time. — The lambing season on hill farms is a time of hard work and much anxiety. As soon as lambing begins, the shepherd requires to see his flock three times a-day.

"His first round is made at early dawn, before the sheep have left their 'moorings,' when any requiring attention can be readily noticed. Some shepherds make this trip before breakfast, but this is not a good plan to adopt. When a shepherd leaves his house he never knows how long he may be detained; and going out hungry may cause him to leave his work when he ought not to do so, especially in bad weather. On returning from his rounds he brings home any ewe that has lost her lamb. Having keb-houses at various parts of the hill is of immense advantage at this time, and saves not only the shepherd a lot of unnecessary work, but is much better for the sheep every way. Then there will be a number of such stock in the hospital individually requiring careful treatment, all of which he needs to see before returning to the house for a meal. There is no time for rest during the day, and no sooner is one journey finished than he starts on another, repeating the same morning, noon, and evening. Much depends on the weather, and the worse it is the more need there is for exertion and daily perseverance, which the shepherds, as a rule, never grudge in behalf of their flocks.

"In order to induce a ewe to take a stranger lamb under her charge, the skin of her own dead lamb is flayed and put on another lamb, when the smell of the old skin is usually enough to deceive and induce her to take kindly to the new-comer. Instead of adopting this method, which involves more or less labour, sometimes the ewe is milked, and the milk is rubbed over the skin of the lamb that is to be transferred to her care; and it is found that the smell of her own milk has the same deceptive effect as the smell of the old skin."[1]

Reviving Hill Lambs.—Hill lambs are remarkably hardy, and when the ewes have plenty of milk, the young creatures make rapid progress.

"Their first and most fatal enemy is cold or hunger. For reviving chilled lambs the shepherd carries constantly in his bosom a bottle of warm milk, and sometimes another containing gin or whisky, of which he supplies a mouthful in extreme cases of weakness. Lambs that are really prostrate with cold have to be carried to some place of shelter. Very often the shepherd's kitchen is turned into a hospital for subjects of this kind. In a stormy day it is not unusual to see 20 or 30 shivering lambs by his fireside, which his wife or children attend to while he is away on his rounds.

"Lambs are, however, never taken from their dams if it can possibly be avoided. There is often some difficulty in getting the ewes to own them again, the natural odour by which they are recognised by the mother having been dissipated by the heat of the fire, or from coming in contact with others of a different smell. A better method of reviving chilled lambs than warming them by the fire is to dip them in a tub of warm water, then, after wiping dry, wrap in a woollen cloth, and leave them beside the ewes in the keb-house.

"On recovery, care must be taken to accustom the lambs gradually to out-door life. A sunny noon is a favourable time to set them out, but if the weather continues cold they should be housed for a few nights, until they are strong enough to withstand the elements to which they are exposed."[2]

After Lambing.

Lambing is usually completed in four or five weeks. The after-treatment of the flock varies in accordance with the class of sheep, and the objects in view. In pure-bred flocks, where ram-breeding is carried on to some extent, the lambs to be kept on as rams are early selected, and may be taken with their mothers to reserved pasture, where, from the outset, the ewe and lamb receive liberal treatment.

Castration.—The male lambs not to be kept as rams are castrated when from ten days to five weeks old. In some cases, indeed, castration is performed when the lambs are only two or three days old, but the more general plan is to delay from two to four weeks.

In hill stocks castration is not usually performed until the lambs are fully a month old; in other words, the ewes commence to lamb in the third week in April, and the "marking" takes place about end of May, varying a little according to circumstances and personal tastes. Some farmers have a decided objection against too early castration, as it tends to give a feminine appearance to the wedders, stunting the growth of horn, and weakening the neck too much.

Great caution is required in castrating

[1] *Blackfaced Sheep*, Scott, 118.

[2] *Ibid.*, 122.

lambs. It should not be done in rainy, cold, or frosty weather; nor should the lambs be heated by being driven before the operation. It is best performed early in the morning, in fresh weather, with a westerly breeze. The ewes and lambs should be driven gently into the sorting-folds, the ewes being run out and the lambs held back. One assistant should catch the lambs, and another hold them while the shepherd operates. It is not easy to catch the leg of a lamb with a sheep's crook, their small active limbs easily escaping through the loop; but it may be effectually used in hooking the front of the neck, when the captor rushes in upon the lamb and secures it. But the historic crook is now seldom used for this purpose, as the lambs when confined may be easily caught without it. On arable land, where there is no permanent fold, a few hurdles may be set up in the corner of the field and the lambs enclosed there, and let out as castrated.

Castration may be performed in this way: Let the assistant hold up the back of the body of the lamb against his

Fig. 248.—*Mode of holding a lamb for castration.*
a Scrotum. *c* Tail.

left breast and shoulder, and with each hand raise a hind-leg towards the body, securing them by the shank; while, to prevent farther struggling, a fore-leg is held firmly in connection with a hind one of the same side. The effect of this arrangement is to exhibit the scrotum to full view, as well represented in fig. 248. The shepherd with his left hand then causes the testicles to make the point of the scrotum smooth; and cutting through the integuments of the scrotum, with a sharp penknife in the right hand, first to one testicle and then the other, he protrudes both testicles forward with both hands, and seizes first one testicle with his teeth, drawing out the spermatic cord until it breaks, and then treating the other testicle in the same manner; and, on adjusting the wounded scrotum, the operation is finished.

Describing the system in the north, Mr George Brown, Watten Mains, Caithness, says: "The pen is provided with a half-door, outside of which stand the cutter and holder. The catcher enters the pen and catches the lambs anyway or anyhow: no man who knows his work will hurt a lamb, and a novice will soon learn by looking on. The catcher hands the lamb over the half-door to the holder, who waits until the cutter completes operations,—the latter using one knife for castrating and another for docking, and then lets it down outside the fold, where it quickly joins its mother."

Another mode of castrating lambs is to cut off the point of the scrotum, and extract both testicles through the large opening. The amputated wound takes a considerable time to heal, whereas the two simple incisions heal by the first intention. It is argued, however, by those who prefer the latter plan, that there is an advantage in the larger opening, as all discharges are more readily got rid of. Whereas when the smaller wounds heal with the first intention there would be no outlet for pus resulting from suppuration, and inflammation would therefore be likely to ensue. Both methods are largely pursued. The penknife should be clean and sharp, and the whole operation should be quickly performed.

Docking.—Advantage is taken of the opportunity afforded at castration to dock the tail, which in Scotland is left as long as to reach the meeting of the hams. In docking, the division should be made with a large sharp knife in a joint, when the wound will soon heal. The lamb, after being docked, is let down to the ground by the tail, which has the effect of adjusting the parts in connection with the castration. Ewe lambs are also docked at this time, but they are not held up, being merely caught and held by the shepherd between his legs until the amputation is done.

In England, docking is performed at the third joint, which gives a stumpy appearance to the tail. The object of docking is to keep the sheep clean behind from filth and vermin; but as the tail is a protection against cold in winter, it should not be docked so short in Scotland as is done in England. Tup lambs, in order to strengthen the back-bone, are allowed to retain their full tails until one year old.

Risks from Castration and Docking.—The scrotum does not bleed in castration, but the tail often bleeds in docking for some time in two minute and forcible streams, though usually the bleeding soon stems. Should it continue as long as to sicken the lamb, a small cord should be tied firmly round the end of the tail, but not allowed to remain on above twenty-four hours, as the ligatured point would die by stoppage of the circulation of the blood, and slough off. In some instances inflammation ensues, and the scrotum swells, and even suppurates, when the wound should be carefully examined, the matter discharged, and the wound soon heals.

The advantage of performing the operation in the morning is, that the several cases may be observed during the day; and should the weather have changed for the worse towards the afternoon, the ewes, with the lambs that have just been cut, should be brought under shelter over night. Besides the state of the weather, one cause of inflammation is the scratching of the wounds in the scrotum by the points of the stubble amongst the new grass; and this irritation is most likely to be aggravated when castration has been performed by cutting off the point of the scrotum.

To avoid this source of irritation, the new-cut lambs should be put on new grass, where the stubble has been shorn by a reaping-machine, or on old grass, for a few days.

A Preventive.—Some farmers use a mixture of pure olive-oil and spirit of turpentine for dropping into the scrotum after extracting the testicles, and the results, to themselves at least, are satisfactory. This practice is pooh-poohed by some veterinary surgeons; but when a farmer who uses such a simple and inexpensive mixture very rarely has a death amongst his lambs, whilst his neighbour, who does not use anything, loses 5 to 10 per cent, we think he is justified in pursuing his own course.

Perhaps a still better preventive of inflammation would be a few drops of a solution of carbolic acid and oil poured into the scrotum.

Rig or Chaser.—Sometimes one of the testicles does not descend into the scrotum, when the lamb ultimately becomes what is called a rig or chaser—one which constantly follows and torments the females of the flock, when near him, from insatiable desire. It is not, as a rule, safe to rely upon such a ram for breeding, although we have known of his becoming a successful and prolific sire. His career should be soon put an end to. If one testicle comes into the scrotum and is taken away, or if neither comes down, the ram may be regarded as barren.

Lambing Risks.—Ewes and lambs are subject to several risks during the first four or five weeks. When they have passed through them in safety, the shepherd may calculate on his results—whether he has increased the breeding part of his flock in the proportion it should have increased. He is not satisfied with his exertions if he has lost a single ewe in lambing. What number of lambs he should have to every hundred ewes will vary greatly with the breed and other circumstances.

The death of single lambs is a vexatious matter to a shepherd, as not only breaking pairs, but imposing considerable trouble on himself in *mothering* lambs of stranger ewes. Yet the trouble must be undertaken, so as to retain the ewes in milk that have lost their lambs, and thus maintain them in the breeding state for future years. Hence the shepherd's anxiety to save the lives of single lambs, and hence, also, his pride in preserving pairs.

Bad Weather and Lambing.—In fine steady weather the shepherd's labour is comparatively easy; but when stormy or wet weather prevails, or comes at unexpected intervals, the number of lambings are not only accelerated, but every ewe creates more trouble, even in the day-time. "Daylight has many eyes," and permits him to observe casualties in time to evade their effects; but at night, in bad weather, with glimmering light, difficulties increase tenfold; and we are convinced that every owner of a large flock would find it repay him at the end of the lambing season, by preserving the number of lambs and ewes, to afford the shepherd assistance in the busiest period of the lambing, and especially in bad weather.

Look to the Pastures.—The state of the new grass-fields occupied by ewes and lambs requires consideration. Ewes bite very close to the ground, and eat constantly as long as the lambs are with them; and as they are put on the new grass in spring, before vegetation is much advanced, they soon render the pasture bare in the most favourable circumstances, and especially so when the weather is unfavourable to vegetation. In cold weather, in spring, bitten grass soon becomes brown. Whenever the pasture is seen to fail, the ewes should be removed to another field; for if the plants are allowed to be bitten into the heart in the early part of the year, the greater part of summer will pass ere they will attain any vigour. In steady growing weather there need be little apprehension of failure in the pasture. At the same time, overstocking grass should be avoided at all times. It not only incurs the risk of the clover plants being bitten into the heart, but the pasture soon becomes foul with the dung of the sheep. Of the sown pastures, consisting chiefly of red clover and rye-grass, the clover is always acceptable to sheep; and in the early part of the season young shoots of rye-grass are much relished by ewes.

Rest beneficial to Pasture.—On removing the ewes from the first to the second field, it is better to eat the first down as low as it safely can be for the plants, and then leave it unstocked for at least a fortnight, to allow the young plants to spring again, which they will do with vigour, and with a much closer bottom, than to pasture every field for a longer time with fewer stock. Such a field, eaten down to the end of May or beginning of June, and then allowed to spring afterwards in fine growing weather, will yield a heavier crop of hay than if it had not been pastured in spring at all. Although the whole of the young grass on a farm, pastured lightly with ewes and lambs in the spring, were to grow, as the season advances, more rapidly than the ewes could keep it down, it will never produce the fine sweet fresh pasture which field after field will yield that has been eaten down in succession, and then left to grow for a time.

Caution in Changing Ewes on Pasture.—But in removing ewes and lambs from a short to a full bite of grass, caution is required in choosing the proper time for the removal. It should be done in dry weather, and in the afternoon; because continued damp or rainy or cold wet weather renders new grass so succulent and fermentable that it is almost certain to produce the *green skit* in the lambs, although that sort of weather increases the milk of the ewes. In the after part of the day the ewes have not time to eat too much grass before nightfall.

No Lambing on Carse Farms.—Carse farms have, as a rule, neither a standing nor a flying stock of ewes, and consequently have no lambing season; neither have farms in the neighbourhood of large towns, nor dairy farms, nor pastoral farms for the breeding of cattle alone. Ewes and lambs are thus found chiefly on pastoral farms devoted to the breeding of lambs, and on farms of mixed husbandry.

Shepherding on Arable Farms.—On low country or arable farms with the softer breeds of sheep, from 200 to 300 ewes are about as many as one shepherd can superintend during the day, to render them the assistance they may stand in need of; to place the new-lambed ewes and lambs in shelter until they have both gained strength, and are able to take to the pasture; and, in case of bad weather, to supply them with turnips and hay, to enable them to support their lambs until the weather improves. If one shepherd fulfils these duties in the day, he does quite enough; so that it will be necessary to have an assistant for him in the night, to gather the ewes into shelter at nightfall, and to take a weakly lamb, or all the lambs that have dropped during the night, into sheds erected on purpose, or into sheltered stells, as a protection against bad weather. To ascertain the state of his flock, he should go through them with a lantern at least every two hours, and oftener if necessary.

Shepherding Hill Sheep.—The hardy breeds of hill sheep need less attention, especially during the night. Indeed, the general plan is to leave the flock undisturbed during the dead of the night. The ewes and lambs are turned out to the dry lair over night, and there the shepherd looks over them carefully, perhaps as late as eleven o'clock, while he or his substitute returns to them as early as 3 or 4 A.M., when daylight is making its appearance. If the lair is dry and free from holes, into which young lambs might fall and get drowned, mishaps rarely occur amongst hill sheep in lambing, and a prudent hill shepherd disturbs his breeding flock as little as possible.

Hill Shepherds.—The observations of Little on the qualifications of a hill shepherd are valuable, as containing much good practical sense. "Much," he says, "of the success in sheep-farming depends on the skill and application of shepherds, as well as on the judgment of farmers. As the situation of a shepherd is one of considerable trust, he ought to be honest, active, useful, and of a *calm temper;* for if at any time a shepherd gets into a passion with his sheep, it is attended with great disadvantage in herding, or in working among them. I have known a hasty, passionate man, with a rash dog, give himself double the trouble in managing a hirsel of sheep, besides abusing the sheep, that a calm good-tempered man, with a sagacious close-mouthed dog, would have had in the same circumstances.

"The qualification required in taking care of a hirsel of sheep, is, not in running, hounding, and training dogs, nor in performing a day's work of any other kind, but in directing them according to the soil, climate, and situation of the farm, in such a manner as they shall obtain the greatest quantity of food at all seasons of the year. Their health and comfort should be carefully looked after by the shepherd; and if his exertions are made with judgment, they are of very great consequence to the farmer. It is not by walking much, and doing a great deal, that a shepherd is a good one; but it is knowing *where* to walk, so as to disturb the sheep the least, and by doing at the time whatever is necessary to be done. There is not an experienced shepherd, who has been any length of time on one farm, who does not, as soon as he rises in the morning, and observing the state of the weather, know almost to a certainty where to find every sheep on the hill, and will accordingly take his course to the places where he knows his presence is most wanted.

"The object in looking over a hill every evening and morning, is to ascertain if there be no trespassers nor disease among the sheep which require looking after. If any of your own or neighbour's sheep have trespassed, it is very foolish to dog or abuse them, for the more gently you can turn them back the better. If the boundary should be on the top of a height, to which sheep are apt to draw at night, it is better to turn your own a little closer to the boundary in the afternoon than to turn back your neighbour's, and it will answer the same purpose; and if the two flocks are gently divided in the morning, without dogs, they will become so well acquainted with their own side, that at the very sight of the shepherd they will take to it without further trouble.

"Those shepherds who dog, force, and shed much about a march, I consider them as bad herds for their masters as for the neighbouring farmer. If the boundary be a brook or low ground, where the sheep graze in the middle of the day, and if trespasses are likely to be considerable, the same plan of turning the sheep should be taken as on the height, except that they are to be turned down in the morning, and set out in the afternoon.

"When a sheep dies on the hill, or any disease appears among them, the dead or diseased sheep should be removed immediately, but particularly so if the disease is of an infectious nature. Looking regularly over a hill is of great consequence, also, in case of any sheep falling into a ditch, or lamb losing its mother, or when they are annoyed by flies or maggots, or by foxes or dogs worrying them, or when they fall on their back and cannot get up again.

"All these incidents an active shepherd with a good eye will soon discover, however much a flock may be scattered over a farm. .

"In good weather the shepherd may possibly do all that can be done among the ewes in the lambing season; but in bad weather it is the farmer's interest to afford every necessary assistance, for the want of which, serious losses have often been incurred. .

"Knowing sheep by head-mark often saves a shepherd much trouble, particularly in the lambing season, and at all sortings of the sheep; yet there are many good shepherds who do not know sheep by head-marks, and there are some very ordinary ones who have a talent in that way. Every individual may be known by the *stock* mark.

"To possess the knack of *counting* sheep readily is of no small service to a shepherd, for he ought always to be able to count his flock when he makes his rounds on the hill. There are few shepherds, who accustom themselves to count sheep, who cannot, wherever they meet with them on a hill, count 100 going at large, or even 200; and it seldom happens that a greater number than 200 will be found together in an open hirsel. To know the number in the different lots is of great use in case of a hasty blast, as you can, in that event, know almost to a certainty whether or not any sheep are wanting, and from what part of the farm.

"A shepherd ought likewise to be able *to do any kind of work about a sheep-farm*, such as cutting lambs, smearing, slaughtering, dressing for the market, repairing stone-dykes, cleaning out drains, mowing grass, making hay, casting and winning peat-turf for fuel, &c.; but he ought at no time to neglect the sheep for such work.

"Shepherds are generally accounted lazy; but those who really care for their sheep will not be so. Much walking unfits a man for hard labour, as much as hard labour unfits a man for much walking; but labourers will generally be found more lazy on a hill, or among sheep, than shepherds at field-work." [1]

[1] Little's *Prac. Obser. Mount. Sheep*, 79-86.

Abortion among Ewes.

Ewes in lamb are liable to abortion, or slipping of the lamb, as it is termed, as well as the cow, but not to so great an extent, nor is the complaint considered epidemical in the sheep. Various causes produce it, such as severe weather in winter, having to endure much fatigue in snow, leaping ditches, being frightened by dogs, over-driving, feeding on unripe watery turnips, &c.

Great Outbreak in Lincolnshire.—In the winter and spring of 1883, a serious outbreak of abortion and premature birth occurred in the flocks of Lincolnshire; and an investigation, carried out on behalf of the Royal Agricultural Society by Professor J. Wortley Axe, brought out information and conclusions of considerable value.[2] The inquiry extended to 106 flocks, numbering 51,475 ewes. Of these, 6234, or about 12 per cent, aborted, and 1494 died.

Causes of the Outbreak.—Professor Axe arrived at the conclusion that the outbreak of abortion was not produced by any special and particular cause, but by the concurrent operation of several hurtful influences of a common character. These he enumerates as follows:—

"First and foremost stands the mischievous and fatal practice of feeding pregnant ewes exclusively on unripe watery roots, and especially on unwholesome filth-laden shells.

"Secondly, pain and suffering caused by protracted *foot-rot*.

"Thirdly, exposure to cold winds and heavy continuous rains.

"Fourthly, fatigue arising out of the deep and sticky state of the ground."

Unripe Roots and Abortion.—The clearest evidence as to the evil influence of exclusive feeding of in-lamb ewes upon unripe watery roots was obtained by Professor Axe. The turnip crop in that season was unusually abundant, and, owing to the mild winter of 1882-1883, continued to grow, and remained throughout the season in an unripe and exceptionally watery condition. Of the total number of ewes (about 7800) fed exclus-

[2] *Jour. Royal Agric. Soc. Eng.*, vol. xxi. (1885), 199.

ively on roots, no fewer than 19 per cent aborted; while, where the roots were supplemented by frequent changes to grass, the rate of abortion fell to 3 per cent, and to 1¼ per cent where the roots were supplemented by corn and cake, or some other substantial aliment. Significant enough, surely!

In reference to the high-pressure system of forcing the growth of roots by the free application of artificial manures, and the growing practice of sowing roots late, and beginning their consumption early, Professor Axe remarks that these are inconsistent with full maturation and ripening of roots, and that on this account "the desirability of a guarded and judicious employment of this description of food in the management of breeding stock cannot be too forcibly insisted upon."

He also very strongly objects to the "too common system which condemns pregnant ewes to live exclusively on filth-laden shells" behind other sheep, which get the best of the fresh roots.

Foot-rot and Abortion.—It was shown clearly that foot-rot contributed largely to the cases of abortion. In flocks where it prevailed to any extent the rate of abortion was 4½ per cent greater than in those in which there was no foot-rot.

Twins and Abortion.—The cases of abortion were much more numerous with twin than with single lambs. Indeed, for every abortion with a single there were six abortions with twin-lambs—pointing, as Professor Axe says, "to the existence of some debilitating cause unfitting the ewes with twins to meet the greater demands on their nutritive resources, while influencing in a less degree those with singles."

Preventive Measures.—As the results of his investigations into this Lincolnshire outbreak of abortion, Professor Axe submitted the following recommendations, with the view of avoiding similar occurrences:—

"1. That from the time ewes are placed on turnips to the time when they lamb down, they should receive a liberal amount of dry food, to be regulated according to the nature of the season and the condition of the roots.

"2. The quantity of roots should at all times be limited, and besides shells, a fresh break should be given every day after the hoar-frost has disappeared, and in the early spring the tops should be removed.

"3. Change from the fold to the open pasture twice or thrice a-week, or for a few hours each day, if convenient, is desirable, and especially when the lair is bad.

"4. Protection from cold winds and driving rains should be provided in stormy weather.

"5. Plenty of trough-room should be provided, and ample space allowed for the ewes to fall back.

"6. All troughs should be shifted daily, and set well apart.

"7. Dry food should be given at the same time as the fresh break of roots, to prevent crowding at the troughs.

"8. Rock-salt should be at all times accessible.

"9. Animals suffering from foot-rot, or other forms of lameness, should be removed from the fold, and placed on dry litter, and receive such other attention as the nature of the case may indicate."

Mr Henry Woods on Abortion.—Sheep-farmers have derived much benefit from the investigations regarding abortion in ewes which have been conducted by Mr Henry Woods of Merton, Thetford, Norfolk, agent to Lord Walsingham. He collected and published a mass of valuable information on the management of breeding-flocks and the causes of the prevalent and excessive loss of ewes from abortion—the facts having been gathered from four hundred flock-masters in all parts of the kingdom. In fifty cases of sheep management, where the feeding and results were satisfactory, there were 25,281 ewes; in that number the cases of abortion amounted to 126, and the deaths from all causes during the breeding season were 222. In fifty unsatisfactory cases, there were 21,682 ewes; and in these returns, twenty-two farmers had very heavy losses, while twenty-eight stated a total of abortions amounting to 1884. In forty of the reports there were totalled 1255 deaths. Thus, fifty satisfactory cases showed 1 abortion and not quite 1½ deaths for every 200 ewes; whereas the other cases showed 17½ abortions and 11½ deaths for every 200 ewes, though nearly one-half the abortions and one-fifth of the deaths were not recorded.

Mr Woods on Preventing Abortion.—In his general conclusions, Mr Woods remarks:—

"A most careful analysis of the returns—in making which I have had some able assistance—shows that sheep fed on turnips *now* are not so healthy as sheep were when fed on turnips *some years ago*. As you will have imagined, and as it needs no philosopher to tell you, ewes fed on grass are much more healthy than when fed on turnips.

"It is very evident that sheep are not so healthy as they used to be. One reason is, I think, the land being farmed more highly for turnips; and I have repeatedly remarked that we lose more sheep after a heavy crop of turnips. I do not think the artificial manure of itself is the cause, beyond forcing a turnip into a *bad quality*, which frequently causes us great loss just at lambing-time. I think it must be clear to any person who has followed my remarks in giving details of cases, that swedes are proved to be unhealthy food for breeding-ewes. I might have adduced many other cases from my returns confirmatory of this. In the few instances where the ewes have done well when feeding on swedes, the daily supply has been limited, and there has almost invariably been an allowance of other food—as hay-chaff, with a liberal admixture of bran.

"I believe that the verdict of a large majority of the thinking and practical farmers and experienced shepherds throughout the country will be this,—that if we make it a rule to flush our ewes by stimulating food during the tupping season, to avoid feeding on swedes as much as possible, to limit the supply of other roots as far as circumstances will permit, to give a fairly liberal allowance of digestible, nutritious, and health-preserving dry food, and to run the ewes out on grass as much as possible (taking care never to over-fatigue them) before lambing, there will in future be far fewer cases of abortion and death amongst ewes than we have now to deplore, and many more strong and healthy lambs will be reared than at present.

"One other point is this. The ewes lost during lambing would appear from my returns to be greatest where short-woolled ewes have been put to long-woolled rams. The evidence, I say, is unquestionable that greater mortality attends lambing where short-woolled ewes are put to large-boned, long-woolled rams, than where the ewes breed after their own kind. Where cross-bred ewes are served by Oxford Down rams, the loss of ewes has been less than in the case of the short-woolled ewes served by long-woolled rams; and I presume the reason is that the half-bred ewes, having their parts more fully developed from the cross, are the better adapted to perform the functions required of them."

Youatt on Abortion.—It is stated by Youatt, that too liberal use of salt will produce abortion. It is scarcely possible to predicate abortion in sheep, on account of their woolly covering, but its immediate effects of dulness on the ewe, and of a redness under the tail, will be symptoms noticed by an observant shepherd. "The treatment after abortion," observes Youatt, "will depend entirely on the circumstances of the case. If the fœtus had been long dead, proved by the fetid smell of it, and of the vaginal discharge, the parts should be washed with a weak solution in water (1 to 16) of the chloride of lime, some of which may also be injected into the uterus. If fever should supervene, a dose of Epsom salts, timeously administered, will remove the symptoms. If debility and want of appetite should remain, a little gentian and ginger, with small doses of Epsom salts, will speedily restore the animal. Care should be taken that the food shall not be too nutritive or too great in quantity."

Ailments among Lambs.—Young lambs, as long as they are dependent on their mother for food, are subject to few diseases. A change to new luxuriant grass in damp weather may bring on the *skit* or diarrhœa, and exposure to cold may produce the same effect. As long as the lamb feeds and plays, there is little danger; but should it appear dull, its eyes watery and heavy, and its joints somewhat stiff, remedial means should immediately be used. "A gentle aperient is first indicated in order to carry off any offensive matter that may have accumulated in and disturbed the bowels;

half an ounce of Epsom salts, with half a drachm of ginger, will constitute the best aperient that can be administered. To that must be added 1 table-spoonful of sheep's cordial, consisting of equal parts of brandy and sweet spirits of nitre, housing and nursing."

But there is a species of apparent purging, which is a more dangerous disease than the skit. "In the natural and healthy state of the milk and stomach, curd produced by the gastric juice gradually dissolves and is converted into chyme; but when the one takes on a morbid hardness, and the other may have lost a portion of its energy, the stomach is literally filled with curd, and all its functions suspended. The animal labours under seeming purging, from the quantity of whey discharged, but the actual disease is *constipation.* It is apt to occur about the time when the lamb begins to graze, and when the function of the stomach is naturally somewhat deranged. Chemistry teaches us, that while a free acid produces coagulation of the milk, an alkali will dissolve that coagulum. Magnesia, therefore, should be administered, suspended in thin gruel, or ammonia largely diluted with water, and with them should be combined Epsom salts to hurry the dissolved mass along, and ginger to excite the stomach to more powerful contraction. Read's stomach-pump will be found a most valuable auxiliary here. A perseverance in the use of these means will sometimes be attended with success; and the little patient being somewhat relieved, the lamb and the mother should be moved to somewhat better pasture."

Watery food in the lambing season lays the foundation of a bad quality of blood, and probably causes a number of deaths in the flock.

"Besides looseness, lambs are at times subject to *costiveness* in the bowels. In the first few days of its existence the fæces they void has a very viscid consistence, which, when it falls on the tail, has the effect of gluing it to the vent and of stopping up that passage. On the removal of the obstruction by scraping with a knife, the symptom will also be removed. A worse species of costiveness is, when a few drops of liquid fæces fall occasionally to the ground accompanied by straining, as it is generally accompanied with fever that may be dangerous. Half-ounce doses of Epsom salts should be administered every 6 hours until the bowels are evacuated, after which both ewe and lamb should be turned into more succulent pasture, as the cause of the complaint is to be found in bare pasture in dry weather. In cases of *fever*, which may be observed from the dulness of the lamb and its quick breathing, the administration of tolerable doses of Epsom salts will generally avert the malady *at its commencement.*"

Inflammation in Ewe's Udder.—After recovery from lambing, the complaint the ewe is most subject to is inflammation in the udder, or *udder-clap* or *garget.* Of this complaint Youatt gives a good idea of its origin and of its treatment: "The shepherd, and especially in the early period of suckling, should observe whether any of the ewes are restless and exhibit symptoms of pain when the lambs are sucking, or will not permit them to suck at all. The ewe, like the cow, or oftener than that animal, is subject to inflammation of the udder during the time of suckling, caused either by the hardness or dryness of the soil on which she lies; or, on the other hand, by its too great moisture and filth, or by some tendency to general inflammation and determination to the udder by the bumps and bruises, sometimes not a little severe, from the head of the lamb. If there is any refusal on the part of the ewe, or even disinclination, to permit the young one to suck, she must be caught and examined. There will generally be found redness and enlargement and tenderness of one or both of the teats, or sometimes the whole of the udder, and several small distinct kernels or tumours on different parts of the bag.

"The udder should be cleared of the wool which surrounds it, and should be well fomented with warm water, a dose of Epsom salts administered, and then, if there are no large distinct knots or kernels, she should be returned to her lamb, whose sucking and knocking about of the udder will contribute, more than any other means, to the dispersion of the tumour and the regular flow of milk. It may occasionally be necessary to confine her in a pen with her little one, in order that it may have a fair chance to suck. A day, however, having passed, and she not permitting it to suck, the lamb must be taken away, the fomentation renewed, and an ointment, composed of 1 drachm of camphor rubbed down with a few drops of spirit of wine, 1 drachm of mercurial ointment, and 1 oz. of elder ointment, well incorporated together, must be rubbed into the affected part, or the whole of the udder, 2 or 3 times a-day. She must also be bled, and the physic repeated. If the udder should continue to enlarge, and the heat and tenderness should increase, and the knots and kernels become more numerous and of greater size, and some of them should begin to soften or evidently to contain a fluid, no time must be lost, for this disease is abundantly more rapid in its progress in the sheep than in the cow. A deep incision must be made into that part of the udder where the swellings are ripest, the pus or other matter squeezed out, and the part well fomented again. To this should succeed a weak solution of the chloride of lime, with which the ulcer should be well bathed 2 or 3 times in the day. When all fetid smell ceases, and the wound looks healthy, the friar's balsam may be substituted for the chloride of lime.

"The progress of disorganisation and the process of healing are almost incredibly rapid in these cases, and the lamb may sometimes be returned to the mother in the course of a few days. There are particular seasons, especially damp and warm ones, when there is a superfluity of grass, in which garget is peculiarly frequent and fatal. Without warning, the udder swells universally with hardened teats, which sometimes bring on great inflammation; and if that is not stopped in the course of 24 hours, part, if not the whole, of the udder mortifies, and the mortification rapidly spreads, and the sheep dies." [1]

Ewe and Lamb Box.—In case of an individual ewe, of a large flock of a pastoral farm, which has strayed a considerable distance from the shed erected to afford shelter to ewes, or has suffered in hard labour, or has a weakly lamb, or has twins which are apt to stray from her or she from them, or has been overtaken by a rude blast immediately after lambing, a contrivance to afford such a ewe

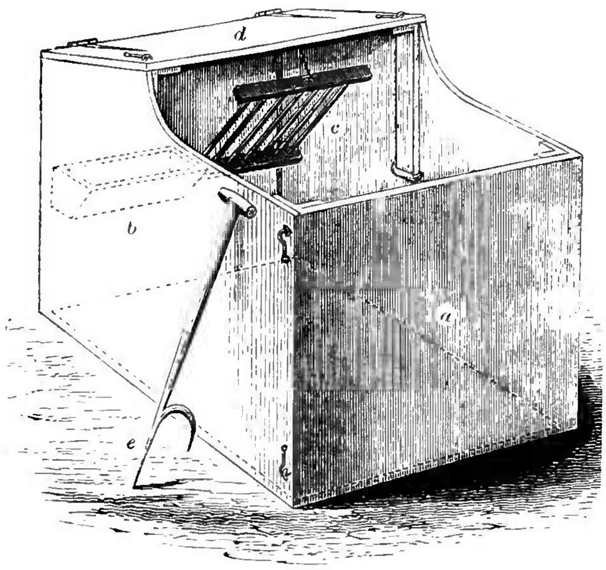


Fig. 249.—*Ewe and lamb house.*

a Movable front of box, with hooks.
b Manger within.
c Rack for hay.
d Broad lid with hinges.
e Fork to assist in lambing.

temporary shelter, used by Nicholas Burnett, Blaik Hedley, near Gateshead, and illustrated in fig. 249, seems to deserve notice. It consists of an enclosure of boards, or a box, whereof the front removes by hooks at the sides to admit the ewe and her lamb within, and where she is provided with a manger to contain sliced turnips or oilcake, and a rack for hay, to fill both of which access is obtained by a broad lid movable on its hinges. The box is light, and can be easily carried to any spot, and it might be the means of saving the lives both of ewes and lambs which would otherwise perish from exposure.

The size of this *ewe-house*, as it is called, may be made to suit that of the sheep bred on the farm; and as it is not costly, any number can be made to be used at a time. A useful size will be found to be the following: Length, 5 feet 6 inches; breadth, 3 feet; height, 3 feet; breadth of the covered part, 2 feet 7 inches; and rise of its slope, 7 inches. The fork leaning against the side of the ewe-house may be used to grasp a ewe's neck, while lying on the ground, and to fasten it down while the

[1] Youatt's *Sheep*, 497-515.

shepherd is lambing her without other assistance; but holding a ewe down between the heel and knee renders such an implement of little use.

Preparing Ewes for Railway Travelling.—Ewes with lambs at foot, unaccustomed to oilcake or hay, will get dry of milk on being sent on a long journey by steam or rail. But if accustomed with oilcake before, they will eat it readily on board ship or truck.

Snow in Lambing.—One of the greatest sources of loss among lambs on hill farms is a fall of snow at the lambing season, and a continuance of it after that period. Ground rendered wet by the melting of new-fallen snow is in a worse state for lambs than when wetted by rain, as rain falls at a higher temperature. Wet ground of any kind, however, is inimical to the safety of new-dropped lambs.

The driest part of the farm, combined with shelter, should be chosen for the lambing-ground, though it may be inconvenient in other respects. But should the best lambing-ground be covered with old snow, and in a sheltered spot, and the temperature of the air above the freezing-point, the snow might be removed.

Snow-plough.—A snow-plough would prove useful in its removal. The snow-plough, fig. 250, is thus described by Mr

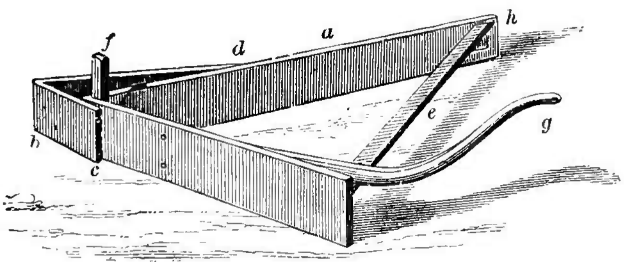


Fig. 250.—*Mountain turn-wrist snow-plough.*

a The plough.
b c d Shifting-head.
b c Head, 18 inches long.
b d Head, 30 inches long.
g Stilt, movable.
f Post for stilt, with a hinge-joint, and for draught-chain.
e Stretcher or cross-bar.
d h Mould-board in this arrangement.

Hepburn of Culquhailzie: "To enable the plough to clear tracks for the sheep along the hillsides, it is necessary it should be made to throw the snow wholly to the lower side. To effect this, I caused to be fitted to the plough—the body of which forms an isoceles triangle, whose sides are 7½ feet and its base 6 feet in length, the depth of the sides being 15 inches—a shifting head with unequal sides, one being 18 inches, the other 30 inches long, fixed by iron pins passing through 2 pairs of eyes attached to the head and to the sides of the plough respectively, so as to bring the point of the attached head of the plough nearly into the line of its upper side, or next the hill. A stilt at the same time was made movable by a hinge-joint at its anterior extremity, fixed to the bottom of the head from the post, so as to be capable of being fixed to a cross-bar or stretcher, either in the line bisecting the angle, which is the position for level ground, or in the line, alternately, of either of the sides, when to be used on a declivity. A draught-chain is fixed, not to the shifting head, but to the upright frame-post, in the nose of the plough, which rises 10 or 12 inches above the mould-boards.

"When the plough so constructed is to be worked along a declivity, with the left hand towards the hill, the shorter limb of the shifting head is fixed on the left side of the plough, near the point, and the longer limb on the right side, towards the middle; and the stilt being fixed in the left extremity of the cross-bar, nearly in a line with the temporary point, the plough is necessarily drawn in the direction of its left side, so as to throw the snow wholly to the right down the hill.

"When the plough is to return across the declivity, with its right side to the hill, the movable head is detached by drawing out the linch-pins, is turned upside down, and fixed in the reverse position; the shorter limb being attached to the right side, and the longer to the left side of the plough, while the stilt is brought to the right extremity of the cross-bar. The plough is then drawn in the direction of the right side, and the snow is thrown wholly to the left, near the lower side. Should the lower side of the plough show a tendency to rise, it may either be held down by a second movable stilt, fixed to the middle of the cross-bar, or a block of wood or other ballast weight may be placed on that side of the plough. The plough will be found to remove considerably more than its own depth of snow. When a plough of 1 foot high passes through snow 18 inches or 2 feet deep, very little of the snow falls back into the track, and what does so fall is easily cleared out by the plough in returning."

Snow - harrow.—The snow - harrow, fig. 251, consists of a single bull, 4½ inches square, and 6 feet long; and in the middle of which, on the under side, a piece of 1¼-inch plank, 3 feet long, is

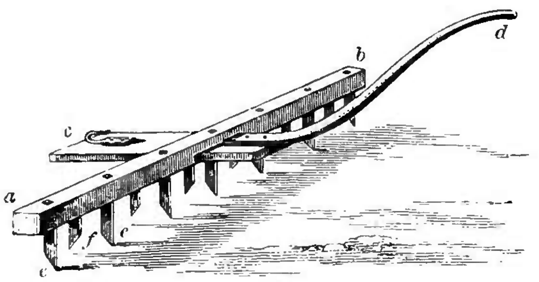


Fig. 251.—*Mountain snow-harrow.*

a b Bull.
c Plank, on which is the draught-hook.
d Stilt attached to plank.
e e 7 Long cutters.
f 6 Short cutters.

sunk flush transversely, for the attachment of a draught-hook and a stilt to steady the motion of the implement. In the bull are fixed, by screw-nuts at intervals of 10 inches, 7 cutters, &c., 9 inches long and 1⅜ inch broad, sabre-shaped, with their points turned backwards, so as to be less liable to be arrested by obstacles on the surface of the ground. Between these cutters are fixed six shorter ones, 3 inches long, having their points turned forwards. This implement, dragged by one horse ridden by a boy, and the stilt held by a man, cuts the frozen snow into stripes of 5 or 6 inches broad, which are easily pulverised by the feet of the sheep, or divided by the snow-plough.

In lowland farms the snow remains around the fences long after the middle of the fields are clear. A speedy means of getting rid of the snow is to cut it with the common plough repeatedly.

Hay-rack for Storm.—A cheap and most portable sheep hay-rack or heck for a storm, is the cart-horse hay-net, which can be fixed in spite of wind and drift, and will save hundreds of sheep where there is hay. Seven or eight sheep can get round one net, which will serve for years with care.

An excellent plan is to hang a wire net 1½-inch mesh upon a double row of ordinary net-stakes, care being taken to have the bag of the net low enough to prevent the sheep from passing under it. A hay-rack which will last for years, and of any desired length, may thus be made at a moderate cost.

But many think the best way of giving hay to ewes during a snowstorm is to lay it out in lines on the snow. Hill sheep will not, as a rule, eat hay unless they are confined, or the ground is covered with snow.

Sheep on Turnips.—The management of sheep on turnips in spring differs very little from that in winter, which has been fully discussed.

Produce of Lambs.

Single and Twin Lambs.—As to the probable produce of lambs, the following remarks by Professor Wrightson will be read with interest: "The number of twins or of single lambs is an important matter affecting the profits of sheep-farming. An abundance of twins is a matter for congratulation, but is not an unmixed advantage. They will not attain the size of single lambs for sale in the following autumn; the ewes require more food, and are often more reduced in condition through suckling, and the strain upon the mother is heavy, especially in the case of two-tooths. Still, a good many twins are required in order to keep up the number of lambs, which is liable to drawbacks from death, barrenness, and slipping. Twins give the opportunity to the shepherd of dividing them, and thus supplying lambs to ewes which have lost their own offspring, and which, otherwise, would go as barreners.

Crop of Lambs.—"Without a fair proportion of twins we should unquestionably suffer from a short supply of lambs, even upon the assumption of a lamb to a ewe throughout the flock. This apparently modest estimate is by no means always realised, in spite of twins, as barren and aborted ewes may easily constitute 5 per cent of a flock, and often double that proportion. Deaths among very young lambs are also frequent, so that the general statement that for every ewe put to the ram there should be a lamb at weaning-time, is not far from correct.

How to obtain a Big Crop of Lambs.—"Some flocks, and some farms, seem naturally adapted for producing a large number of lambs. It may be reasonably expected that twins will in turn produce twins, and hence rams and ewes which have been twins might properly be selected to propagate their species. Fertility is as likely to be inherited as any other property, and with it the natural accompaniments of good nursing and abundant milk-supply. I am inclined to think that ewes are naturally disposed to produce a pair of lambs, and that single lambs are to be regarded as a degree less normal than twins. Thus, when ewes are in good order and keep is abundant—both of which conditions must be regarded as strictly natural—the number of twins is immediately increased, and sometimes almost the whole flock produces doubly. This indicates the best method of obtaining a big crop of lambs, namely—keeping the ewes well throughout summer. Extreme fatness or extreme poverty both militate against fertility, but a judicious mean and plenty of good food during the period of conception produces an opposite effect. Ewes which have been barren during one season will often conceive early and produce two strong lambs the succeeding spring, and sale ewes which have been caked will generally produce a lot of lambs."[1]

Flushing—that is, forcing the ewes with rich and abundant food for a week or two before tupping, and during tupping—is known to have a wonderful effect in increasing the proportion of twin lambs.

Prolific Ewes.—Some remarkable instances of the prolificacy of ewes have been recorded. A ewe, the property of J. Amall, of Thrussington, Leicestershire, had the immense number of 22 lambs in six years. She had 3 lambs three times, 4 lambs twice, and 5 lambs once.—T. Stephens, of East Deanes, St Neot, had 12 ewes, which in one season produced 30 lambs—viz., 1 ewe, 4 lambs; 4 ewes, 12 lambs; and 7 ewes, 14 lambs.

Lambing Table.

The *duration of pregnancy* in the ewe is generally reckoned at *twenty-one* weeks, but may vary from 136 to 160 days.

From the following table, which shows when twenty-one weeks expire from the 1st and 14th of any month, the date for the lambing of ewes may be easily ascertained:—

From		To	
January	1.	May	27.
	14.	June	10.
February	1.	"	28.
	14.	July	12.
March	1.		26.
"	14.	August	8.
April	1.	"	26.
"	14.	September	8
May	1.	"	22.
"	14.	October	8.
June	1.	"	25.
"	14.	November	8.
July	1.	"	25.
	14.	December	9.
August	1.	"	26.
"	14.	January	8.
September	1.		26.
"	14.	February	9.
October	1.	"	25.
"	14.	March	10.
November	1.		26.
"	14.	April	9.
December	1.	"	25.
	14.	May	9.

[1] *Live Stock Jour.*, p. 114, 1889.

MANURES AND MANURING.

In the advanced agriculture of the present day the question of manuring possesses far more importance and involves greater difficulties than were associated with it in the elementary farming of olden times. The extension and accumulation of knowledge, in regard to the maintenance, utilisation, and recuperation of fertility; the discovery and development of new sources of manurial commodities; and the vastly increased and still growing consumption of farm produce of all descriptions, have with their combined influence contributed largely to the great revolution which, since 1840, has taken place in British farm practice.

The farmer can no longer wait for the recuperating power of nature to restore reduced fertility. He is not content to merely "turn over," as it were, the natural store of plant-food which the soil possesses. Before the advent of "artificial" manures and feeding-stuffs the prevailing system of farming was little else than a "turning over" of the inherent fertility of the soil—the abstraction of fertility from one field in certain crops, and the returning of it, or a great part of it, to another field in the shape of farmyard manure. This, however, was a slow process, quite unequal to the wants, the aspirations, and resources of the progressive age in which we live.

A speedier, more intense, more artificial system of farming has arisen, and to make provision for the greater demands which are now made upon the productive powers of the soil, active and persistent attention has for years been devoted by scientists, capitalists, and practical farmers to the all-important question of *manuring*. Indeed the development of the manure-trade is to some extent the cause rather than the result of the increased activity and progress of agriculture. They have grown up, as it were, hand in hand, the one fostering and encouraging the other.

By the discovery of vast natural deposits of manurial elements, and by the manufacture of useful fertilisers from waste products and other material, great possibilities, hitherto undreamt of, have been placed in the hands of the farmer. By the means of these agencies it is possible for him to vastly increase and hasten the production of his farm—not only by adding to the supply of plant-food already in the soil, but also by so stimulating, equalising, and preparing that supply, as to render it far more serviceable and nutritious to the growing crops.

The farmer is not now dependent upon the residue of his crops for the restoration of fertility to the soil. So far as concerns the question of the fertility of the soil, the farmer may now grow what he pleases and sell what he pleases. The abstracted fertility may be replaced by purchased fertilisers, so prepared and proportioned as to return to the soil in the most useful form the exact quantities of the elements of plant-food withdrawn by the crop.

It is not to be said here that this system of selling crops and buying artificial manures is preferable to the older and still more general method of consuming a large portion of the crops on the farm, and so restoring fertility by farmyard dung. The point is mentioned merely for the purpose of indicating the vastly extended scope which the development of the manure-trade has imparted to the practice of farming.

It is thus seen that the subject of *manures and manuring* is now one of surpassing importance. It has, indeed, become the very keystone of British agriculture. We have therefore deemed it right that in this edition of *The Book of the Farm* the subject should receive somewhat exceptional attention. It is dealt with more fully than has before been attempted; and while dogmatism as to the precise composition and quantities of specific manurial doses has been avoided, an effort is made to submit in convenient form such information as will safely guide the intelligent farmer in the economical and efficient manuring of his land.

There is probably no process connected with agriculture as to which there is more difference of opinion, or in which greater diversity of practice prevails, than the manuring of land. This remark, too, is quite as applicable to professional chemists as to practical farmers. To attempt to reconcile all these contradictory views and customs would be hopeless; yet in the majority of cases the contradiction is more apparent than real. The more intimately one becomes acquainted with the routine of farm management in the various parts of the British Isles, the less is one inclined to dogmatise and to assert that a certain system is right and all others wrong. The system which gives the best results in the cold regions and light friable well-drained lands in the north of Scotland, may be utterly unsuited to the stiff clayey lands of England, or the moist soil and mild climate of the Emerald Isle. One may be assured that the marked divergences in farm practice are not mere accidents. As a rule, they will be found to be fully justified by variations in local conditions, differences in soil, climate, and objects and possibilities of the farmer. Then, as to the differences amongst men of science, it should be borne in mind that the great field of agricultural chemistry is only in process of exploration, and that while our knowledge regarding its wonderful truths has, in recent years, grown with gratifying rapidity, it is still far from being perfect and entire.

In dealing with the subject of manures and manuring, the Editor has been deeply impressed with these considerations, and, keeping them in view, he has sought the counsel of many recognised authorities. The writings of our most eminent chemists and practical agriculturists have been carefully consulted and freely drawn upon, notably those of Johnstone, Cameron, Voelcker, Anderson, Lawes, Gilbert, Wilson, Sibson, Morton, Ville, Liebig, Hellriegel, Wrightson, Warington, Aitken, Jamieson, Falconer-King, Aikman, MacAdam, Bernard-Dyer, Lloyd, Cooke, Fream, Curtis, Brown, &c. And from several experienced practical farmers, who have made a special study of the subject, and who reside in and farm different parts of the kingdom, the Editor has received most valuable help and advice in his effort to present the readers of this work with useful information as to the economical manuring of land.

EXHAUSTION AND RESTORATION OF FERTILITY.

In the section on "Fertility of Soils" (p. 56, Div. I.), the principles relating to the existence, exhaustion, and restoration of fertility in soils are fully explained. The reader should be familiar with what is said there before perusing what follows here.

Abstraction of Fertility.—It has been seen that the fertility of the soil becomes reduced by the removal of ingredients in crops and animals raised upon it, and by soluble matters being carried away in drainage-water. It is also more than probable, as will be explained in connection with the Rothamsted experiments in this chapter, that loss of plant-food occurs through evaporation of volatile ammonia.

Prior to the introduction of artificial manures, farmers relied almost entirely upon farmyard dung to replace the abstracted fertility. This, however, was not sufficient, for much of the ingredients of the soil were sold off in the form of grain, meat, milk, cheese, &c. It is thus obvious that, if no other means of restoring fertility had been found, the soil would have, in course of time, become exhausted.

Deferring Exhaustion.—The agents which were most effective in deferring this exhaustion were careful and seasonable tillage, drainage, subsoiling, the decay of the roots of crops, rotation of crops, and bare fallow. The combined influence of these agents is certainly by no means insignificant. It has been well shown in the Rothamsted experiments that tillage and the decay of the roots of crops have a very important bearing upon the duration of fertility in soil.

It is a curious and important fact that the growth of crops in itself, while robbing the soil of certain ingredients, tends to enrich it in other elements of fertility. The plants absorb nitrogen from the atmosphere, and draw nutritious ingredients from the subsoil. By the decay of their roots they thus leave the surface soil richer in certain elements than it was before. And the larger the crop the more does it enrich the soil in these elements, for the greater is the residue of plant-food in the roots which remain in the soil. See pp. 60 and 61, Div. I.

Restoring Fertility.—But it is clear that something more is necessary to restore to the soil the particular elements removed in the produce exported from it. For this restoration we have now at hand an exhaustless store of artificial manures.

Ingredients Removed by Crops.—The important question now arises: What are the ingredients which are removed in crops, and what are the quantities of each? As to the elements of plant-food and the sources of their elements, see p. 57, Div. I.

On p. 63, Div. I., will be found an exhaustive table, showing the weight and average composition of ordinary farm crops in pounds per acre. From that table it is easy to calculate the quantity of each ingredient of plant-food removed in any rotation of the ordinary farm crops.

And from the full explanations which accompany the table, useful deductions may be drawn as to the manurial treatment which should be pursued under the various systems of cropping, stocking, and disposal of crops and stock.

The subject is so fully and clearly dealt with by Mr Warington, in the pages referred to, that any further discussion here of the general principles relating to the exhaustion and restoration of fertility would be needless repetition.

Exhaustion in a Norfolk Rotation.—It may be interesting to show here in tabular form the quantities of the chief elements of plant-food which would be withdrawn from the soil in the course of the Norfolk rotation of wheat, turnips, barley, and clover; and with this total is contrasted the amount of these ingredients which would be returned in an ordinary dressing of farmyard manure—8 tons or 16 yards of dung:—

Crop.	Dry Matter.	Nitrogen.	Potash.	Magnesia.	Phosphoric Acid.
	lb. per acre.	lb. per acre.	lb. per acre.	lb. per acre.	lb. per acre.
Wheat, 30 bushels per acre .	4183	48	28.8	7.1	21.1
Turnips, 17 tons "	4657	112	148.8	9.5	33.1
Barley, 40 bushels "	3827	48	35.7	6.9	20.7
Clover, 2 tons "	3763	102	83.4	28.2	24.9
Totals		310	296.7	51.7	99.8
Rotten farmyard dung, 8 tons per acre		96.8	95.2	18.94	48.0
		213.2	201.5	32.76	51.8

It is thus seen at a glance that an ordinary dressing of farmyard manure, say 8 tons or 16 yards per acre, applied once in the above four-course rotation, would restore barely one-third of the elements of fertility removed by the crops. Such a large dressing as 24 or 25 tons of dung per acre is impracticable; hence the economy and advantage of having at command the various artificial fertilisers in which, in a highly concentrated and readily available form, the deficient elements may be supplied.

Removal and Return of Plant-food in Different Systems.—This supplemental work is indeed the chief function of artificial manures. Upon all farms, less or more farmyard dung is made; and as a means of restoring fertility, it is first reckoned upon and employed. Under certain systems of farming, where not only the great bulk of the produce of the farm, but also large quantities of purchased foods, are consumed on the farm by stock, the quantity of dung may be almost sufficient for all the manurial requirements of the holding. Indeed, under such a system, the manurial residue of the purchased foods might supply more plant-food than would be exported from the farm; and thus, without the aid of any of the artificial fertilisers, there would be an accumulation rather than an exhaustion of fertility. But extreme cases of this kind are very rare.

The extreme on the other hand is where the growing and selling of crops are the main features in the system of management, and where few or no stock are kept beyond what is necessary for the working of the farm.

Between these two extremes there are many gradations—an endless variety of systems, in which there is an ever-changing relation between three great factors in successful agriculture—viz. (1), the amount of plant-food withdrawn from the soil; (2) the amount returned in farmyard manure; and (3) the quantity of purchased fertilisers necessary to make up the deficiency in the latter, as compared with the first, or to furnish any increased fertility which the farmer may desire to impart to the land.

Sum and Substance of Successful Manuring.—Here, then—in securing the proper relations of these factors—we have the sum and substance of successful manuring. It is by no means a simple matter. It is beset with many problems requiring the most careful and intelligent study, as well as technical knowledge. The farmer has to consider not only what quantities of the various elements of plant-food he would have to purchase to make up the deficiency in his supply of farmyard manure. He must also see that he procures these elements from the best and cheapest sources at the time, and that they are in the forms most suitable to his objects.

And it has to be kept in view that the ascertaining of the amount of purchased manure necessary to supplement the farmyard dung is not the simple matter the uninitiated might at first sight regard it. It is not sufficient to merely subtract the supply of plant-food in the stock of dung from that contained in the crops removed from the soil. For instance, we have seen from the table on page 90, that during the four-course rotation there mentioned the quantities of plant-food removed in the crops would exceed those returned in 8 tons of dung by 213 lb. of nitrogen, 201.5 lb. of potash, 32.76 lb. of magnesia, and 51.8 lb. of phosphoric acid, per acre.

Resources of the Soil to be Reckoned.—Now it is not enough for the farmer to have ascertained this. If he were to supply the full quantity of each ingredient here represented as deficient, he would most likely be pursuing a wasteful system of manuring. The natural resources of the soil must be reckoned with. In many soils there is a great natural store of certain elements of plant-food, which will be capable of furnishing the wants of crops for several years to come. For instance, if it is a clayey soil, there will most likely be such an abundance of potash in it as that any direct application of this element would, for the time being, be entire waste of money, perhaps even hurtful to the crop.

The farmer has therefore a fourth factor to reckon with—namely, the *reserve* of plant-food in the soil.

Chemical Analysis Unreliable.—The accurate ascertaining of the quantity and condition of this "reserve" of plant-food in the soil is perhaps, of all, the most "knotty" point in the whole question of manuring. The acumen of the chemist fails in this particular point. By the aid of his powerful acids, alkalies, and other decomposing agents, he can tell us the entire quantity of any element in the soil and subsoil; but he has not as yet succeeded in determining definitely how much of that element exists in a form available to the plant, and how much of it is locked up in combinations which the weaker acids at the command of the plant are unable to break up. True, by diluting and weakening his acids and alkalies, so as to bring them as near as possible to the strength of the dissolving agents at the command of the plant, the chemist endeavours to *estimate* the amount of *available* plant-food in a soil. In this way he is able to obtain information of undoubted value. Yet it is merely an *estimate*, and in practice has to be followed with caution.

Evidence of the Crops.—Recognising the difficulty of accurately estimating the fertility of soil by analysis, Georges Ville, the eminent French chemist, recommended the more elaborate and more reliable plan of testing the soil by the "evidence of the plants themselves." He says:—

"I laid down the principle that by means of four substances—phosphoric acid, potash, lime, and nitrogenous matter—it was possible to bring the most barren soil to the highest degree of fertility. We have learnt more than this—viz., that these four substances, however efficacious they may be, only remain so as long as they are associated and united one with the other; for by suppressing one, the remaining three are often rendered inert, and frequently lose the greater part of their activity.

"We have further said that these four substances are not of the same degree of utility to all descriptions of plants, but that each has a preponderant or subordinate action by turns; that for cereals, colza, and beetroot, nitrogenous matter was the preponderant constituent; phosphoric acid fulfils a similar function with respect to maize, cane-sugar, and swedes; whereas potash preponderates in the case of potatoes and leguminous plants. If you thoroughly understand these three fundamental propositions, you will readily see by what natural deductions we shall be able to found upon them a practical method of analysis that will be accessible to all.

"Suppose, for instance, that we experiment upon the same soil with five different manures: first of all, a manure composed of the four substances of which we have been speaking, and to which we have given the name of normal manure; and next with four manures composed of three ingredients only, excluding in rotation nitrogenous matter, phosphoric acid, potash, and lime, and with these produce a parallel series of crops—

With the normal manure.
Manure without nitrogenous matter.
" " phosphates.
" " potash.
" " lime.
The soil without any manure.

The result will be that the complete manure produces 43 bushels of wheat per acre; manure without nitrogenous matter produces 14 bushels; manure without phosphates, 26½; manure without potash, 31; manure without lime, 41; and the soil without any manure, only 12 bushels per acre.

"The conclusion is evident and conclusive. The soil requires, above all, nitrogenous matter; it is provided with lime, but insufficiently supplied with potash and calcic phosphate. What analysis, I ask, be it as delicate as it is possible to conceive, will ever be able to furnish us with a series of results like this? According as the crops obtained with the incomplete manures differ from or resemble those resulting from the use of the normal manures, the conclusion we arrive at is, that the soil lacks the ingredient excluded from these manures, or *vice versâ*.

"But this is not all. In every soil there are two portions to be considered—the surface soil and the subsoil, the upper and under layers—and it is most important that we should have definite ideas upon this subject. We may gain the necessary knowledge very easily by substituting for wheat some tap-rooted plant; beetroot, for instance, which buries itself in the ground to a much greater depth.

"With potatoes, the information gained is no less instructive and precise:—

	Crop per acre of Potatoes.	
	tons.	cwt.
Normal manure .	11	3
Manure without lime	8	4
" " phosphate	6	6
" " nitrogen	5	18
" " potash	2	2
Soil without manure	2	14

The potato, then, tells us that the soil of Vincennes does not contain sufficient proportions of potash and of nitrogen; and if it shows a preference for soil that is rich in potash, it is because that substance is its dominant constituent—that is to say, it is the ingredient in manure that acts most beneficially upon that special crop.

"The evidence of these two plants is not contradictory but confirmatory, and you will observe how the preponderance of certain constituents gives an additional value to the same facts. In order to gather an exact idea of the richness of the under layer or subsoil at Vincennes, it is necessary to consider the result which was obtained at the same time with wheat and potatoes. A series of crops of wheat shows plainly that nitrogenous matter and potash are present in restricted proportions, and a series of potato crops confirms and ratifies this testimony; only with manure without potash, the crop of potatoes is feebler and comparatively smaller than that of wheat, because potash is a dominant constituent in potatoes, and only a subordinate constituent in wheat.

"Here, then, is a perfectly accurate system of experiments, and the information gained may at once be applied to practical use. With an experimental field we always determine the nature of the substances useful to plants contained in the soil, and also determine in what constituents the soil is deficient, and with this knowledge we can decide what sort of manure it will be advisable to employ.

Method of Test Experiments.—"I will briefly show you how we should proceed in the formation of such fields, according to the purpose for which they are to be used. If the results of our experiments are somewhat important, we must choose a piece of land representing the mean fertility of the whole estate, and divide it into ten plots, each containing, say, a quarter of an acre, to be fertilised, as shown beneath :—

No.	1	is to receive	24 tons of farmyard manure.
"	2		12
"	3	"	very rich normal manure.
	4	'	ordinary "
"	5	"	manure without nitrogenous matter.
	6		manure without calcic phosphate.
	7		manure without potash.
"	8		manure without lime.
"	9		manure without mineral matter.
	10	"	soil without any manure.

Here is a system equal to all the exigencies of every kind of culture. Thanks to this method of growing crops side by side, we are able to follow methodically the exhaustion of the soil; that advanced-guard of the field of experiments indicates with certainty the precise moment when the soil is ready to receive nitrogenous matter, potash, or calcic phosphate, as the case may be.

"But it will be said that on every farm it may happen, as it nearly always does, that there are soils of very different nature. The experimental field, of which we have just been speaking, does not suffice for an extended inquiry, and in order to arrive at useful results, it is necessary to set aside an additional quarter of an acre, divided into four parts, on which to experiment with these different manures: normal manure, mineral manure, and nitrogenous matter, the fourth part receiving no manure at all.[1] With these four combinations of manure, under the condition that if necessary the trial may be repeated, we can acquire with certainty all information of which, practically speaking, we have need. The first field, by reason of its greater extent, and the more numerous and varied combination of manure that it receives, is, as it were, a centre towards which all the others must gravitate. The results given by the smaller plots are tested by those of the first field, which acts as a sort of touchstone, and in a certain measure completes and rectifies their signification. When you are once familiarised with this mode of investigation, every kind of culture becomes a source of information concerning the state of the soil—its richness or its exhaustion. Here, for instance, is an example :—

"On two contiguous portions of land, say of a few square yards, sow peas and wheat without any kind of manure. This little experiment will amply suffice to ascertain if the soil contains nitrogenous and mineral matter. We have already seen that nitrogenous matter was the dominant constituent in wheat, and that it was only of very secondary importance to peas, if indeed its action could be regarded as of any use at all to them; whilst the dominant constituent in peas was potash. You see now, by the light of these simple facts, with how much importance the experiment just quoted can be invested. If the two squares of wheat and peas are equally fine, it proves that the soil contains a sufficiency both of nitrogenous and mineral matter.

"Now, if the wheat becomes small, yellow, and rather soft, whilst the peas flourish well, it proves that the soil is lacking in the dominant constituent of wheat, which is nitrogenous matter, whilst it contains, on the contrary, a sufficiency of mineral matter, and above all of potash.

"We will extend the range of our observations. Lucerne has roots which penetrate deeply into the subsoil. It is from these under layers that it principally obtains the mineral matter, of which it requires a large quantity. Suppose that lucerne prospers whilst peas are weakly. What are we to conclude from this? That the superficial layers of soil are lacking in potash and phosphates, whilst the deep layers are provided with them; but if the two plants progress equally well, we know that the superficial and deep layers of soil are well provided with mineral matter." [2]

Farmers' Experiments.—Mr F. J. Cooke, Flitcham Abbey, Norfolk, in a paper read before the London Farmers' Club, on March 25, 1889, urged farmers to make trials upon their own land as to

[1] The best arrangement as to experimental plots in fields is to select so many drills if the crop is roots, or so many ridges or yards wide if corn or pasture, so that each plot may run from end to end of the field, and thus, as far as possible, embrace all the variations in the character and condition of the soil.

[2] *Artificial Manures.* G. Ville, 176-183.

the kinds and quantities of manures best suited to their farms. He stated that he had been doing so himself annually for some twenty years, and he was not aware of any other separate practice which had been so useful to him. The information he thus obtained had saved him much unprofitable outlay on manures which had formerly been unnecessarily or imprudently applied.

Mr Cooke's method of testing the wants of the soil and the crops is quite simple, and similar to that recommended by Ville,—namely, the use of the four necessary elements of plant-food—nitrogen, phosphoric acid, potash, and lime—*separately* and together, and as far as possible in the most economical forms,—one plot remaining unmanured, another having all the ingredients, whilst upon the other plots each ingredient is in turn omitted.

An interesting example of the value of experiments in discovering the manurial wants of separate farms, and of the unreliability of chemical analyses of soils for this purpose, is given by Mr Cooke. A dressing of 3 cwt. of nitrate of soda and 3 cwt. of superphosphate was applied to a plot of barley at Flitcham, upon which the crop failed. An adjoining plot got these manures, and in addition 2 cwt. of muriate of potash, and produced 54 bushels of barley per acre. Yet the soil of both the plots was found by chemical analysis to contain as much potash in the top foot of it as would be found in 3 tons per acre of muriate of potash. There was an abundance of potash in the soil, but it was not available to the barley. Hence, on this soil an application of potash was essential for profitable cropping, and no amount of other manures would succeed without it.

All this tends to show not only the importance of, but also the difficulties involved in, the question of manures and manuring. In arranging the dressings of manure to be applied, the farmer must consider the probable contents and condition of the soil, as well as the wants of the particular crop. He will endeavour, as fully as possible, to utilise the "reserve fund" of fertility in the soil, and aim in particular at having the crop provided with a supply of plant-food, which will not only be ample in quality, and present in an available form, but likewise contain in *due proportion* all the essential elements of plant nutrition.

Law of Minimum.—This due proportioning or balancing of the elements of fertility is a point of the utmost importance. It is illustrated by what is known as Liebig's law of minimum. Every soil contains a maximum of one or more, and a minimum of one or more, of the ingredients necessary for plant growth. Now the growth or produce of the plants on this soil is governed not by the combined quantity of all the ingredients present in the soil, but by the producing power of the essential ingredient present in the smallest proportion, no matter how small a part this deficient element may play in the economy of the particular crop. Again, let it be remembered that the strength of the chain is governed by the weakest link.

The object of manuring is to provide against deficiencies of this kind, and at the lowest possible cost to furnish the crops with a full supply of readily available well-balanced wholesome plant-food.

VARIETIES OF MANURE—FARMYARD DUNG.

In a description of the various commodities employed as manure, the first place naturally falls to *farmyard dung.* At one time the only kind of manure available, it is still, in this connection, the mainstay of the farmer. Its pre-eminence is gradually lessening, yet it will always be an important agent in maintaining the fertility of the farm. There are now many farmers who depend more largely upon artificial manures than upon dung. Upon the whole, however, "muck" is still the staple manure, and artificial fertilisers merely supplementary to it.

Variety in the Quality of Dung.—Farmyard manure consists of the solid and liquid excrements of farm live-stock, and of the litter provided to them. Except when made and kept wholly under roof, it also contains a considerable quantity of rain-water. Its manurial value depends upon the class of animals by which it is made, the age of these animals, the kinds and quantities of food supplied to them, the kind and quantity of litter employed, and the manner in which the manure is made and managed generally—whether well trodden, evenly mixed, the fermentation kept duly in check, and waste prevented.

In the chapter on the "Treatment of Farmyard Manure" (p. 501, Div. II.), information is given, not only as to the "making" of good and bad dung, but also as to the characteristics of the different kinds of dung. In this connection the succeeding chapter on "Liquid Manure" (pp. 514-529, Div. II.) should also be consulted.

The system of feeding is mainly responsible for the original quality of the dung. The feeding of draught-horses varies but slightly, so that farm-horse dung is comparatively even in character. With cattle—by which the great bulk of farmyard manure is made—the case is very different. All sorts of dietary are given to them; from very poor and scanty—such as will barely sustain the existing "condition" of the animal—to very rich and abundant, far beyond the power of the animal to assimilate. Then in one case the supply of litter, generally cereal straw, which has little manurial value (see tables on pp. 285-287, Div. II.), may form a much larger proportion of the bulk of the dung than in another.

Obviously, therefore, there must be many degrees of quality in farmyard dung,—a fact which farmers should keep carefully in view in considering how many tons of dung, and what supplementary manure, should be given to this field or that. Moreover, as we have seen, in pp. 501-513, Div. II., the original character of the dung may be greatly altered—improved or damaged—by the manner in which it is made, and treated generally. These considerations should never be lost sight of. One ton from a certain dung-heap may be worth two tons from another.

The information given on pp. 283-289, Div. II., as to the "manurial value" of foods, indicates how, and to what extent, the manurial value of dung may be affected by the food supplied to the animal. It has long been recognised that dung made by fattening stock is much more valuable than that made by store cattle, which are sparingly fed; yet, in practice, this fact does not always have due consideration.

What is said on pages 226-232, Div. I., as to manure in covered and open courts, should also be consulted here.

Manurial Value of Straw.—The straw of the cereal crops does not possess such high manurial value as is by many accorded to it. The constituents of fresh straw are for the most part insoluble, so that straw is of little use in the soil unless it is well rotted. Indeed, the principal value of straw in the making of manure is that it, in the first place, forms comfortable litter for the animals, and thereafter becomes a suitable vehicle for absorbing and holding in a manageable condition the solid and liquid excreta. From this it is apparent that the excessive use of straw as litter is imprudent and wasteful; for, while the bulk of the dung may be thereby greatly increased, there may be little more fertilising value than if one-third less litter had been supplied.

Composition of Dung.—From the foregoing it is of course obvious that the chemical composition of farmyard dung is liable to great variation. The following detailed analyses of samples of farmyard dung were made by Dr A. Voelcker.

Composition of *fresh* dung, composed of horse, cow, and pig dung, about fourteen days old:—

Water		66.17
*Soluble organic matter		2.48
Soluble inorganic matter		1.54
†Insoluble organic matter		25.76
Insoluble inorganic matter		4.05
		100.00
*Containing nitrogen .	.149	
Equal to ammonia	.181	
†Containing nitrogen	.494	
Equal to ammonia .	.599	
Total percentage of nitrogen		.643
Equal to ammonia		.780
Ammonia in a free state		.034
Do. in form of salts		.088

Composition of the whole ash:—

Soluble in water, 27.55 per cent.	Soluble silica .	4.25
	Phosphate of lime	5.35
	Lime	1.10
	Magnesia	0.20
	Potash	10.26
	Soda .	0.92
	Chloride of sodium	0.54
	Sulphuric acid .	0.22
	Carbonic acid and loss	4.71

Insoluble in water, 72.45 per cent.	Soluble silica	17.34	
	Insoluble silicious matter	10.04	
	Phosphate of lime	...	
	Oxide of iron and alumina, with phosphates	8.47	
	containing phosphoric acid		(3.18)
	equal to bone-earth		(6.88)
	Lime	20.21	
	Magnesia	2.56	
	Potash	1.78	
	Soda	0.38	
	Chloride of sodium	...	
	Sulphuric acid	1.27	
	Carbonic acid and loss	10.40	

The composition of *rotten* dung, mixed horse, cow, and pig dung, six months old, dark brown, almost black in colour, well fermented and short, is as follows:—

Water	75.42
*Soluble organic matter	3.71
Soluble inorganic matter	1.47
†Insoluble organic matter	12.82
Insoluble inorganic matter	6.58
	100.00

*Containing nitrogen	.297	
Equal to ammonia	.360	
†Containing nitrogen	.309	
Equal to ammonia	.375	
Total amount of nitrogen		.606
Equal to ammonia		.735
Ammonia in a free state		.046
Do. in form of salts		.057

Composition of the whole ash:—

Soluble in water, 18.27 per cent.	Soluble silica	3.16	
	Phosphate of lime	4.75	
	Lime	1.44	
	Magnesia	0.59	
	Potash	5.58	
	Soda	0.29	
	Chloride of sodium	0.46	
	Sulphuric acid	0.72	
	Carbonic acid and loss	1.28	
Insoluble in water, 81.73 per cent.	Soluble silica	17.69	
	Insoluble silica	12.54	
	Phosphate of lime	...	
	Oxides of iron, alumina, with phosphates	11.76	
	containing phosphoric acid		(3.40)
	equal to bone-earth		(7.36)
	Lime	20.70	
	Magnesia	1.17	
	Potash	0.56	
	Soda	0.47	
	Chloride of sodium	...	
	Sulphuric acid	0.79	
	Carbonic acid and loss	16.05	
		100.00	

Fresh Dung.—The comparatively small proportion of soluble, organic, and mineral substances in fresh dung accounts for its slow action compared with rotten dung. Insoluble matters are very large—of organic matters, ten times as great as soluble; and of mineral matters, three times as great as soluble. Fresh dung contains a mere trace of free or volatile ammonia, and but a trifling quantity of ammoniacal salts. The amount of nitrogen in fresh dung is inconsiderable. It is gradually liberated as the dung progresses in putrefaction, and is contained in the portion insoluble in water. Hence little nitrogen exists in fresh dung in a state to be assimilated by plants. The principal constituent of soluble ash in quantity is potash 37.26 parts, equal to 54.7 parts of pure carbonate of potash, also silicate of potash; and in the insoluble ash, lime, and in the soluble, phosphate of lime, 19½ per cent. Chemically, farmyard dung is a universal manure, because it contains *all* the constituents of our cultivated crops; and it is a perfect manure, because its constituents are in that state of combination favourable for the luxuriant growth of our crops.

Fresh and Rotten Dung.—Fresh dung contains considerably more potash than rotten, as also more phosphate of lime. There is more nitrogen in rotten than in fresh dung; rotten dung has less insoluble organic matter, and contains more insoluble inorganic matters than fresh. On the whole, weight for weight, rotten dung is richer in soluble fertilising constituents than fresh, and contains more readily available nitrogen, and therefore produces a more immediate and powerful effect in vegetation. The preference evinced by farmers for rotten over fresh dung is thus sanctioned by chemistry.

Open and Covered Court Dung.—Farmyard dung, kept under roof for three months, was found to have suffered little change in organic and mineral constituents in comparison with fresh dung, and the soluble and insoluble portion of the ashes was almost identical. Rotten dung exposed to the air in cold weather loses little substance, but in warm weather the loss may be considerable—principally in the soluble constituents, nitrogen and ammoniacal salts rapidly becoming exhausted. Fresh dung undergoes putrefaction rather than fermentation, the nature of which process consists in the gradual alteration of the original organic matters, and in the formation of new chemical compounds. Putrefaction is accompanied with evolution of heat; air and water are both requisite for putrefaction. If kept perfectly dry, organic substances remain unaltered for an indefinite period.

Fixing Ammonia.—Ammonia is generated in large quantities during the putrefaction of the nitrogenised constituents of dung. It is this free ammonia which is liable to be lost. Fortunately some natural provision is made for its conservation. The straw in course of putrefaction is, to a great extent, converted into humic and ulmic acids, which have a powerful affinity for ammonia, and which, therefore, to a certain extent, fix the ammonia as it is generated. These acids form, with potash, soda, and ammonia, a dark-coloured, very soluble compound. Hence the dark colour of the drainage of dung-heaps.

Dr Anderson on Dung.—The chemical remarks of Anderson on the analyses of Voelcker are worthy of attention by the farmer: "On comparing and examining these analyses, it appears that the differences are by no means great, although on the whole they tend to show, weight for weight, well-rotted dung is superior to fresh, *provided it has been properly treated.* Not only is the quantity of valuable matters existing in the soluble state materially increased, whereby the dung is enabled to act with greater rapidity, but, owing to evaporation and escape of carbonic acid, produced by the decomposition of organic substances, the proportion of those constituents which are most important to the plant is increased. This is particularly to be noticed in regard to the nitrogen, which has distinctly increased in all cases in which the dung has been kept for some time; and the practical importance of this observation is very great, because it has been commonly supposed that, during the process of putrefaction, ammonia is liable to escape into the air. It would appear, however, that there is but little risk of loss in this way, so long as the dung-heap is left undisturbed; and it is only when it is turned that any appreciable quantity of ammonia volatilises. It is different, however, with the action of rain, which soon removes by solution a considerable quantity of nitrogen contained in farmyard manure; and the deterioration must necessarily be conspicuous in rotten dung, which sometimes contains nearly half of its nitrogen in a soluble condition. . Well-made and well preserved farmyard manure will generally be found to differ comparatively little in value; and when bought at the ordinary price, the purchaser is pretty sure to get full value for his money, and the specialties of its management are of comparatively little moment to him. But the case is very different when the person who uses the manure has also to manufacture it. Though the manure made in the ordinary manner may, weight for weight, be as valuable as at first, the loss during the period of preservation is usually very large, and it becomes extremely important to determine the mode in which it may be reduced to the minimum. In the production of farmyard manure of the highest quality, the object to be held in view is to retain, as effectually as possible, all the valuable constituents of the dung and urine. In the management of the dung-heap there are three things to be kept in view: first, to obtain a manure containing the largest amount of nitrogen; secondly, to convert that nitrogen more or less completely into ammonia; and, thirdly, to retain it effectually."[1]

Other analyses of dung show from 65 to 80 per cent of water, from 0.40 to 0.65 per cent of nitrogen, and ash (exclusive of earth and sand) from 2.50 to 3.00; the ash containing from 0.4 to 0.7 potash and from 0.2 to 0.4 phosphoric acid per cent.

Fertility in a Ton of Dung.—Even greater variations than these are to be met with in the analyses of farmyard dung. The manurial value of dung is governed by the amount it contains of nitrogen, potash, and phosphoric acid. The quantity of these in one ton may *range* as follows:—

	lb.
Nitrogen	8 to 16
Potash	8 to 17
Phosphoric acid	2½ to 9

[1] Anderson's *Agric. Chem.*, 176-179.

A ton of first-class well-made farmyard dung, all kinds mixed, should contain the following, or thereby:—

	lb.
Nitrogen	12 to 14
Potash .	11 to 15
Soluble salts of phosphoric acid (equal to soluble phosphate of superphosphate) . .	8 to 9
Insoluble phosphates (as in bones)	10 to 13

Produce of Dung per head of Stock.—The quantity of dung produced by a given number of stock will vary with the class of stock, the amount of food consumed, the quantity of litter supplied, and the amount of rain-water admitted amongst the dung. Each farm-horse will make about 12 tons of dung in a year—producing about three-fourths of its food in manure. In stalls or covered courts, full-grown feeding cattle will each produce from 10 to 12 tons of dung in the year, allowing, say, from 10 to 20 lb. of litter to each per day. In open yards the weight might be about 2 tons per head more. The solid excreta of an ox has been estimated at from 50 to 65 lb. daily, and liquid from 65 to 95 lb. daily. The above quantities of manure made by stock would thus be still greater if the whole of the urine were incorporated with the solid excreta and litter.

Fresh and Rotten Dung.—In reference to the effects produced by the rotting of farmyard dung, Dr A. Voelcker says:—

"Direct experiments have shown that 100 cwt. of fresh farmyard manure are reduced to 80 cwt. if allowed to lie till the straw is half-rotten; 100 cwt. of fresh farmyard manure are reduced to 60 cwt. if allowed to ferment until it becomes 'fat or cheesy'; 100 cwt. of fresh farmyard manure are reduced to 40–50 cwt. if completely decomposed.

"This loss not only affects the water and other less valuable constituents of farmyard manure, but also its most fertilising ingredient, nitrogen. Chemical analysis has shown that 100 cwt. of common farmyard manure contain about 40 lb. of nitrogen; and that during fermentation in the first period 5 lb. of nitrogen are dissipated in the form of the volatile ammonia; in the second, 10 lb.; in the third, 20 lb. Completely decomposed common manure has thus lost about *one-half* of its most valuable constituents.

"According to other experiments, the loss on the weight of fresh, common, mixed farmyard manure, at different periods, approximately, is as follows:—

"10 cwt. of dry food and straw yield—

	cwt.
Of recent dung	23 to 25
At the end of six weeks .	21
After eight weeks	20
When half rotten	15 to 17
When fully rotten .	10 to 13."

Character and Uses of Farmyard Dung.

A Complete Manure.—Farmyard manure contains all the elements necessary for plant-growth, and is therefore a *complete manure.* If applied in sufficient quantity, it will, without any extraneous aid, maintain fertility even under an intense system of cropping.

Mechanical Uses of Dung.—As a manure, dung is valuable, not only for its chemical but also for its mechanical properties. Referring to this point, Sir John Bennet Lawes says that by reason of its bulk and the quantity of organic matter it contains, it serves to render the soil more open and porous, and so enable it not only to retain more water in a favourable condition, but also to absorb and retain more of the valuable constituents of the manure, and so arrest the passage of them in solution into the drains. Further, by the gradual decomposition of the organic matter of the dung, the pores of the soil become filled with carbonic acid, which probably serves to retard the oxidation of the ammonia into the more soluble form of nitric acid, in which it would be more liable to be washed out and lost by drainage. From these facts, Sir John considers it will be readily understood how it is that dung is more lasting in its effects than the more active artificial manures.[1]

It is well known that, by repeated applications of farmyard dung, stiff clays have been rendered more friable. And its mechanical influence on such soils is more effective when the dung is applied in a rank state,—that is, before the straw it contains—or rather, the straw which contains the manure,—has become thoroughly rotten.

[1] *Jour. Roy. Agric. Soc. Eng.*, ii. 8, 1875.

Dung Heating Soil.—Then it is equally certain, though not so generally recognised, that a heavy dressing of rank dung benefits the soil by raising its temperature. "The temperature of the soil is affected by other causes than the sun's rays. Decaying vegetable matter is a source of heat, as evidenced by the high temperature arising from the fermentation of dung. Farmyard manure thus supplies heat to the soil from two different sources, while it helps to retain much valuable manurial ingredients, which, in a more purely mineral soil, would be washed away."[1]

Lasting Influence of Dung.—The great lasting influence or "staying power" of farmyard manure is an important factor in practical agriculture. For the full understanding of the extent, advantages, and risks of this enduring power and slow-acting characteristic of farmyard dung, it is necessary to refer the reader to the results of the Rothamsted investigations, as described by Mr Warington, under the heading of "Rothamsted Experiments" (pp. 135-169, Div. III.) See particularly what is said there as to the accumulation of fertility in soil heavily dressed with dung (pp. 153-167); as to the lower immediate efficiency of the nitrogen in dung, as compared with a corresponding amount of nitrogen supplied in ammonia salts or nitrate of soda (pp. 139-146); as to the loss of the nitrogen of dung in nitrates formed during autumn and winter, and washed away in drainage-water (pp. 154-168); and as to the loss of surplus nitrogen—that is, of available nitrogen not immediately assimilated by a growing crop—by evaporation in the form of nitrogen gas (pp. 166-168).

Similar results are shown in the Rothamsted barley experiments. For twenty years up to 1871, 14 tons of dung were applied every year to one plot for barley, and the average produce was 48¼ bushels. No further manure of any kind was applied to this plot, upon which barley was continued, with the result that the average yield for the next twelve years fell off by about one-third. It was estimated that of the 4000 lb. of nitrogen per acre supplied to the soil in the 14 tons of dung for twenty years, only about 14 or 15 per cent had been recovered in the increase of crop. From this it was calculated that if all the remaining 3400 lb. of nitrogen had been stored up in the soil, in a form as available as that which had already been used in the crop, this plot should have been able for 150 years to produce an average of 48 bushels of barley per acre per annum. Yet with the stopping of the annual dressing of dung, the crop showed a very marked decline.

How is this decline to be accounted for? There had, no doubt, been some loss of nitrogen in drainage, and some may have been volatilised. But, upon analysis, the soil was found to contain a great accumulation of nitrogen, as well as other constituents. This great accumulation of nitrogen and other constituents of the dung, if it had remained in the soil in a *sufficiently available* form, would have supplied the crop with all the food it could absorb for many years. Why, then, does this abundant residue give such a poor account of itself? In reference to this important question, Dr Gilbert remarks "that it is only the comparatively small proportion of the nitrogen of farmyard manure which is due to the liquid dejections of the animals that is in a readily and rapidly available condition; whilst that due to more or less digested matter passing in the fæces is more slowly available, and that in the litter remains a very long time inactive."

The potato experiments at Rothamsted afforded equally striking evidence of the slow recovery of the nitrogen supplied in dung. Fourteen tons of farmyard manure, applied every year for six years, yielded in potatoes only 6.4 per cent of its nitrogen; while in the next six years, the same crop every year, without any further dressing of manure, recovered from the residue only 5.2 per cent more—that is, only 11.6 per cent in the course of the twelve years. In other words, at the end of the twelve years there was still about 88 per cent of nitrogen supplied in the dung unrecovered by the crop.

An Old Custom Questioned.—All these are considerations which—although subject to modifications under ordinary farm practice—should have studious attention from farmers. They unquestion-

[1] *Mark Lane Express*, 1889, p. 412.

ably suggest that in the past farmers have placed rather too much faith in farmyard manure—that the old custom of manuring only once in a rotation—of applying with the root-crop a heavy dressing of dung, in the belief that what of the manure the roots do not appropriate will remain in the soil and be available for the use of the succeeding crops—may, in certain circumstances, be found to be seriously mistaken.

Loss of Residual Manure.—The unused portions of the manure unfortunately do not, in their entirety or nearly so, remain in the soil available for future crops. Much of this residue — of the most valuable portion of it too—is now found, under certain circumstances, to escape through channels which were formerly unsuspected as means of loss. The discovery of the great loss of excess or residual nitrogen by the washing away of nitrates in drainage-water, and by evaporation as nitrogen gas, throws new light upon the theory and practice of manuring, which farmers cannot afford to disregard.

Soil an Unreliable Custodian of Manure.—In times past we have placed too much faith in the soil as the custodian of costly manure. While nourishing a growing crop, the soil is commendably faithful to its trust, and does not then readily part with its available plant-food, except to the crop itself. But the moment the crop is removed, the soil loses retentive power, and if the conditions favourable to the washing away or volatilising of nitrogen are present, loss of residual nitrogen is liable to set in. Moreover, results obtained at Rothamsted seem to suggest the question whether some portion of the nitrogen which accumulates in the soil may not, in certain circumstances, undergo some sort of reversion by which it is rendered more slowly instead of more readily available to the crops.

Superiority of Dung Questioned.—Now nitrogen is the most costly of all the elements of manure. It is therefore obviously desirable that it should not only be drawn from the cheapest sources, but should also be supplied to the soil so as to guard as far as possible against any portions of it being lost in the manner just described. At first thought, one might say that the best plan would thus be to apply nitrogen in a readily available form, just when it is required by the crop, and only in such quantity as may supply the wants of that particular crop. This is, no doubt, sound enough theoretically, and may often be carried into practice with the best possible results.

But such a course will not, as a rule, be practicable. It would practically exclude the use of farmyard manure; and while it would be unwise to overlook or disregard the important results obtained under certain conditions at Rothamsted, it would be a still more serious error now to hastily jump to the other extreme, and unreasonably depreciate or discredit the great value of the fertilising materials in the solid and liquid excreta of farm animals.

Practical Conclusions. — The practical points to be kept in view are, that from the investigations as to the behaviour of nitrogen in the soil, it is seen that the enduring character of farmyard manure is not an unmixed advantage to the rent-paying farmer; that the excess nitrogen accumulated in the soil by heavy dressings of farmyard manure is, in certain circumstances, liable to serious losses by drainage and evaporation, and cannot, therefore, in all cases be to the *full extent* depended upon for the nourishment of future crops; that, therefore, the practice of so entirely or mainly trusting to heavy dressings of dung at long intervals for the production of profitable crops is neither reliable nor economical; and that the loss of nitrates from land which is rich in residual nitrogen, may be reduced to a minimum by having the soil covered with vegetation throughout the entire year, or in cold northern districts by having it bare only in the winter months when the temperature is usually too low for the formation of nitrates to proceed in the soil.

Vegetation Preventing the Loss of Nitrates. — For the last-named object many farmers, especially in England, sow some forage crop, perhaps rye, soon after the removal of a cereal crop. This not only engages the attention of unused nitrogen, thus preventing the washing away of nitrates, but most likely affords a useful feed to sheep in the course of the winter, and likewise further enriches the soil when ploughed down in spring.

Cold Weather and Loss of Nitrogen.—The above safeguard, to be sure, cannot be provided in the cold regions of the north, but then there is, fortunately, much less necessity for it there. It is in the form of nitrates in which nitrogen is washed away in drains. Nitrogen is transformed into nitrates by the operations of myriads of living atoms, commonly called *bacteria*. In very cold weather, with the temperature at or near to freezing-point, these wonderful little atoms of life seem, with commendable beneficence, to relapse into idleness; so that at this cold season of the year the northern farmers may with tolerable, if not complete, immunity from loss of nitrogen, till their land and leave it exposed to the action of frost, as has been their wont from time immemorial.

Making Dung or Selling Crops.—We are not to discuss fully the question as to whether farmers should endeavour to make as much dung as possible, or should sell produce and purchase artificial manures. Local circumstances vary so much that the conditions which determine the best system in one case may not apply equally to another. Much will depend on the locality and character of the holding, and the tastes of the tenant—whether favourable to the breeding and feeding of stock, or the growing and selling of crops; also upon the fluctuations of market prices — especially as to the relative prices of beef, feeding-stuffs, and litter, on the one hand, and of artificial manures on the other.

Farmers now less Dependent on Dung.—With the abundance of excellent artificial manure in the market, and with the great advance that has been made in the investigation and elucidation of the principles which govern economical and successful manuring, farmers are now much less dependent upon farmyard manure than in former times. They have no need any longer to consume their crops on the farm for the sake of providing manure with which to restore fertility to the soil. This may now be accomplished cheaply and efficiently by the use of other manurial substances, of which exhaustless supplies are at hand. It is unquestionable, therefore, that dung, as a source of plant-food, has been depreciated in its relative intrinsic worth, and in its importance as a factor in agriculture; and that it should not count for so much on the credit side of the feeding account as it has often done in times gone by.

Dung not likely to Diminish in Production.—But farmyard manure is a necessary accompaniment of the rearing and feeding of stock, and there is little likelihood that, with the growing importance of the live-stock industry, there will be any falling off in the production of farmyard manure. In all probability it will be of a more concentrated character than in former times. Straw is now being turned to better purpose as food for stock, or in other ways than as litter for cattle. The animals may therefore be littered with smaller quantities of straw, or with other substances less bulky, such as peat-moss litter. But while the dung may thus be more concentrated, and less bulky per head of stock than it would be with freer use of straw as litter, it is not likely that the amount of fertilisers annually available in the form of farmyard manure for application to the soil will be less in the future than it has been in the past.

A Word for Dung.—Although farmyard manure is not likely to lose its hold upon the affections of British farmers, it nevertheless seems desirable to remind the reader that in considering the practical lessons to be drawn from the Rothamsted experiments with dung and other manures, it should be kept in view that these experiments were not framed as a guide to farmers in pursuing the ordinary routine of farm practice. The scientific conclusions arrived at are undeniably of great value to farmers, but it would be imprudent to attach to them a significance which they were not intended to and do not possess. If the course of cropping and systems of tillage pursued at Rothamsted had been similar to those observed in the rotations followed throughout the country, the dung would, in all probability, have given a much better account of itself. In particular, it is probable that the accumulation of inert nitrogen would have been roused to greater activity and usefulness, so that under a rotation of crops, with the thorough tillage necessary for roots, the influence of the residue of the dung would have been more marked than it has been upon the continuous growth of the same crops on the same respective plots.

Professor Wrightson on Dung.—Professor Wrightson is a strong advocate of the superiority of farmyard dung over artificial manures. As to the reasons why he thinks farmyard dung should hold a strong position in the estimation of the British farmer he says:—

"The first reason, no doubt, is what has been already advanced—the general composition of dung. A great many science students stop here. When they are asked why farmyard manure is a more potent and more valuable manure than many artificial fertilisers, they say it is because of its general composition. But there are a good many other reasons beside, one of which is, no doubt, its effect upon the mechanical condition of the soil—a subject which we have already had before us, and which it is therefore not necessary to further enlarge upon. Then, in the third place, there is the reaction of the carbonic acid gas which is evolved from farmyard dung, upon the mineral matter in the soil. I do not doubt in the least that it digests the soil.

"I do not doubt that Jethro Tull was perfectly right when he said farmyard manure prepared plant-food. No doubt it does; it is the source of carbonic acid gas, and we know that that gas in watery solution reacts on the mineral matter in the soil with great effect.

"Now take another reason. Farmyard dung is rich in nitrogen; that alone places it on a superior basis to most artificial manures. It is rich in nitrogen in a state of organic combination, from which it is liberated slowly by the process of decay, that liberation of nitrogen being known as nitrification. Performed under favourable temperatures, with access of air, and no doubt also assisted by the agency of certain bacteria which work in the soil and produce the peculiar fermentation necessary, this nitrification of farmyard manure in the soil is arrested at freezing-point. It proceeds very slowly at low temperatures, and with accelerated speed at higher temperatures. Especially does it take place freely during the summer months, when vegetation is most luxuriant.

"Hence farmyard manure subjected to gradual decay yields up its materials, especially nitrogen oxidised into nitrates, at that period of the year when they are wanted. It is worth notice that the same forces which liberate nitrogen must also liberate the mineral and other constituents of farmyard dung, gradually and as required."[1]

ARTIFICIAL AND SPECIAL MANURES.

In addition to farmyard manure there are the various artificial or special manures, which supply one or more of the ingredients necessary for the growth of plants.

Classification.—These are classified in accordance with the proportion of the more valuable or abundant constituents present in them, and they are accordingly divided into the following groups: nitrogenous, phosphatic, potassic, calcareous manures. The liming of land will be dealt with in a subsequent division of the work.

Peruvian Guano.

The chief of the nitrogenous manures is guano in its various forms.

In the year 1839, some twenty barrels of a red or light-brown substance were imported into Liverpool from one of the islands which lie adjacent to the Peruvian coast. The substance had been in use as a manure amongst the natives of Peru for many centuries. It became known as guano, a term which takes its origin from the Peruvian word "huana," dung or manure, which consists of the accumulated droppings of sea-fowls during long periods of time.

As the temperature stands very high in those regions (lying between 13° and 21° south latitude), these bird-droppings soon dry; and as the climate is almost a rainless one, much of the soluble ingredients are preserved.

The resulting manure is a complex one, possessing a composition similar to farmyard manure. After experiment, and when the merits of the guano were

[1] *Principles of Agric. Prac.*, 152.

brought home to the mind of the farmer, the demand for it rose very quickly.

We can form some idea of the estimation in which this manure was held by the Peruvians from the proverb, "Huano, though no saint, works many miracles;" and from the fact that, under the government of the Incas, the killing of birds which frequented the islets in which guano deposits were formed, was made a capital offence.

When the exportation attained considerable proportions, the Peruvian Government, by exercising its lordship of the soil, created a monopoly of the sale of guano, which was sold at so much per ton irrespective of quality. The first contract made by British merchants was in 1840 or 1841. They made it a condition of the contract that for a period of four years they would have the exclusive right to export from the island of "Chincha" 20,000 tons of guano yearly.

The increasing demand and the monopoly, which raised the price of guano above its real value, together with the fact of the richer deposits becoming exhausted, led to guano being sold on analysis. This arrangement is still in existence; and as a consequence, it is customary for sellers to attempt to sell cargoes upon "official analysis."

From the year 1850 to 1870 there was a large increase in the demand for guano, as many as 200,000 tons having been imported in a single season. The quality of the Peruvian deposits was yearly deteriorating, and accordingly other coasts were explored, resulting in the discovery of deposits in the African coast which lies between these latitudes. Ichaboe was the richest, and Mejillones the poorest. These two guanos are fair representatives of what is known in the trade as high-class and low-class guanos. The one contains a large percentage of ammonia and a low percentage of phosphates; the other a high percentage of phosphates and a low percentage of ammonia or none at all.

Composition of Guanos.—The following may be considered as an average analysis of these guanos, to which is added the analysis of "Pabellon," which is now offered in the market, and which will be seen to be very much lower than the others in quality:—

	Peruvian.	Ichaboe.	Mejillones.	"Pabellon."
Phosphates	24.00	10.86	71.16	32.38
Potash	2.00	2.00	2.00	2.10
Ammonia	17.00	13.00	.75	9.39

These analyses show Peruvian, Ichaboe, and Pabellon to be rich in nitrogen, and are therefore called nitrogenous or high-class guano. To these may be added "Punta de Lobos," "Huanillos," which are somewhat richer in phosphates and poorer in ammonia.

Mejillones is purely phosphatic, and is a low-class guano. The latter term, however, embraces guanos which contain anything under 4 per cent ammonia and over 40 per cent phosphates. The absence of ammonia is due to these guanos being deposited in climates where frequent and heavy rains occur. These heavy rains supply the moisture necessary to set up fermentation in the guano, and they wash away the soluble salts and ammonia which are the products of this fermentation.

Fish Guano.

Formerly there was great loss of fish-offal. In many cases no attempt was made to utilise this offal, which, besides the heads and entrails of all the larger fish, and the cleanings of the herring-curing stations, often included large quantities of entire herring which the curers were unable to manipulate. Neighbouring farmers bought large portions of this offal; but frequently they could not use up the supplies, so that many boat-loads of fish were emptied into the sea as being the only means of getting rid of the material.

Such excessive waste could not long continue in the light of the nineteenth century. At length, at the various fishing-stations, factories were erected in which the offal is submitted to the action of steam at a high pressure, and afterwards it passes through the hydraulic press, by which means the greater portion of the oil is extracted. The whole mass is next passed through the disintegrator, and thus is produced the article known as *fish guano.*

Composition of Fish Guano.—The composition of fish guano varies from 8 to 12 per cent of ammonia, and from 15 to 30 per cent of phosphates. The fish guano in the market seldom contains more than about 9 or 10 per cent of ammonia and 16 to 20 per cent of phosphates. But there is also present from 3 to 6 or 8 per cent of oil, which detracts from the value of this manure, as the oil retards the dissolving of the elements of plant nutrition which the fish guano contains.

Frey Bentos Guano.

In the manufacture of Liebig's extract of meat there is a large residue of flesh, bone, and muscle. These substances are mixed together, dried, and ground, the product being a flesh guano, if we may so term it. In other instances a large supply is obtained from diseased meat and animal refuse of all kinds.

Composition. — The composition of flesh guano varies from about 8 to 13 per cent ammonia, and from about 10 to 20 per cent phosphates.

Dissolved Guanos.

The unequal character of natural guano in recent years has led to its being treated (some would say spoiled) with sulphuric acid, and its composition being otherwise altered by the introduction of ammonia from sulphate of ammonia, dried blood, or other organic source. This process dissolves the phosphates and organic matter, making these more soluble, and the nitrogenous matter raises the percentage of ammonia, so that an active manure is the result. This commodity is known as Dissolved Peruvian Guano.

Composition. — Dissolved Peruvian guano is usually in good mechanical condition. It seldom contains more than 8 per cent ammonia, and perhaps from 20 to 23 per cent soluble phosphates, and 3 or 4 per cent insoluble phosphates.

Dried Blood, &c.

Dried blood, horn-dust, shoddy, and other waste products from the shambles or factory, may all be treated as insoluble nitrogenous substances, coming into action slowly. They contain from 5 to 16 per cent of ammonia, but no other fertilising matter of much importance. They are used principally in the manufacture of dissolved and compound manures, and contribute to the percentage of ammonia in these.

Nitrate of Soda.

Nitrate of soda, otherwise known as Chili saltpetre or cubic nitre, is the most abundant and best known of these salts.

This salt is a natural product of the soil in tropical climates, and as to its formation, several theories, less or more different, are entertained. A full description or discussion of these theories need not be attempted here. Some hold that it is made from the action of water, impregnated with soda salts upon guano. Others attribute its formation to seaweeds, which, by their decay, have given rise to nitrate of lime, which reacted upon sulphate of soda, the products being nitrate of soda and sulphate of lime. It is supposed that these beds were at one time isolated lagoons—isolated by volcanic action. The sea-water on its evaporation would leave a large salt deposit, thus furnishing the source of the large quantity of soda salts found in these nitrate beds. The lime would, according to this sea-weed theory, be supplied by sea-shells, &c.

The chief sources of supply are Chili, Peru, and Bolivia, where it occurs in beds varying from 10 inches to 16 feet in depth, sometimes quite near the surface, but generally covered by several feet of a layer known as "Costra." The regions in which nitrate of soda is found are quite destitute of vegetation, and there is often a period of several years without rain. These beds lie in the Pampas known as "Los Salinas," which is over 40 leagues in extent, and literally covered with beds of nitrate of soda.

The supply may be looked upon as almost inexhaustible. In its native state it is mixed with impurities, notably chloride of sodium (common salt) and sulphate of potash, soda, lime, &c. But before exportation it undergoes a process of refining which renders it comparatively pure, 5 per cent being about the amount of impurities remaining in it.

Nitrate of soda, when first introduced

as an artificial manure, came into great repute amongst farmers as a fertiliser. Its high price, however, and the lack of correct views as to its action and unsound mode of application, brought it into such ill favour that on some estates its use as a manure was in certain circumstances prohibited.

In recent years, however, with more enlightened views as to its character and action, a steady increase in the demand has arisen. Indeed this salt is to a large extent, as a source of nitrogen, taking the place of that now more variable commodity Peruvian guano. We find that in the year 1880, 50,000 tons of nitrate of soda were imported, while in 1887 the imports of it exceeded 110,000 tons. It is likely, indeed, that the output of nitrate of soda will soon reach a million tons annually. At the present time nitrate of soda is the cheapest source of nitrogen in the market, and has become the most important of the artificial manures. It usually consists of 95 per cent pure nitrate of soda, which is equal to about 19 per cent of ammonia.

Nitrate of Potash.

This salt is much more valuable than nitrate of soda, both commercially and from an agricultural standpoint. Nitrate of soda supplies only one of the ingredients of plant-food, whilst nitrate of potash provides two—nitrogen and potash, —and is a valuable manure where applied to soils poor in clay and where no farmyard manure has been applied.

Nitrate of potash has been imported from India for many years, it being the nitre or saltpetre of commerce. The source of this Indian nitrate of potash is believed to be human urine which had at some time been poured upon the soil, these nitre-beds being found near the sites of ancient cities. Until lately its high price prevented farmers from using it as a manure.

It is, however, produced by artificial means, which is of interest to farmers, as seen in the nitre-beds or saltpetre plantations which originated in France during the last century so as to obtain a supply of nitre for the manufacture of gunpowder. The manner in which this nitre is produced ought to be studied by every farmer, as he is in many instances, perhaps unknown to himself, producing this salt in the soil of his farm.

Forming Nitre-beds.—A brief description of how nitre-beds are formed will place the matter clearly before our readers. A quantity of fertile loam is procured, and with it is incorporated highly nitrogenous organic matter—such as blood, flesh, liquid manure, stable manure, &c. To this is added chalk or old mortar-lime, and the whole mass turned over once or twice, after which the soil is washed and the water evaporated, when the residue is found to be crystals of nitrate of potash.

The chemical changes which here take place are as follows: The decay of organic matter is hastened by the lime, and produces nitric acid. Ammonia is produced, and becoming oxidised it is converted into nitric acid, which combines with the lime in the first instance, and afterwards with the liberated potash, and thus is evolved the nitrate of potash.

Nitrification.

Theory of Nitrification.—The latest theory in connection with nitrification is that organic matter, when it is allowed free contact with the air and moisture within certain ranges of temperature, undergoes changes which break it up into simple bodies. This result is produced by the presence of myriads of minute organisms termed "bacteria" —the *Micrococcus nitrificans* of Van Teighern, and other forms of bacteria. These living bodies feed upon the nitrogenous matter, and increase in numbers at a rate of which we can have but little conception. Every fertile soil, therefore, becomes the home of countless millions of these living organisms which carry on the work of nitrification, so that, as Professor Cohn tersely puts it, "Putrefaction is the concomitant not of death but of life."

Conditions which favour Nitrification.—The conditions necessary for the life and development of the nitrification ferment are,—(*a*) temperature above 40° Fahrenheit and under 130° Fahrenheit—most favourable temperature, 100° Fahrenheit, development at that temperature being as great in a few days as in months at a lower; (*b*) a certain amount of moisture; (*c*) presence of organic matter, mineral constituents of plant-food, carbonate of lime, and a plentiful supply of oxygen. Any excess of putrefying organic matter in a soil is against nitrification. It is found to be most active near the surface of the soil; it is not found much below 18 inches. Strong sunlight is not so favourable as darkness. The bacteria are easily killed by poisons, such as ferrous sulphate of iron, coal-tar, and sulphuretted hydrogen.

Hellriegel's Theory.—A still further development in the theory of the formation of nitric acid has been recently announced by a Continental *savant* named Hellriegel, who by careful observation, and a series of experiments on the manner of growth of legumes or pod-plants, has arrived at the conclusion that the excrescences or warts found on the roots of these are largely composed of bacteria, or fungoid matter, which have the power of changing the inert nitrogen of the atmosphere into the active form, as seen in nitrates or ammonia.

There appears to be a wide difference between the organisms of this order and those present where organic matter is in process of decay, as the latter can work only upon organic nitrogen, and break it up into simpler forms. It would be unsafe as yet to draw definite conclusions; but if this discovery is confirmed by further research, there can be no doubt it will lead to a considerable change in the system of cropping and manuring. The preceding will, at all events, serve to suggest the reason why a big crop of wheat generally follows a heavy crop of clover.

Sulphate of Ammonia.

Until recently, the chief source from which sulphate of ammonia was obtained was a by-product from the distillation of coal in the manufacture of gas. The ammonia set free is absorbed in water at a low temperature, which, on being heated by steam, gives off the ammonia, which is received in vessels containing sulphuric acid. These enter into combination, and sulphate of ammonia is the result. Pure samples contain from 22 to 25 per cent of ammonia. Another source of supply, which appears to be almost without limit, is obtained in the manufacture of pig-iron into steel, but perhaps the largest source of sulphate of ammonia is that obtained by the conversion of shale into paraffin-oil. The production has been largely increased by, if it has not been altogether due to, the introduction of the retort, invented by Young and Beilby, by the oil companies into their works. The process by which the sulphate is produced is similar to that carried out at the gas-works.

The preceding are the chief nitrogenous manures which are at present marketable commodities. Other substances might be mentioned, but they are either too expensive for use as manures, or contain their organic matter in such insoluble compounds as to be practically worthless.

Characteristics of Nitrogenous Manures.

There are a few points in connection with manures which should be carefully considered by farmers, so that they may be guided to a wise selection of manures to suit their varied circumstances as to soil, climate, and crop.

Essential Points.—It should in particular be borne in mind, (1) that the solubility of a manure depends on the minute division of its parts; (2) that the greater the solubility, the quicker its action; (3) that the shorter the time a crop occupies the ground, the more abundant and the more soluble must be the manure; and (4) that the rate of the growth of a crop ought to indicate the kind of manure, and the best state in which to apply it.

If these points are kept in view, the classification of manures in relation to their activity, and their action on the crop and in the soil, will be comparatively easy.

Slow and Active Manures.—A manure may, however, be perfectly soluble and yet not be available to the plant. It depends on the form in which its elements are combined whether the plant will absorb it or not.

For instance, nitrate of soda and sulphate of ammonia are equally soluble salts, but both are not alike available for plant-food. Nitrate being a compound of nitric acid and an alkaline base, is readily absorbed and elaborated into the tissues of the plant; whilst, at any rate to most plants, sulphate of ammonia is not available until the ammonia absorbs oxygen, and is converted into nitric acid. The latter, therefore, does not come into action so quickly, and ought to be applied to the land before the plant is ready to absorb it. Nitrate of soda, on the other hand, is most economically applied after the plant has developed its leaf-surface to a greater or less extent.

Assimilation of Ammonia by Plants.—It is considered by some to be too sweeping an assertion to say that ammonia is not in any case available to plants until it is converted into nitric acid. It is admitted that most plants assimilate their nitrogen in the form of nitrates; but that some plants, more especially at certain periods of growth, have the power of assimilating their nitrogen in the form of ammonia would seem to be indicated by certain experiments by Lehmann. It is pretty generally admitted that the leaves of plants have the power of absorbing carbonate of ammonia from the air.

Action of Nitrate of Soda.—Nitrate of soda, as will be seen further on, is feebly retained by the soil, and should therefore be applied only to supply the wants of the crop then growing. The surplus will find its way to the subsoil, and may escape in the drainage-water. It exhausts the soil more quickly than any other manure, if the soil is unaided by the application of other manures. The reason of this is, that its action in the first instance tends to increase the leaf-surface of crops, which therefore make larger demands upon the soluble constituents of the soil, resulting in a heavier yield per acre. But if care is taken to have the soil sufficiently furnished with the other elements of plant-food, this exhausting influence of the nitrate may be effectually counteracted.

The turnips and other roots produced from nitrate of soda are light in weight, porous and inferior in feeding qualities, and are apt to decay when touched by frost. In a dry season, nitrate of soda gives better results than sulphate of ammonia, and increases the produce of straw, but produces light grain. When applied to grass, nitrate of soda checks the growth of clover, which, it would seem, dislikes the presence of an acid, although the acid is of great benefit to plants of a different order.

Action of Sulphate of Ammonia.—Sulphate of ammonia being slower in its action—see above—gives more time especially for roots to grow, and on this account the roots grown on land to which sulphate of ammonia is applied are often denser and heavier, and of better feeding qualities than where nitrate of soda has been applied. This is true, although the *direct* action of the two is identical, and chiefly confined to the shaws, the roots being injured in keeping and feeding qualities by an excessive dressing of either.

It has been shown by experiment that sulphate of ammonia improves grass both in quantity and quality.

Nitrate of Soda and Sulphate of Ammonia Compared.—We have seen that sulphate of ammonia contains considerably more nitrogen than nitrate of soda, the most general proportion being about 13 in the former to 10 in the latter. Experience, however, has shown that the nitrogen in the nitrate of soda is the more effective, producing at Rothamsted and Woburn about 14 per cent more barley, and from about 5 to 25 per cent more wheat, than sulphate of ammonia; while, when applied with potash salts and phosphates to grass-hay and potatoes, similar results were obtained. When applied alone, the nitrate of soda was far superior to the sulphate of ammonia. With mangels the evidence in favour of nitrate of soda has been still more striking. It may thus be taken as fully established, that although sulphate of ammonia may contain nearly one-third more nitrogen than nitrate of soda, it is not, as a rule, worth to the farmer more than from one-tenth to one-eighth more money per ton.

Guano, when of fairly good quality, gives better results than either nitrate of soda or sulphate of ammonia.

Excessive Nitrogenous Applications Injurious.—The excessive application of nitrogenous manure tends to increase the percentage of nitrogen and diminish that of phosphoric acid in the composition of plants. This fact leads to wide issues; for the relation between the soil and plant is in no way closer than that between plants and animals. From this cause we have weed and diabetes in horses, and, where phosphates are deficient, rickets, rotten teeth, and late dentition, &c., &c.

Nitrogenous Salts are not suited for grain crops when applied alone, as the tendency is to produce straw at the expense of the grain. But when these are mixed with phosphates, excellent results are obtained.

Slow Manures for Slow Crops.—The period of time during which the crop occupies the ground has a considerable influence upon the economical use of soluble manures. Wheat takes often seven to nine months to mature, and during that period will have plenty of time to use up the soil constituents which are slowly soluble. Barley, on the other hand, is often harvested in four months or less; so that this cereal, being a shallow-rooted plant, will require readily soluble manure in greater abundance. For this reason, top-dressing once or twice with any of the more soluble nitrogenous manures, mixed with superphosphates, would give the best results; for it must be kept in view that crops can take up nitrates only when soluble phosphates and potash are present.

Action of Guano.—Guano is both a quick and a slow acting manure. The ammonia present in guano is to the extent of one-third or more in the form of salts which are readily soluble; the other portion is in the form of compounds more or less soluble. Its phosphates are of secondary consideration; but when guano of good quality can be obtained, it is undoubtedly the best manure in the hands of the farmer—that is, next to farmyard manure. Its use has now become limited by its high price and very variable composition.

Horn, Dried Blood, Shoddy, Wool-waste, &c., are very slowly acting manures, and are, in consequence, more fitted for pasture-land than for quick-growing crops. But in a dry season they may prove as effective on the root crops as the more soluble forms. They are used chiefly to fortify dissolved manures.

Power of Soils to retain Manures.—In connection with the more soluble manures, one should not overlook the fact that some soils have a greater power of retaining manures than others, and that some manures part with one or more of their elements more readily than others. The power of a soil to retain manure was at one time thought to be a mere physical property pertaining to it, but later research has modified that opinion. Mr Way, in the *Journal of the Royal Agricultural Society of England*, clearly proves by experiment, that when solutions of the various salts are filtered through a layer of earth, and the solution, after filtration, is analysed, it is found to have lost all or nearly all the substances which it held in solution—it being the base rather than the acid which the soil had the power of retaining. This affinity is greater in some soils than in others, the following being the order: arable soil—clay, peaty, calcareous, sandy. It has also been found that the soil has a greater power of retaining some manures than others, the following being the order, those having the greater affinity being placed first: ammonia, potash, magnesia, lime, soda.

In explanation of this, Mr Way advances the following theory: In soils there are double silicates of lime and alumina. If potash be brought into contact with this double silicate, it replaces the lime; sulphate of lime and the double silicate of potash and alumina are produced. Silicate of alumina combines readily with ammonia, and least so with soda, &c.

Others, again, maintain that the oxide of iron, which is abundantly present in most soils, absorbs the ammonia. Mr Warington also finds that this oxide acts upon superphosphates. The soluble phosphoric acid may also be retained by recombining with lime and forming a slowly soluble salt.

Conserving Manures in Soils.—All agree, however, that the soil has little or *no power of retaining nitrates* in any combination. We must therefore look to some other means to preserve this valuable manure. The growth of catch crops has been recommended for this purpose. But this is impracticable in many instances, such as in ploughed land preparatory to the turnip crop. The work of the farm must go on in a regular manner, and the leaving of the fallow unploughed until spring would throw the work into confusion. Where the land can be kept under crop of any kind this should certainly be done, for the nitrates will be preserved by being absorbed by the roots and elaborated into the tissues of the plants as albumen.

It seems, however, that in this as well as in many operations connected with agriculture, where the farmer fails nature steps in and provides a remedy. This may be understood when we are aware that nitrification proceeds in exact proportion to the rise or fall of temperature, being at a minimum during winter, and ceasing entirely about freezing-point. We thus see that, during the season of least growth, nitrates are not produced, or produced only in small quantity; but as the temperature rises, and growth begins, then the bacteria resume operations, increasing in their productive powers until they reach the maximum during summer when the heat is greatest, and at the period of the greatest growth, and when nitrogen is most largely required for the further development of the plants.

Action of Nitrogen greatest on Young Plants.—We learn from experiments conducted by Arendt that the presence of albuminoids, which are largely composed of nitrogen, is greatest during the first period of the growth of plants, and becomes a gradually diminishing quantity until it nearly reaches maturity. The beneficial action of a soluble form of nitrogen, such as in nitrate of soda, may be understood from this, especially when applied to young grass or corn crops when they come into braird.

Phosphatic Manures.

Bones.—The use of bones as a source of phosphoric acid and nitrogen for the growth of crops, began long before the underlying principles of manuring were understood. The reason why an increase of crops should follow an application of bones was consequently the subject of many unsound theories.

Early use of Bone-manure.—The first authentic account we have of the use of bones in this country tells of their application in many parts of Yorkshire. Soon after they were applied to the exhausted pastures of Cheshire, the farmers of the latter county would seem to have fully appreciated the beneficial action of bones. Their active system of grazing with dairy cattle had greatly exhausted the phosphates of the soil, and the effect which followed a liberal dressing with bones was simply marvellous. Indeed the pastures to which they had been applied very soon increased in value by 30s. per acre.

Fame of Bone-manure.—As would be expected, the story of this wonderful result rapidly attained notoriety, and led to an extended use of bones as manure in these districts. The small home-supply of bones soon became exhausted, and the importation of bones from Germany and Northern Europe speedily developed into a regular trade, of which Hull was the chief centre.

The bone-trade of Hull now became a leading factor in the agricultural world, and the benefits which arose to all classes in the community may be summed up in the proverb, "One ton of German bone-dust saves the importation of ten tons of German corn."

Benefits from the use of Bone-manures.—But a direct increase in production was not the only benefit resulting from the use of bones as manure. The use of bone-manure played a leading part in the extension of turnip-culture, and in the consequent change of the whole system of farming formerly practised—changes which have led not only to a large increase in the production of food, but gave rise to that spirit of inquiry which has evolved and placed within our reach the mass of valuable information embraced in the term "Agricultural Chemistry."

Forms of Bone-manure.—Bones have been applied to the soil in many forms and conditions—raw or green, boiled, burned, broken, bruised, ground, fermented, and dissolved.

Raw, Broken, and Bruised Bones.—Raw bones, when dried so as to lose no more weight, are found to be made up on an average of 28 per cent organic matter and 72 per cent of inorganic matter or bone-earths. The presence of these is determined as to quantity by the kind of animal, its age, and the state of preservation of the bone.

Organic Matter in Bones.—The organic matter is almost entirely composed of ossein or cartilage. This substance is very rich in nitrogen, which yields on an average 22 per cent of ammonia. It is not, however, present in all bones in the same proportion. In young growing animals the cartilage is present in greater proportion than in an aged one, as the bones of the latter are composed largely of bone-earth, and are in consequence much more brittle, and when broken in a live animal take a much longer time to mend. Bones, again, are often collected from the plains of Russia and various parts of America, where they have been so long lying exposed to atmospheric influences, that it is found much if not all of the cartilage has disappeared. It has also to be considered that the manufactures of soap, glue, and gelatine often abstract a part of this substance along with fatty matter which adheres to fresh bones. It may therefore be accepted as a rule applicable to this as well as to all phosphatic manures which have not been adulterated, that the higher the percentage of ammonia, the lower the percentage of phosphates; and conversely, a high rate of phosphates means a low rate of ammonia.

Preparing Bone-manure.—When bones were first used, they were simply chopped into pieces or broken by hammers. The advantage of their being broken was soon apparent, and mills were erected at nearly all the ports at which cargoes of foreign bones arrived. Steam-power was first employed in breaking bones by Mr Anderson of Dundee in 1829, his machinery preparing the bones in the form of ½-inch, ¼-inch, and dust.

For some time farmers seemed to be satisfied with these sizes, as they considered that grinding the bones smaller detracted from their beneficial and lasting effect. The more observant, however, by watching the progress of their crops, noticed that the bone-dust came more quickly into action, and that it was mainly due to impurities that dust was not in favour. The dust being the small particles which passed through the riddles of the mills, would contain all the sand and earthy matter which would find a lodgment in the hollow parts of the bone; and much of the old bones which had lost part of their organic matter would also largely enter into the composition of this dust. Hence their inferior quality.

Fineness of Division appreciated.—The requirements of the turnip crop, however, increased the demand for quickly acting manure, so that farmers began to find out that the smaller the division the more soluble the manure. Thus bone-meal came into use, and has ever since remained the favourite form in which to apply insoluble phosphates to the soil.

Fermented Bones.—Before Liebig's discovery of dissolving bones with acid, various methods were tried to increase the solubility of bones, fermentation being one of many. It consists of mixing the bones with earth and saturating the mass with liquid manure, and allowing the heap to remain for a week or two before using. Some farmers in the present day ferment their bone-meal by throwing it into a heap after mixing it with water. In about a week the heat of the fermentation is at its greatest height, after which the heap will decrease in bulk and change in colour, the latter being due to the presence of insects and germ-life, which attack the organic portion of the bone and decompose it. There can be no doubt this process hastens the solubility of bones.

Bone-ash and Bone-flour.—In the manufacture of glue and gelatine, and as a source of ammonia, bones have been long used. The residue was found to be an excellent manure in a much more soluble form than could be attained by any process of grinding. Steamed bones were thus brought under the notice of farmers. But before this, bones were boiled to extract the fatty matter and part of their gelatine, by soap-boilers for the manufacture of soap. The residue was found to be more active than ordinary crushed bones. We are now aware that in the manufacture of dissolved bones this fatty matter carbonises and forms an impervious layer over each fragment of bone, preventing the acid from acting upon it.

Fat in Manure disadvantageous.—The same process occurs in the soil. An impervious envelope is formed around the bone-fragments by the fat, and the action of acids which are generated is prevented, thereby retarding solution. We would therefore infer that bone-meals of all descriptions would be enhanced as fertilisers if these fats were removed before grinding.

Steamed bone-flour undergoes a more searching process, as the bones are introduced into a Papin's digester, and submitted to the action of steam at a high pressure, which removes a portion of, and in some instances nearly all, the organic matter, thereby disintegrating the substance of the bone, which is afterwards reduced to an impalpable powder. The abstracting of the gelatine decreases the manurial value, as it is the only source of nitrogen; but the percentage of phosphates is largely increased, which counterbalances this fact to a certain extent. Fat is of no manurial value.

Burned Bones.—The burning of bones is a wasteful process to effect the same object. In this form they are largely imported from South America for the manufacture of superphosphates. In this process the nitrogen is entirely dissipated. No doubt it is a concentrated form in which to obtain phosphates, but the plan is not commendable. Its only redeeming point is that the charcoal resulting from the burning of bones can be used for other purposes, sugar-refining, &c., before it comes to the farmer as a manurial substance.

Analyses of Bone-manure.—The following are analyses of average samples:—

	Crushed Bones.	Bone-meal.	Steamed Bones.	Russian Bones (steamed).
Moisture	7.13	7.45	5.20	6.80
Organic matter[1]	36.61	41.85	17.50	16.70
Phosphate of lime	48.32	46.36	67.53	59.31
Carbonate of lime	7.11	3.66	9.31	...
Insoluble matter	.83	.68	.46	...
	100.00	100.00	100.00	...
[1] Yielding ammonia	4.56	5.27	1.94	1.80

Analyses similar to the above are very general in trade circulars. It may be explained, however, that bone-meal, made by crushing pure bones from cattle, horses, or sheep, would not contain quite so much as 5.27 per cent of ammonia. In a bone-meal with the above analyses there would likely be a good deal of skinny matter crushed up, or it might be made partly of the bone of fish. The Russian bones of commerce are steamed.

Dissolved Bones.—About the year 1840 a new departure was made in the manufacture of bones as manure. The development of this trade was rapid and extensive, but farmers became at last alive to the fact that the division of bones could not be carried to such a point as to suit the requirements of the turnip crop. Mechanical means had been tried, and had not, to the full extent, fulfilled the purpose.

But when Liebig announced that "the most easy and practical method of effecting their division is to pour over the bones, in a fine powder, half their weight of sulphuric acid diluted with three or four parts of water, and after they have been digested for some time, to add about 100 parts of water, and to sprinkle this acid-mixture (phosphate of lime) before the plough," it was thought a solution to the problem had been found.

The plan could hardly be said to have come into use, as it was open to much objection on account of the form in which the bones were to be applied to the soil. A dressing of 1 cwt. of the dissolved mixture, entailing the application of nearly a ton of water, was simply impracticable in most cases of ordinary farming. A remedy was found in putting less acid in the mixture, and thereby producing a nearly dry product which could be sown by hand or machine. This substance came quickly into favour with all classes of farmers, as they found the manure to be easy of application, rapid in its action, and in most climates and soils never failed to produce an increase of crops.

Dissolving of doubtful Advantage.

—From the accounts to which we have had access, there would seem to have been, until recently, a good deal too much manuring with dissolved bones. There can be no doubt of their efficacy, but we cannot help agreeing with Dr Aitken when he says, "Considering the enormous quantity of mineral superphosphates now available, I am strongly of opinion that it is a mistake to dissolve bones, and that they are put to a much better use by applying them in their natural state in as finely ground a condition as they can possibly be got. The germ-life in the soil and in the bones will very rapidly convert the whole into a form available for the nourishment of plants; but to dissolve bones in sulphuric acid is to kill out the germ-life within it, and retard the decay of any nucleus of bone it may contain."

Bones and Mineral Phosphates.—Bones contain nitrogen and phosphates. Mineral phosphate contains only phosphates, but when dissolved this phosphate is probably as efficient a plant-food as phosphate obtained from bones. Some chemists still maintain that the origin influences the manurial value of the phosphates; but the idea is gaining ground that the only difference which exists between the forms—bone and mineral phosphates—is the presence of nitrogen in the bones. This nitrogen, however, can be readily introduced in some other form; and thus would result a manure about equal to bones. To put it another way, ordinary dissolved bones are made up as follows:—

7	cwt.	bone-meal
14		coprolites
15		acid sulphuric
3	"	water
1	"	gypsum
40		

This will give about 22 to 25 per cent soluble phosphate, from 8 to 12 insoluble, and about 1 per cent ammonia. It is specially important to notice that the material from which the manure derives its name is present only to the extent of nearly 1-6th part, the balance being made up of cheaper materials. Now let a mixture of bone-meal and ordinary superphosphates be made up to give the foregoing percentages, and our point is made.

But there is another view. The farmer is paying the dissolved-bone price for materials which he can buy at a superphosphate rate. That is, for 2 tons of a substance which is made up to the extent of 33 cwt. of superphosphate materials, he is paying a dissolved-bone price.

Further elucidation of this, and the chemical changes which are involved in dissolving bones, are given under *Superphosphates*, p. 116.

The dissolving of bones and other manures has developed now into a great industry, and, as a consequence, all qualities are offered in the market, from high-class dissolved bone down to adulterated rubbish entirely unworthy of the name of manure.

Analyses of Dissolved Bones.—The following are average analyses of three classes of dissolved bones:—

	No. 1. Dissolved Bones.	No. 2. Dissolved Bones.	No. 3. Dissolved Bones.
Phosphoric acid in a soluble state [1]	10.68	9.92	9.40
Phosphoric acid in an insoluble state [2]	7.12	5.32	3.28
Lime, sulphuric acid, &c.	78.36	78.30	80.92
Insoluble matter	3.84	6.46	6.40
[1] Equal to tricalcic phosphate, rendered "soluble"	23.32	21.68	20.56
[2] Equal to insoluble phosphate of lime	15.56	7.76	7.20
Ammonia	3.03	2.00	1.38

Coprolites.

Origin of the Manure trade.—It has been shown that a new era began in the agriculture of this country with the introduction of bones as a manure. As the results obtained became known and appreciated, increased attention was given to the question of manuring, and active research was made for other fertilisers.

Fresh substances were found, and proved to be successful and economical as fertilisers. A large increase in the demand for these manures rapidly arose, and with this movement began the manure-trade of this country, which has developed from small beginnings to the immense volume of about 600,000 tons per annum.

Cambridge Road-scrapings.—In the rise and progress of this trade the effect of any substance when used as a manure was closely observed, and thus we can therefore understand how the road-scrapings of Cambridge came into notice. These scrapings, on being examined, were found to be in part composed of phosphate of lime, obtained from phosphatic nodules, which were dug up out of the underlying "greensand," and used for repairing roads. Dr Buckland, their discoverer, found these nodules to be a mineral phosphate, and consequently nearly insoluble. They are now known under the name of *coprolites.*

A considerable period elapsed after the discovery of these nodules before they came to be used as manure. The writings of Henslow and Hérapath, who minutely described the extent and composition of this manurial wealth, effected this object by bringing these resources under the notice of the Royal Agricultural Society of England.

Origin of Coprolite.—Coprolites, or dungstones, are the excrements and remains of saurians or lizards, *Ammonites, Belemnites,* &c.

Sources of Coprolite.—The digging of coprolites was at first confined to the midland counties, where they were found in the greensands of Cambridge, the green marls, the gault, the bone-beds of the Lias, Ludlow bone-beds, Suffolk Crag, &c. After a time immense deposits were found in various parts of Europe and America. These deposits are of various qualities. Those found in the Suffolk Crag, in Buckingham, &c., were at one time known as false or *pseudo-coprolites,* from their containing a considerable quantity of alumina and oxide of iron. It has been suggested by Dr Buckland that the coprolite of this description was at one time chalk, which, after absorbing phosphoric acid from the decay of organic matter, was ultimately altered by natural forces into a mineral phosphate.

Another theory as to the origin of these and other mineral phosphates has also had support. It was supposed that they were at one time nearly the same as many of the phosphatic guano deposits, and had been altered by rains and afterwards by changes in the earth's crust, so as to be converted into the nodules or phosphatic rocks, now so largely employed in the manufacture of *superphosphates.*

Dissolving or Grinding.—Until recently, chemists were of opinion that mineral phosphates, unless treated with acids, were practically useless as a manure. Modern research, however, has shown that, if ground to an impalpable powder, they are of considerable value as fertilisers.

We shall not here attempt to determine or pronounce upon their precise relative value in a dissolved or undissolved state. As yet, indeed, this question occupies a debatable position in chemical investigation. All, however, agree that coprolites, when dissolved, become a safe and valuable source of phosphoric acid for plant-growth.

Composition of Coprolites.—The following are average analyses of coprolites by Sibson:—

	Cambridge.	Bedford.	Suffolk.	Carolina.	French.
Moisture	1.24	2.06	1.03	1.04	1.90
Phosphoric acid	26.80	23.52	25.50	25.70	20.80
Lime	43.26	33.46	37.24	37.38	31.94
Carbonic acid	7.10	...	3.60	...	3.80
Other matters	12.70	16.54	20.50	16.76	15.03
Sand	8.90	24.42	12.13	19.12	26.53
	100.00	100.00	100.00	100.00	100.00
[1] Equal to tribasic phosphate of lime	58.50	51.34	55.67	56.10	45.41

The preceding are very similar in composition, and may be taken as fair representatives of the phosphatic nodules.

But there are many other sources of insoluble phosphates. We shall mention briefly a few of those best known.

Apatite, Phosphorite, and Phosphatic Layers.

These substances occur in varied proportions in nearly all rocks, but are more abundantly present in the Metamorphic. They are much alike in character and composition. The existence of these layers, veins, and pockets seems to be due to the decay of organic matter; the residue being mixed up with shells of various kinds in which phosphate of lime is present in considerable abundance—these being deposited during long periods of time, and compressed amongst the other rock-material. Granite and syenite seem to be more largely interspersed with these substances than other rocks, and we have, in consequence, the best corn-growing lands on soils which overlie these rocks.

Apatite is found largely in Canada and Norway, where it is present in veins and masses. It exists in lesser quantities in other parts of the world.

Phosphatic layers are generally poor in quality, and are met with in the Silurian rocks, notably in Wales. *Phosphorite* is very abundant in some parts of Portugal, but these sources have not as yet been fully developed in consequence of bad roads. It is more sparsely present in Spain and Germany. The Canadian phosphorite beds have not been fully explored. The specimens which have been sent to the market are extremely hard and brittle, very difficult to grind; the powder obtained being minute glassy particles of a crystalline form. This renders it more insoluble than most other phosphatic materials.

These substances are for the most part manufactured into superphosphates.

Composition of Phosphorite.—Undernoted are analyses of average specimens:—

	Canadian Phosphorite.	German.	Spanish.
Moisture	Traces.	1.30	Traces.
Phosphoric acid [1]	35.30	28.02	33.60
Lime	47.22	37.11	42.02
Other constituents	11.98	15.44	8.11
Sand, &c.	5.50	18.13	16.27
	100.00	100.00	100.00
[1] Equal to phosphate of lime	77.06	61.17	73.35

Sombrero or Rock Guano.

This substance is found in the West Indian island of Sombrero, hence its name. There can be little doubt that the greater part of the islands in the Caribbean Sea were at one time covered with guano deposits in the same manner as those found on the islands of the South American and African coasts. These deposits, by natural agencies, have been converted into the phosphatic rock which covers the greater part of this and the other islands of the West Indies. This rock has become known in the manure-trade as Sombrero guano, and is largely used in the manufacture of compounds and other soluble phosphatic manures.

"Redonda" and "Alta Vela" Phosphates.

The preceding are all phosphates in which the phosphoric acid is in combination with lime as a base. In Redonda phosphate we have instead of lime a base composed of alumina and iron. This substance can be applied to the soil in its natural state only in a finely divided condition, as the absence of lime in its composition prevents the treatment of it with acid.

There would seem to be a considerable amount of conflicting opinion as to the efficacy of this substance as a manure. Many hold it to be utterly useless. From its composition we would infer that it should become more readily available than many other mineral phosphates, for it not only depends on the fineness of division, but also on the composition whether a substance becomes more or less dissolved in the soil.

The hard, brittle, and crystalline character of some of the phosphorites, with little or no carbonate of lime or iron in their composition, must necessarily be less soluble than those phosphatic materials in which these substances are present to the extent of about 11 per cent carbonate of lime, and 7 per cent oxide of iron. These substances being dissolved out of the minute particles, must render them more liable to disintegration.

Composition of Sombrero, Redonda, and Alta Vela.—The following is average analyses of a few of these materials by Sibson:—

	Sombrero.	Redonda.	Alta Vela.
Moisture	6.50	21.13	16.50
Phosphoric acid [1]	31.60	30.24	27.20
Lime	44.67	3.16	8.93
Other constituents	15.99	24.84	26.23
Sand	1.24	20.63	21.14
	100.00	100.00	100.00
[1] Equal to phosphate of lime	68.98	66.01	59.38

Alta Vela contains 7.20 oxide of iron and 14.16 alumina.
Redonda " 3.64 " 15.72 "

Thomas Slag.

We have in this substance not only the most recently discovered, but also the cheapest and most abundant source of phosphoric acid. It has been in the market only since 1886. The results obtained from carefully conducted experiments in Germany and this country clearly indicate that this substance is an excellent source of phosphorus to plants. It is, indeed, more quickly available to plants than any previously known form of insoluble phosphate. As it is now produced in Europe to the extent of about 600,000 tons per annum, the discovery of its manurial value is of great importance to agriculture.

Source of Thomas Slag.— Thomas slag is a by-product obtained in the conversion of pig-iron into steel. Before the discovery of this new process, all the slag resulting from the Bessemer method was treated as a waste product, and it often became a serious difficulty with manufacturers how to get rid of this supposed rubbish. It was therefore allowed to accumulate in those unsightly heaps which are always seen in connection with iron factories.

Manufacture of Thomas Slag.— The new process was patented in 1879 by the inventors, Messrs Thomas & Gilchrist, but the waste product was not utilised until some six or seven years later. The method consists of mixing the molten iron with about 20 per cent of lime. The converter, which is a large pear-shaped vessel, is also lined with lime instead of brick. The various impurities, such as manganese, silicon, phosphorus, and carbon, combine with the oxygen present in a stream of air which is forced through the molten mass, and either burns off or forms oxides with these substances. But on an increase of the already high temperature the phosphorus is converted into phosphoric acid, which combines with the lime, and the resultant product is the Thomas slag, or phosphate of lime.

Solubility of Slag.—This substance can be readily ground into a very fine powder; and after being passed over powerful magnets, which abstract a part of the iron, it is presented to the farmer in the best form for application. In this state it is quickly rendered available to the plant by the carbonic acid and water present in every arable soil. This solubility arises from its peculiar composition.

In bones and mineral phosphates we have three atoms of lime as a base combining with one atom of phosphoric acid to form the salt termed phosphate of lime. The combination may be stated thus, it being remembered that the atomic weight of calcium is 40, oxygen 16, and phosphorus 31:—

		Chemical formula.	Weight.
Lime Lime Lime	Phosphoric acid	$\left.\begin{matrix} CaO \\ CaO \\ CaO \end{matrix}\right\} P_2O_5 =$	$\left.\begin{matrix} 56 \\ 56 \\ 56 \end{matrix}\right\} 142$

Now, Thomas slag has four molecules of lime in its composition, in combination with one molecule of phosphoric acid, thus—

Formula. Weight.

$$\left.\begin{array}{l}\text{Lime}\\ \text{Lime}\\ \text{Lime}\\ \text{Lime}\end{array}\right\}\begin{array}{c}\text{Phosphoric}\\ \text{acid}\end{array}\left\{\begin{array}{l}CaO\\ CaO\\ CaO\\ CaO\end{array}\right\}P_2O_5=\left\{\begin{array}{l}56\\ 56\\ 56\\ 56\end{array}\right\}142$$

In other words, 168 parts of lime are combined with 142 parts of phosphoric acid in the one instance, and 224 parts of lime with 142 parts of phosphoric acid in the other. That is to say, in Thomas slag the acid is combined with too great a proportion of lime to enable it to cohere firmly. To put it in still another way, its chemical affinity is weakened from being over-saturated with lime, so that the compound is more readily broken up. Hence the solubility of Thomas slag.

Oxide of Iron in Slag.—There seems to be one drawback which, in the opinion of many farmers, detracts from the value of slag as a manure. This is the great quantity of oxide of iron in its composition, many samples containing from 10 to 20 per cent and over. From experiments conducted by Sir John B. Lawes, and in Germany, it seems that the presence of this material has little or no effect on the growth of crops. The farmer, therefore, just loses the value of the fertilising ingredients in proportion to the quantity of this substance which may be present in the slag bought by him.

Composition of Slag.—Slag also contains, beside phosphate and silicate of lime, a considerable quantity of caustic or free lime and magnesia. The following is an average analysis of Thomas slag:—

Phosphoric acid	18 per cent
Lime	50 "
Oxides of iron, &c.	22 "
Silica .	7 "
Magnesia	3 "

The quantity of phosphoric acid in a sample depends on the amount of phosphorus present in the iron, and the quantity of lime which is added to the molten liquid. If an excessive quantity of lime be added, then the residue must be poor in phosphoric acid, and *vice versâ*. The caustic lime, although a good manure, prevents slag forming an all round ingredient in mixing manure, as in this form it is a strong alkaline base, which will readily drive out a volatile one, as ammonia. If these be mixed, the lime combines with the sulphuric acid, and the ammonia escapes in a volatile state into the atmosphere.

Further information on this point will be found under mixtures and mixing.

Soluble Phosphates or Superphosphates.

When Sir John Bennet Lawes, about the year 1840, announced that he could obtain *soluble phosphate of lime* from the mineral phosphatic nodules as represented by *coprolites*, it is not to be supposed that he then realised that from this discovery a special industry would develop, which would go on increasing in volume until it reached, as it had done by 1888, the placing upon the markets of Great Britain of over half a million tons of superphosphates yearly. The great value of this discovery to the agricultural world becomes apparent by a consideration of the large and increasing quantities of superphosphate which farmers require under the changes which the application of artificial manures has effected in the rotation of crops, and the ever-diminishing supply of phosphates.

Composition of Phosphate of Lime.—Phosphoric acid and lime in combination are the principal ingredients in the salt, phosphate of lime. These substances are present always in the same proportion whether the phosphate is derived from bones or mineral phosphatic materials—with the one exception of slag. This combination is known as insoluble, tribasic, or tricalcic phosphate, which consists of three atoms of lime and one atom of phosphoric acid, thus—

Formula. Weight.

$$\left.\begin{array}{l}\text{Lime}\\ \text{Lime}\\ \text{Lime}\end{array}\right\}\begin{array}{c}\text{Phosphoric}\\ \text{acid}\end{array}\left\{\begin{array}{l}CaO\\ CaO\\ CaO\end{array}\right\}P_2O_5=\left\{\begin{array}{l}56\\ 56\\ 56\end{array}\right\}142$$

Solubility of Phosphate of Lime.—In this form phosphate of lime is very slowly soluble. Were it not that this substance when applied to the soil comes into contact with water impregnated with carbonic and other acids, the phosphate would remain unaltered for years. But the carbonic acid and water possess considerable dissolving power, and when insoluble phosphate is acted upon by carbonic acid, a molecule of lime is taken away, and water takes its place, so that the phosphate is now changed into a more soluble form, known as biphosphate of lime or dicalcic phosphate.

Precipitated, Reverted, or Reduced Phosphates.—This form is also effected by mixing dissolved phosphates with bones, slag, or caustic lime, before applying it to the soil. These phosphates also assume this form after being applied, as the phosphoric acid rendered soluble will then combine with any free base which may be present in a fertile soil. The combination may be stated thus—

		Formula.		Weight.	
Lime Lime Water	Phosphoric acid	CaO CaO H_2O	$P_2O_5=$	56 56 18	142

The preceding form may be looked upon as the natural process by which phosphate of lime is rendered soluble, and consequently available for plant-food.

Dissolving of Phosphate of Lime.—We have next to consider the artificial method of rendering insoluble phosphates soluble. The raw material is first ground into a fine powder, after which it is placed in a vessel termed a mixer, and treated with sulphuric acid. It depends upon the composition of the raw material and the strength of the acid as to the exact proportions in which these substances are mixed, more acid or less being employed in proportion to the carbonate of lime present. The general rule is to give as much acid as the material will take up quickly and dry readily after. In practice the quantity of acid varies from one-third to the full weight of the phosphatic material.

The value of a superphosphate depends on the amount of soluble phosphates present. It is therefore questionable policy to stint acid — at least from a manufacturer's point of view — as the unit value of soluble is much greater than that of insoluble phosphates. For this reason, in low-class superphosphates the material is saturated with acid to prevent reversion, with old mortar, chalk, and other inferior substances which sometimes form a considerable portion of such mixtures. When the acid is put into the mixer, chemical action at once begins by the sulphuric acid, which is strong, driving out the weaker carbonic acid. It then attacks the phosphoric acid combination, and abstracts two atoms of lime from it, the vacancy being made up with water. After a short time the bottom of the mixer is opened, and the whole mass drops into an enclosure known as the den. In a day or two the mixture dries quickly, it is then passed through a disintegrator, bagged up, and sold under the name of "superphosphate."

This product, on examination, is found to have undergone a change different from the other forms, as the compound now retains only one atom of lime in combination with the phosphoric acid, and may be stated thus—

		Formula.		Weight.	
Lime Water Water	Phosphoric acid	CaO H_2O H_2O	P_2O_5	56 18 18	142

In chemical parlance this substance is designated monocalcic phosphate, but it is usual in analysis not to state the quantity of this substance, but the quantity of tricalcic phosphate from which it was made—that is, the tribasic or tricalcic phosphate of lime rendered soluble by an acid. In this form it is in its most soluble condition, as it can be held in solution by water.

Biphosphate. — But some chemists consider that in this state the phosphoric acid is not available for plant-food—that before becoming so, it has to pass into the biphosphate form. When this change is effected, it becomes a precipitate, and is then in the most finely divided condition a substance can assume. Many farmers consider the biphosphate the best form in which to apply phosphate of lime, holding that it is more quickly effective upon crops, and that the superphosphate form is over-soluble, and liable to escape into the subsoil or drains if a base is not present.

But there are advantages which arise from the use of phosphates, as in superphosphate—viz., the greater power of diffusion a substance has when it is held in solution by water; because, wherever this water, which is impregnated with phosphoric acid, comes into contact with the soil in which lime or other base is present, there a portion of the phosphoric acid is precipitated, and in this manner the phosphoric acid is interspersed throughout the soil in a way which could never be attained by any mechanical means.

Bone or Mineral Phosphate.—It is held by eminent chemists that the soluble phosphates obtained from mineral phosphates are equally as good as those from bones, and that there is no special virtue in one form over the other. It is therefore of little importance to the farmer from which source his soluble phosphates are made, provided the material is fully dissolved, and in a dry, powdery condition.

But from this we do not infer that superphosphates are as good a manure as dissolved bones. We merely conclude that the soluble phosphates present in each are equal in value as fertilisers. The dissolved bone owes its greater efficacy to the nitrogen; but then this nitrogen can be supplied to the superphosphate either as bone-meal or sulphate of ammonia, by which means we can secure a cheaper manure, with an equal if not a greater amount of fertilising matter.

An additional benefit which bone possesses over mineral phosphate is due to its containing a certain percentage of organic matter, which, in the process of decay, gives rise to carbonic acid and other organic acids, which have a dissolving action on the phosphate of lime, —an advantage of considerable importance, especially when no dung is being applied.

Composition of Superphosphates.—Superphosphates are of three kinds — low, medium, and high-class. As a rule, amongst the superphosphates which abound in the market the medium is the best form, as the first too often contains a considerable quantity of coarsely ground phosphate, which, in that rough condition, is comparatively worthless as a manure; whilst high-class is not unfrequently in bad condition, being wet and lumpy, and difficult to handle. But it should be understood that these defects in the so-called low-class and high-class superphosphates are not always present. Better attention is now given than formerly to fineness of grinding, and with skilful dissolving the high-class superphosphates should be dry, powdery, and quite free from lumps.

The percentage of soluble phosphates which average samples should contain is shown below:—

	High-class Superphosphate.	Medium Superphosphate.	Low-class Superphosphate.
Soluble phosphate (per cent)	35	28 to 30	23 to 26

Characteristics of Phosphatic Manures.

In the selection of the form in which to apply phosphate to his crop, the farmer has to consider the character of the soil, climate, and crops to be grown. The remarks made upon nitrogenous manures apply with equal force to all kinds of phosphates.

Activity of Phosphatic Manures.—We have already tried to impress on the minds of our readers that the solubility of a manure depends on the minuteness of its division: we can have therefore little difficulty in placing them in the order of their activity, beginning with those which come into action slowly—crushed bones, finely powdered mineral phosphate, fine bone-meal, steamed bones, precipitated phosphates, Thomas slag, dissolved phosphates.

Bones are the slowest in their action, and become available as plant-food only after being mixed with the soil for some time. It is therefore a safe rule to apply them early. In some soils they come more quickly into action than in others. This is especially the case in porous soils where organic matter is present. In clays, and soils of like texture, they may remain unchanged for years. Bones are, however, good "stayers"—that is, being slowly soluble, they last long, and raise the fertility of the soil. Therefore all mixtures of manure intended to last a rotation should contain a proportion of bones. In a wet climate bones are also rendered more quickly soluble than in drier parts. Indeed, in wet seasons bones decompose rapidly.

The softer or less compact forms of *mineral phosphates* when ground into a very fine powder, have been found to be moderately quick-acting manures, about equal, some consider, to very finely ground bone-meal or bone-ash.

Finely ground *steamed bone-flour* is the most active form of bones prepared by mechanical means, and gives a high-class superphosphate when treated with an acid. The fineness of division of this substance counterbalances the want of organic matter with relation to solubility. But this preparation is coarse when compared to *precipitated or reverted phosphates*, which possess the highest degree of solubility of any of the forms of phosphates except *slag*. Slag comes next to superphosphate, and has a great future before it, being, as we have seen, the cheapest source of phosphoric acid in the market at present, while the supply is abundant.

Dissolved manures are the most active. The chief advantage of this solubility is their certainty of action, the rapid manner in which they become available in any soil or climate. The young plant is in consequence supplied with this essential ingredient at a period of growth when it is liable to sustain damage from untoward influences which may infest its surroundings. An abundant supply of manure or food at this critical period to a great extent determines the future crop, an increased yield of well-filled grain and early maturity being the results.

Large crops require large doses of manure, and short-lived crops require quick-acting manures. A crop such as wheat, which occupies the ground for a long period, will not be benefited to the same degree by a ready supply of phosphates as a short-lived crop like barley. Wheat abstracts the ingredients at leisure, and can search for them over a much larger area of the soil. And as phosphates are present in some proportion in all soils, this crop can, as a rule, acquire all its wants during the period of growth. Barley, on the other hand, grows rapidly, building up its tissue in a comparatively short time, and, owing to its root-surface, has not the area nor the time to search for its supply of phosphates.

In the well-known work, 'How Crops Grow,' we are told that the phosphorised oils require phosphates for their elaboration; that phosphates increase the diffusive rate of albumen, and thus help its transference to the different parts of the plant; and that phosphates co-operate with the other ash ingredients in building up the proximate constituents, such as starch, dextrine, &c., and is ultimately deposited in the seed. We are also aware that a deficient supply of phosphates produces light grain and diminished yield. Phosphates produce dense roots, of excellent feeding quality and high keeping properties.

POTASSIC MANURES.

The use of potash manures is of recent date. Even yet many farmers do not consider the application of potash to the soil necessary.

Sources of Potash.—The only available sources of potash, before 1860, were wood-ashes, sea-weed, and farmyard manure. In 1859, vast deposits of potash salts were found by the Prussian Government when sinking a shaft at Stassfurt in the hope of discovering rock-salt. Overlying large deposits of rock-salt, they found layers of kainit, a name given to carnallite or muriate of potash; and magnesia, polykalite or sulphate of potash; gypsum and kieserite, or sulphate of magnesia. Similar deposits were also found at Leopoldshall, in Anhalt.

The discovery of these deposits put the use of potash as a manure within the reach of the farmer. It can now be bought at about 35s. per ton, containing on an average 23 per cent of potash.

Use of Potash.—But notwithstanding its low price, potash has not come into general use. As a rule, it can be applied with advantage only to certain crops, and on land deficient in clay, such as sandy or peaty soils.

When farmyard manure is applied, a separate dose of potash is unnecessary. Indeed it would be liable to lessen the produce, and also lower its quality, as with the potash in the dung there would be more available potash in the soil than would be beneficial for the crop. On most soils containing a fair proportion of clay, and where a good deal of farmyard manure is used, there is, as a rule, a sufficiency of potash. But where it is deficient, the gain in produce obtained by a small application of potash, at a cost of a few shillings per acre, is often remarkable. By observation and experiment with light doses on plots, farmers may ascertain if their soil needs potash, and if so, its application in moderate quantity will be sure to be profitable. Potash has been found of some benefit when applied to mangels, and appears to be of considerable benefit when mixed with other manures and applied as a top-dressing for hay and grass seeds. It also may be applied with advantage to leguminous crops, beans in particular.

Wherever applied it ought to be sown early, and care should be taken not to apply it in conjunction with farmyard manure. It is positively injurious to green crops when given in excess.

GYPSUM.

Sources of Gypsum.—Gypsum, or sulphate of lime, occurs as rocks in the form of beds, generally in conjunction with rock-salt. In the compact form it is commonly known as alabaster and selenite. Many of the deposits owe their origin to the evaporation of salt water, which contains gypsum in solution. At one period, where rock-salt is now found, there must have been inland lakes or seas, and by changes of the earth's surface the outlets have been gradually cut off from the sea; so that all the saline matter brought down by the drainage has been accumulating, the water becoming more and more impregnated with these salts, and thus, when evaporation has gone on for a certain period, the salts cannot be longer held in solution, and, becoming crystallised, they are deposited in the form of beds, which by compression assume the compact form.

Use of Gypsum.—From an agricultural point of view, gypsum is valuable chiefly as an absorber of ammonia (see p. 527, vol. i.) It is of benefit to clover and other leguminous crops.

The value of gypsum as a manure was the subject of much discussion about 1850 to 1860; but since the introduction of dissolved phosphates it has been unnecessary for the farmer to trouble himself about it, as the application of 5 tons of superphosphate involves an application of 2 tons of gypsum.

GAS-LIME.

In the manufacture of gas, many impurities have to be got rid of before the gas is ready for combustion. Amongst these are gas-liquor, from which sulphate of ammonia is obtained, and gas-lime, which is produced by spreading quick or caustic lime over plates in a close chamber, through which the gas containing sulphuretted hydrogen is forced. This latter substance combines with the lime, forming in the purifying chamber sulphide of lime. In this form it is destructive to vegetable life; but after exposure to the atmosphere it absorbs oxygen, and is thereby changed into *sulphate of lime or gypsum.* The caustic lime which may be present is also changed into carbonate.

Use of Gas-lime.—Gas-lime ought to be applied in autumn, or allowed to lie some months before using, so as to allow time for the changes just explained to take place. It is unsafe to apply it to any growing crop.

Many Berwickshire and Roxburgh farmers mix gas-lime and salt, and apply the mixture to their leas which are to be broken up for oats. They consider this application to be of service to the corn crops, and a preventive of anbury or finger-and-toe in the green crop. Gas-lime is also much used as an insecticide.

COMPOUND MANURES.

In addition to the various manures already enumerated, there are in the market many *compound manures* or special crop mixtures bearing different names, such as cereal, turnip, potato, bean, and grass manures.

Disadvantage of Compound Manures.—Many of these mixtures are skilfully made up, and, when manufactured by respectable firms, analyse well, and give good results on soils for which they are adapted. But there is one great drawback to this system of preparing manures, and it is this, that with such variation in soil, climate, and customs of farming, it is impossible to compound one manure equally suitable for all farms, even in one district. Moreover, the trade in compound manures opens a wide field for the unscrupulous dealer who would sell inferior stuff as good material. Upon the whole, therefore, it is safer for the intelligent farmer to avoid mixed manures and select fertilisers from sources as to which there can be no suspicion, and blend these in mixtures suitable for the soil and climate where they are to be applied.

Still there are many farmers who are not sufficiently acquainted with the characteristics of the various manures to enable them to ensure perfect mixing, and in these cases it will be advantageous to have the mixtures prepared by a thoroughly respectable firm, by whom the composition of the mixture will be guaranteed.

ECONOMICAL PURCHASING OF MANURES.

In the purchasing of manures there are a few points which farmers should always keep in view. From simple examination of any article sold as manure, the purchaser can have little or no idea of its quality or value as a fertiliser. For this reason the farmer ought—

(1.) To buy only from respectable firms.
(2.) Never buy without obtaining a guaranteed analysis.
(3.) Always buy the valuable ingredients from the cheapest sources in the market.

The first point is so self-evident as to require no further remarks.

Analysis explained.

It may be useful to explain some of the terms used by chemists in an analysis of manure.

Insoluble and Soluble Phosphates.—As to the meaning of the terms insoluble phosphate and soluble phosphate some explanation has already been given in the notes upon superphosphate, p. 117. It was there seen that *soluble phosphates* always mean *tribasic phosphate of lime made soluble by an acid.* It is no matter whether they are termed monobasic phosphate, monocalcic phosphate, biphosphate, phosphoric acid in a soluble state, or superphosphate, the term superphosphate is generally applied to all dissolved phosphates in which ammonia is not present.

In analyses of manures, the term phosphoric acid in a soluble state is often met with. This means the acid will melt or dissolve in water, like sugar or salt; but to assist practical men to arrive at conclusions more correctly as to the value of the manures, the percentage of dissolved phosphate of lime is also given—that is, the amount of tribasic phosphate of lime or bone-earth required to give that quantity of phosphoric acid in a soluble state.

Organic Matter.— Chemists apply this term to every substance that will rot or decompose by "heating" or burn by fire—no matter whether it belong to the animal or vegetable kingdom. The value of the organic matter in a manure depends mainly upon the amount of nitrogen in its composition, and whether or not that nitrogen becomes readily available for the use of plants. For instance, straw, wool, blood, or sawdust are all organic matters, but the amount of nitrogen present in each is very different. Straw and sawdust in themselves may almost be looked upon as non-nitrogenous substances, while blood and wool show a very large percentage of nitrogen.

Again, we have to consider how soon the nitrogen shall become available for food to plants. This must necessarily depend upon whether those substances are subject to rapid decomposition or otherwise. Blood decomposes quickly, while wool may lie in the soil for years unchanged, and its effects upon vegetation cannot therefore be the same, because all substances before they become available as a manure must be broken up into the elements of which they are made up, or in other words, *decompose or rot.*

It should also be noted here, as already indicated, that organic matter is of value as an indirect improver of the texture and mechanical properties of a soil as well as the generator of carbonic and other acids, whose action on the dormant fertilising constituents of a soil is most beneficial.

Nitrogen and Ammonia.—It may be here explained that when nitrogen is liberated from a substance, it may go into combination with hydrogen and form ammonia, or it may be evolved as free nitrogen and pass off in the atmosphere, or it may be converted into nitric acid, which, combining with lime, potash, or soda, forms nitrates of these bases. But in most cases where organic nitrogen occurs in a manure it becomes converted into ammonia—hence the term, nitrogen equal to ammonia.

Alkaline Salts.—These may be accidentally present or may be added in the drying agents employed. They consist chiefly of sulphate of soda or potash salts. The latter is of considerable value, but the former is not of much importance.

The foregoing are the more valuable constituents in the analysis.

Lime and Sulphuric Acid.—Lime and suphuric acid are present in pretty large quantities in the form of sulphate of lime or gypsum, this being a result of the sulphuric acid applied to render soluble the insoluble phosphates. The acid, as before explained, acting on the phosphate of lime, abstracts from the phosphoric acid two equivalents of lime; while, where carbonate of lime is present, it drives off the carbonic acid and combines with the lime to form the foregoing salt. Gypsum is also employed as a drying agent.

Moisture.—Moisture is present in a manure as the water of combination, and also as the water which is mixed with the materials to enable the acids employed to act with the greatest advantage.

The amount of moisture present in a manure is of considerable importance to the purchaser, as when a quantity of manure dries, the water lost by evaporation is a direct loss of weight.

The Cheapest Source.

The greatest difficulty the farmer has to encounter when purchasing manure is to know the cheapest sources from which to obtain phosphoric acid, nitrogen, and potash. In order to enable him to form an approximate opinion of relative values, we shall try to explain the theory of valuation by units, preluding it with the remark that the *value of a manure to the farmer* depends on the amount of valuable ingredients which may be present in its composition, but that its *market price*, like that of all other commodities, is regulated by the law of supply and demand.

Valuable Ingredients of Manure.—The valuable constituents in manure are: (1) nitrogen, equal to ammonia, quickly available, as in nitrate of soda and sulphate of ammonia; (2) nitrogen slowly available, as in bones, blood, &c.; (3) phosphoric acid quickly available, as in superphosphate; (4) phosphoric acid slowly available, as in bones, guano, &c.; and (5) potash, as in kainit.

Nitrogen, phosphoric acid, and potash are available from many other sources, but the foregoing will give an average. What the farmer has to carefully consider is the form in which these are present, whether *quickly or slowly available*, and then judge which will be most suitable for his purpose.

Unit Value.—Let us now see how the unit value is arrived at. Taking the prices per ton stated below as the selling price of the manures, and dividing the cost price by the percentage of units of the various useful ingredients, we find the value per unit of these ingredients would be as follows:—

				Per ton.		Per unit.
Sulphate ammonia	= 24 per cent	ammonia, at		£12 5 0	=	£0 10 3
Nitrate of soda	= 19 "	" at		10 12 6	=	0 11 3
Phosphatic guano	= 46 "	phosphates, at		2 12 6	=	0 1 2
Slag	= 40 "	" at		1 10 0	=	0 0 9
Superphosphate	= 27 "	soluble phosphates, at		2 15 0	=	0 2 0
"	= 23.5	" at		2 7 6	=	0 2 4
Muriate of potash	= 50	potash, at		7 7 6	=	0 3 0
Sulphate of potash	= 26 "	" at		4 2 6	=	0 3 2
Bones	= { 50 4.5	phosphates ammonia	at	5 15 0	=	{ 0 1 4 0 10 3

The only difficulty is in regard to a compound manure such as bones. In such a case the unit value of the constituents of a similar substance is taken. Sulphate of ammonia is adopted in this instance. The bone-manure, we have seen, contains 4½ per cent of ammonia. This multiplied by 10s. 3d. (the cost of ammonia per unit in sulphate of ammonia), gives £2, 6s. 2d. as the proportion of the cost of the bones represented by the 4½ per cent of ammonia. This deducted from the cost price of £5, 15s. per ton, leaves £3, 8s. 10d. for the 50 per cent of phosphates.

The foregoing, of course, cannot be taken as hard - and fast rules. The chemist generally exercises a good deal of discretion, and often raises the unit value above what it will actually work out upon paper, much depending on the source of the material and its condition. For instance, the phosphates in bones, although showing a net unit value of 1s. 4d., may, on account of the first-class origin of the phosphate, be worth perhaps 3d. to 4d. per unit more. The foregoing figures will, however, give a useful idea of the approximate value, and indicate how, from the cost price and analysis, the value per unit is arrived at.

Estimating the Value of a Manure.—Now, let us reverse the process, and from these values per unit and the analysis of a manure, find what the cost price per ton should be. Take, say, *dissolved bones*, showing analysis of—

22 per cent soluble phosphate, worth 2s. 2d. per unit.
12 " insoluble " worth 1s. 2d.
2¾ " ammonia, worth 10s. 3d. "
The total cost per ton should be £4, 9s. 10d.

Dissolved bones with this analysis can just now be bought at £4, 10s. per ton, and are therefore fair value in comparison with other fertilising substances.

Guide to Analysis.—The following table, compiled by Dr Aitken, will be found very useful in *reading* and understanding an analysis of manures:—

Amount of	nitrogen,	multiplied by	1.214	gives amount of	ammonia.
"	"		6.3		albuminoids.
"	ammonia,	"	3.882	"	sulphate of ammonia.
	"		3.147	"	muriate of "
"	"	"	3.706	"	nitric acid.
"	"	"	5.0	"	nitrate of soda.
	potash,		1.85		sulphate of potash.
"	"	"	1.585		muriate of "
"	phosphoric acid,	"	2.183	"	phosphate of lime.
"	"	"	1.4	"	biphosphate.
"	"		1.648	"	soluble or mono-calcic phosphate.
	soluble phosphate,		1.325		phosphate of lime.
"	biphosphate,	"	1.566	"	"
	lime,		1.845	"	"
"	"	"	1.786	"	carbonate of lime.

MIXTURES AND MIXING.

Dangers of Careless Mixing.—In mixing manures, a knowledge of their character and composition is indispensable if loss is to be averted. Indiscriminate or careless mixing is almost certain to end in loss of fertilising material, and may even, by generation of poisonous gases in a close compartment, incur danger to human life.

It should therefore be kept in view that while the substances used as manure are more or less in the form of salts, which are harmless in themselves, yet if their complex forms are broken up, the products of the decomposition assume a very different character.

Chemical Processes in Mixing Manures. — The chemical processes which take place in this decomposition need not be fully described here. For all practical purposes, the substances which result may be regarded as acids in chemical combination with alkalies as bases. In chemical action, a strong or free acid will drive out a weak one, and a strong alkali will usurp the place of one possessing a less degree of affinity for acids. If we examine our manure-lists, we find that in

(1.) Highly soluble phosphates, to which, as is sometimes the case, an excess of acid has been applied, there is present free sulphuric acid; in
(2.) Nitrate of soda—an alkali having a strong affinity for sulphuric acid; in
(3.) Slag—a strong alkali in the form of caustic lime; and in

(4) Sulphate of ammonia—a weak or volatile alkali, ammonia.

When soluble phosphates are mixed with nitrate of soda, a portion of the phosphoric acid rendered soluble abstracts a portion of the soda from the nitrate of soda, the products of the decomposition being lime and soda and an orange-coloured gas, better known as nitric acid vapour—a deadly poison. If ⅓ of nitrate of soda and ⅔ of superphosphates are mixed, and allowed to lie for six weeks or so, it may be found that nearly ⅓ of the nitric acid has been lost from this cause alone.

Again, if superphosphate and bones or slag are mixed, and allowed to remain for some time, the soluble phosphoric acid will combine with another molecule of lime, and more or less precipitates, reverted or reduced phosphates, will be produced.

Then if we mix sulphate of ammonia with slag, the caustic lime of the slag will drive out the ammonia, which, being volatile, will become dissipated in the atmosphere, and the resulting product becomes sulphate of lime or gypsum.

Comparatively few realise the loss and disappointments which have occurred to the great body of farmers by haphazard mixing of manure. The fact is, there are very few manurial substances which can be mixed at random, and allowed to lie, without some important change occurring in their composition.

Safe Mixtures.—The following manures may be mixed with impunity: (1) bones with nitrate of soda or sulphate of ammonia; (2) superphosphate and sulphate of ammonia; (3) bones and slag; and (4) slag and nitrate of soda. These mixtures will not, however, suit the requirements of farm practice. Organic nitrogen, such as fish guano or Frey Bentos guano (or meat-meal), may be mixed with any other manure without incurring loss.

Method of Mixing.—The following plan of mixing has been adopted with a fair amount of success. As short a time as possible before application, the superphosphates are emptied, and the lumps are broken by striking the lump a smart blow with the back of the shovel. Next, a heap of bones, and another of slag, are put down, leaving a clear space in the centre. A man is now placed at each heap, and alternate shovelfuls, less or more—the quantity being determined by the relative proportion of materials desired—are thrown into the centre, where a new heap is formed containing the three materials. After this mixture is made, it is turned over, care being taken to always shovel the material from the bottom of the heap. The top portions of the material slip down, and thus by shovelling from the bottom, a thorough mixing is brought about.

In a day or two the sulphate of ammonia or nitrate of soda, when such is to be applied, may be added. The mixture is then driven to the field in carts, the mixing process being completed by the material being shovelled from the bottom of the heap into the cart. When the manure is to be sown by hand, equal quantities should be placed in each cart, in order to facilitate even application.

By mixing in this manner, the risk of loss through any excess of sulphuric acid having been added to the superphosphate will be averted, as any free acid will combine with the free lime of the slag, or with the bones if there is no slag in the mixture. A neutral salt is thereby formed and loss prevented. As already indicated, it would be unwise to allow a mixture of fine steamed bone-flour or slag and superphosphate to lie long, as the phosphates in the superphosphates would be precipitated by the carbonate of lime in the bone-flour, or by the caustic lime in the slag.

Another Method of Mixing.—Mr William Grant, Wester Alves, Morayshire, writing in the *Farming World* (p. 206, 1889) thus describes his method of mixing manures for turnips: "The mixing is done in a turnip-shed, about 16 ft. square, as follows: A layer of bone-manure is laid down over the whole area, next a layer of superphosphate, next another of bone meal or dust, on which is put a layer of fish guano; then another of the bone-meal, on which is laid a layer of kainit, and the same system gone over a second time till a quantity sufficient for 20 acres is laid down. A layer of the bone-manure is always put between each of the other kinds used, and, as a rule, only a day or two before being required for use. The heap has sometimes lain two weeks without, as far as I could see, sustaining any injury; but I am always careful to have a layer of the bone-meal between the other layers, and *do not stir up the heap till we begin to use it.*"

Mixtures injured by lying long.—If a long time is allowed to elapse before application, then reversion of phosphates will set in; nitric acid and ammonia will be evolved, although in less degree; and the mixture will become damp and lumpy, and form into cake, which will prevent its even distribution.

Early application after mixing is therefore a matter of great importance.

Guano, dissolved bones, superphosphate, and sulphate of ammonia ought all to be riddled, and lumps broken before mixing.

Compounding Mixtures and Character of Manures.—In order to enable the farmer to make an approximate calculation of the quantities of the several manures, he will require to make up a mixture containing certain proportions of phosphoric acid, soluble; phosphates, insoluble; nitrogen, and potash, we append a very useful table compiled by Dr Aitken, slightly condensed:—

Nitrate of Soda.—The most available source of nitrogen; contains 95 per cent pure nitrate, equal to 19 per cent ammonia.

Sulphate of Ammonia.—Not so quickly available; contains 95 per cent pure sulphate of ammonia, equal to 25 per cent ammonia.

5 parts nitrate equals 4 parts sulphate of ammonia.

5 parts nitrate equals 1 per cent of ammonia.

Dried Blood.—A slowly available source of nitrogen; contains 12 to 16 per cent ammonia.

Horn, Shoddy, Wool-waste.—Insoluble nitrogenous materials—therefore slowly available; containing about 17 per cent, 5 to 10 per cent of ammonia respectively.

Peruvian Guano.—A nitrogenous manure containing soluble and insoluble nitrogen—therefore in part available when applied, and balance slowly available; contains from 8 to 10 per cent ammonia, and from 30 to 40 per cent phosphate of lime, slowly available.

Low-class Guano.—Contains less ammonia and more phosphates, 3 to 5 per cent of ammonia, and 40 to 50 per cent phosphates.

Standard Guano.—Being similar to improved, equalised, fortified, &c., these are mixtures of low-class guano and sulphate of ammonia, and are generally guaranteed to contain 8 to 10 per cent ammonia.

Fish Guano.—Should contain from 10 to 12 per cent of ammonia, 18 to 30 per cent phosphates, and not more than 3 per cent oil. These substances are present in insoluble compounds, therefore this manure is slowly available. The oil retards decomposition.

Frey Bentos Guano.—Contains 6 to 12 per cent ammonia, and from 16 to 30 per cent phosphates, both in an insoluble form, consequently slow in their action as manures.

Bone-meal.—Contains on an average 50 per cent phosphates, and 4½ per cent of ammonia. These are insoluble and slow acting. Their solubility depends on the fineness of their division.

Steamed Bone Flour.—Contains on an average 60 per cent phosphates and 1½ per cent ammonia. This material can be ground into very fine powder, and is quicker in its action than bones, ground or fermented.

Pure Dissolved Bones.—These ought to contain about 20 per cent soluble and 10 per cent insoluble phosphates, with 2½ to 3½ per cent of ammonia. When pure, this substance is the most soluble and best form of phosphates. It is, perhaps, also the dearest.

Dissolved Bones.—Differ from the preceding by being largely composed of mineral phosphates and nitrogen obtained from cheap sources; dissolved together so as to generally contain 15 to 30 per cent soluble phosphates, and 1 to 3 per cent of ammonia—to be purchased with caution.

Superphosphates of a high class are made from mineral phosphates, which contain a high percentage of phosphate of lime. They contain between 30 and 40 per cent of soluble phosphates.

Medium-class Superphosphates contain from 26 to 28 per cent soluble phosphate.

Low-class Superphosphates are dear at comparatively low prices, and it is a safe rule to avoid them.

Mineral Phosphates, Coprolites, &c., ought to contain on an average between 50 and 60 per cent of phosphate of lime, and be ground into an impalpable powder.

Slag ought to contain from 36 to 41 per cent phosphate of lime, and the material, as also mineral phosphates, be so ground that 85 per cent of it will pass through a screen containing 10,000 holes to square inch.

Uncertain Character of Compound Manures.—Compound manures are so numerous and varied in their composition that it is impossible to indicate those most suitable for any crop or soil. They usually contain phosphate, nitrogen, and potash in various proportions. But the purchaser must not only ascertain the percentage of these ingredients which may be present, but also the sources from which they are derived, and the form in which these are present.

Home Mixing preferable.—It is therefore considered more prudent for a farmer to buy a suitable combination of materials derived from known sources, such as bones, superphosphate, nitrate of soda, guano, &c., and make up the desired mixture for himself—that is, if he has taken the very necessary precaution of acquiring a knowledge of the characteristics of the different manures.

APPLICATION OF MANURES.

The application of manures is a subject which should receive careful consideration and timely attention from the farmer. Upon the manner in which this part of the work is done will, to a large extent, depend the success or the failure of the manurial treatment. Amongst the points to be considered are the character and composition of the soil, the nature and requirements of the crops, the rotation of crops pursued, the climate of the district in which the farm is situated, and the character and condition of the manure itself.

Application of Dung.

In the application of farmyard manure, simple as the matter may seem, there is great divergence of practice.

Turning Dung-heaps.—Differences of opinion exist as to whether or not it is necessary or desirable to "turn" dung-heaps before applying the manure to the land. This depends mainly upon the manner in which the manure has been made and treated generally during the time it has been accumulating. A certain amount of fermentation is necessary to prepare or "ripen" the dung. Turning promotes fermentation. It is desirable that the dung should be as uniform in texture and character as possible. This may be ensured by turning. Rank, fresh, unevenly made dung, will therefore be improved by being turned over and well mixed two or three weeks before application.

Mr Gilbert Murray says that "in no case is the dung in a fit state for use until the manure in the yards has been turned over and allowed a little time to ferment;" and he adds, that "when treated in this way the liquid manure remaining in the pond should be pumped over the heap."

On the other hand, many farmers and chemists regard the turning process as both unnecessary and injurious. Mr Milne, Mains of Laithers, Aberdeenshire, looks upon the turning of ordinary dung-heaps as waste both of time and of ammoniacal matter. The more dung rots the denser it becomes, and therefore the more difficult to spread evenly on the land, while the unbroken lumps will the longer lie on the land in a useless condition. This, Mr Milne says, any one can verify after a dry summer. If the drills into which the dung had been put are split up, little or none of the fresh dung will be seen, while the rotten dung will turn up almost as solid as when applied. In his part of the country, Mr Milne has not seen a dung-heap turned for twenty years; and if artificial manure is to be used along with the dung, he considers turning quite unnecessary.

In so far as concerns the dung itself, there will, as a rule, be little necessity for turning, provided it has been properly made and taken care of in the cattle-court—that is, if the litter has been evenly distributed (or, better still, cut into short lengths), and well and regularly saturated with urine, so that the dung may come out moderately short and of uniform texture and quality. Indeed, with dung so made and treated, there are strong considerations in support of the contention of many farmers, that it is better to cart such dung right from its original position in the court to the land for distribution.

Carting out Dung.—In many parts of the country the dung is turned, not because the turning itself is considered necessary, but because it is deemed advisable, in order to facilitate work in the busy season of laying down roots, to have the dung carted into heaps on the field some time during the winter, when in these parts there is little other work which can be done by either the men or horses. In reference to this point, Mr George Brown, Watten Mains, Caithness, remarks that it would be impossible for farmers in many parts of the north to put in the turnip crop seasonably without another pair—in some instances perhaps two pairs—of horses, if the dung had all to be carted from the steading at this busy time of the year. He also points out that if rank fresh dung is once turned before application, it is easier to spread it on the land. This is unquestionably true, provided it is not allowed to become so rotten as to get into the dense lumps referred to by Mr Milne. Thus, while a certain amount of turning and fermentation facilitates the even spreading and speedy action of dung in the soil, excessive rotting may to some extent operate against both. It is certainly very important, in carting out or turning dung, that great care should be taken not to allow fermentation to go too far, as in that case a considerable portion of the valuable plant-food in the manure might be lost. Fermentation may be regulated by compressing the dung when it is too rapid, and by opening up the dung when it is too slow.

Process of Turning.—If a dung-heap in the field is to be turned, a beginning should be made at the end farthest from the head-ridge. The unturned dung-heap slopes a little at both ends, but the turned dunghill should be made of the same height throughout. A dunghill is turned over in a succession of breadths of 3 feet, which affords sufficient room for people to work in; but the first few breadths should be narrower than 3 feet, until the desired height of the turned dunghill is attained at that end. At the centre, the height is lowered to that of the first end, and the last end is heightened to the general level.

There is more of good management in attending to these particulars of turning a dunghill than is at first apparent. A turned dunghill will not putrefy equally when of different heights—the greatest heat will be at the highest part, where the dung will become short and compact, whilst at the shallowest it will continue comparatively crude and unprepared; and such different states of the manure will have different effects upon the crop. In ordinary practice, the uniform height of the dunghill is often miscalculated, and thus the ends still continue lower than the centre. The endeavour to equalise the height by throwing dung from the middle to the ends does mischief, inasmuch as no complete union takes place between the turned dung and that thrown upon it, the two portions remaining in different states, and rising unequally to the graip when thrown into the cart. Besides, trampling the centre when the dung was thrown to the ends, causes it to become harder than the rest of the heap, and so to undergo a different degree of putrefaction. In fact, the whole job is bungled.

Dung, properly speaking, does not ferment, but putrefies.

Intermixing.—The outside and drier portions of the dung are put into the inside of the dunghill, and, where different sorts of dung are met with, they are intermingled intimately. Each dace is cut off, and turned over from the top to the bottom. When the bottom is reached, the earth damped by the exudation from the dung-heap is shovelled up by the men with the square-mouthed shovel, or the frying-pan shovel, fig. 252, and thrown upon the breast of the turned dung.

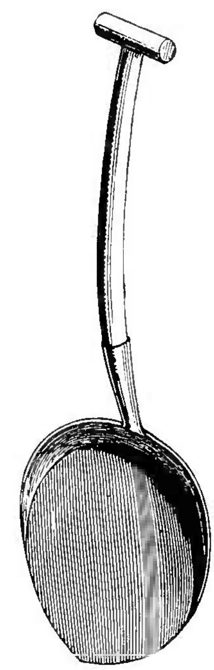


Fig. 252. — *Frying-pan or lime shovel.*

When straw ropes are met with, they should be cut into small pieces and scattered amongst the dampest parts of the dung-heap. Though the dung-heap is cut into parallel trenches, the dung from the top of the new trench is not thrown down upon the bottom of the former one, like trenching land, but upon the breast of the turned dung, which slopes upwards away from the workers. The advantage of this arrangement is not only that the dung is thereby intimately intermixed and not in separate independent trenches, but that when the dung is carting away, it rises freely with the graip.

Fig. 253 represents an excellent steel graip, such as is used in filling dung, made by Spear & Jackson, Sheffield.

In finishing the dunghill, the men shovel up all loose dung and earth along its sides and ends to the top, and a dung-heap thus turned over forms a parallelopipedon, and is a good-looking piece of work.

Lime-shovel.—Fig. 252 is a frying-pan shovel, which is so named from its similarity to that culinary utensil. It is also called the lime-shovel, as being well adapted for the spreading of lime upon the land, the raised back protecting the hand from the lime, while the sharp point passes easily under it and makes its way along the bottom of the cart. This shovel is chiefly confined to the Border counties. It makes clean work at everything, and is easily handled.

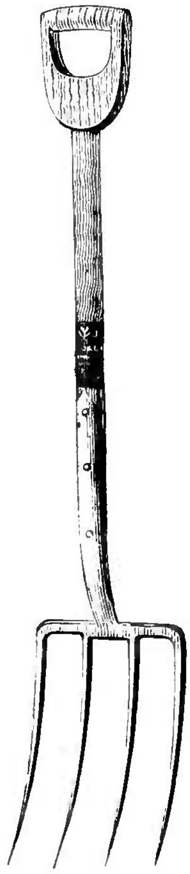


Fig. 253.—*Steel graip.*

Turning and Putrefaction.—Unless much rain has fallen from the time the dung was led out of the court until the heap is turned, the dung will not be very moist, and not at all wet, but in a good workable state, with a slight degree of heat in it. Any evaporation as yet will contain no valuable material, merely moisture, as decomposition of the dung has not begun. Very little moisture will have come from the heap.

After this turning over, shaking up, and mixing together, which should be quickly done, a heat will manifest itself in the course of a few days. The first putrefaction produces no great degree of heat, as the air is still cool at night, and the largest proportion of the heap consists of cattle-dung, which is slow of putrefaction.

Symptoms of Putrefaction.—The first external symptom of general putrefaction is subsidence in the bulk of the heap, which, in the course of 2 weeks, may contract 1 foot of height. A perceptible smell will then arise from the dung, accompanied with a flickering of the air over it, which is occasioned by the escape of vapour and of gases. By inserting a few sticks into the heap here and there, a heat considerably above that of the hand will be felt, and the relative heat of different parts ascertained; and the greatest heat may be expected at the side opposite from whence the wind comes. The actual degrees of heat may be ascertained by the dung-thermometer.

The substance of the dunghill consolidates uniformly, and a black-coloured liquid oozes out at the ground. If the soil upon which the dunghill stands is soft, the oozing is absorbed by it; but if firm, the moisture remains on the surface, and forms small pools in the ruts of the cart-wheels or open furrows. The leakage is trifling; and much moisture cannot exude from dung derived from courts in which the cattle are supplied with as much litter as keeps them dry and warm.

In some cases dung intended for turnips is twice turned, but the losses by excessive fermentation are now better understood than formerly, and farmers are therefore more careful in the treatment of their dung.

Turning Court Dung.—For potatoes, particularly well-made court dung, which has perhaps been made under roof, and is concentrated rather than rank, is considered by many to give the best results when taken direct from the court without previous turning and applied to the soil. Turning is by most farmers regarded as more necessary for turnips than for potatoes. The riper the dung—that is, if the rotten dung is thoroughly broken and evenly spread on the land—the earlier does it begin to afford nourishment to the plant, which, with the young turnips, is a matter of special importance.

Less Necessity for Turning.—The object of turning, we have seen, is to promote the rotting of the dung. One of the main objects of having the dung well ripened or rotted is to ensure its speedy action after application to the soil. Formerly, before the introduction of more quickly acting manures, there was great necessity for this, as otherwise, on account of the slow decomposition of fresh dung, the crops would be liable to suffer from scarcity of available food in their earlier stages. Now, however, the crops can be efficiently nourished in their youth by highly soluble artificial manures, which are fit for assimilation by the crop as soon as they are applied. Thus more time can be afforded to the dung for decomposition in the soil, so that there is less *necessity* for its prior ripening—less *neces-*

sity for turning, thereby saving labour and lessening the risk of loss by excessive fermentation. See pp. 501-530, vol. i.

Time of Application.—The best time for applying farmyard manure will depend upon a variety of circumstances. Chief amongst these are the character of the soil, the climate of the district, and the crop to be grown.

On very *strong land* in preparation for a root crop, the autumn may be the best time. The dung will thus have more time to exercise its beneficial mechanical influence upon the soil, while summer tillage, which would be detrimental to such land, is avoided. But there is one great obstacle to this practice. Dung cannot be applied until it is made, and the main portion of dung is made during the winter months. Thus autumn manuring is impracticable, except where stock are fed in the house in summer, or where there is on hand a reserve supply of manure.

Southern Practice without Drills.—In many parts, especially in England, the system is as follows: Assuming that the stubble is clean, such manure as exists is carted from the yards after harvest, spread on the land, and turned in with a moderately deep furrow. The land remains without further disturbance throughout the winter. As the root-sowing season approaches, the land is scuffled and harrowed, care being taken not to bring any of the crude soil to the surface. The chief desideratum on such soils, and the great secret of success, is to maintain a finely pulverised seed-bed. The mangel or turnip seeds are in this case sown in rows on the flat surface. In this way the moisture is retained, which is an important consideration under the more arid climate of the south. By careful attention to these details, a braird is almost invariably secured.

With Drills or Ridges.—If the land is to be ridged for the roots, then a somewhat different course must necessarily be pursued. The stubble is broken up by a deep furrow early in autumn. As soon as the land has become mellowed by the rains and frost, the soil is ridged up in the rough. Then when the land becomes sufficiently dry, or should a frost set in, the farmyard manure is carried and spread in the ridges which are split, and the manure covered in at the earliest opportunity. The land remains in this state until the season for sowing arrives. Advantage must then be taken of the first favourable state of the land, when a chain harrow is passed lengthways over the ridges. This has the effect of further pulverising the surface, already reduced by the action of the atmosphere.

Supplemental Manure.—If *artificial manures* are used along with the dung, now is the time to apply them, sown broadcast over the surface. A double mould-board plough is then passed between the ridges, and the fine soil set up and the seeds sown. Great care must be taken not to bring any of the solid soil to the surface. Here the young seeds find a congenial soil in which to vegetate, and a supply of moisture within available distance.

Dunging Light Soils.—The once popular system of autumn manuring on light soils is now discontinued by the best and more intelligent class of farmers. The very process of deeply stirring such soils in the autumn *in warm climates* is a source of much waste. Tillage stimulates nitrification, and the rain-water passing through the soil washes out nitrates, whether in the soil or in the manure, or both. In the south, where the winter is so mild that there may not be sufficient cold to check nitrification, such soils are usually more fertile when broken up in spring.

Northern Practice.—In the northern and colder counties different systems of tillage and manuring are pursued. Here the winter tillage of land for roots is universally pursued, so that the full benefit of the pulverising influence of the winter frosts may be secured. And this is done in these northern parts without incurring any serious loss of nitrates in drainage-water, as the winters are too cold to permit nitrification to proceed. Thus the general plan in the north is to plough land for roots with a deep furrow in the autumn or early in winter, let it lie bare till spring, then cross-plough it, and apply the dung in summer just before the seed is sown, the dung being usually spread in drills. This is the usual practice in Ireland also.

Dung for Wheat.—For wheat, the dung is either spread in the autumn, and at once ploughed in, or it is spread over the young plant during dry or frosty weather. Mr Gilbert Murray says the best results are obtained by the latter method of application.

Dung for Grass Lands.— In top-dressing grass or meadow land with dung, the general practice is to apply the dung in the autumn. Little or no loss arises through its exposure on the surface.

Surface-manuring.—It is a mistake to bury dung deeply in the soil. Indeed it is now well known that nitrification proceeds in inverse ratio to the depth at which the manure is buried; hence the best results are obtained from farmyard manure when kept near the surface. This system of surface-manuring also benefits the layers of grasses and clovers as well as the young wheat. The alleged waste by exposure to atmospheric influences is now regarded as a popular error.

Mr Gilbert Murray states that he has farmed side by side with men occupying good turnip land, whose practice was to draw out and spread the manure on the prepared land, and turn it in with a shallow furrow. The roller closely followed the plough. Their usual sowing time was the last week in June. The land, having lain three or four weeks, was scuffled, harrowed, and rolled, and the seed drilled 20 inches wide on the flat. A considerable portion of the manure was brought to the surface, yet he says he had considerable difficulty in growing a heavier weight of roots per acre on his 27-inch ridges with the manure carefully covered.

Quantities of Dung per Acre.—The old practice of applying excessive quantities of dung at one time has been shown to be wasteful. On an average of years better results will be obtained by a moderate quantity of farmyard manure, supplemented by a good selection of artificial manures.

So much depends upon soil, system of cropping, and quality of the dung, that to attempt to give definite directions as to what quantities should be applied for each crop might be more misleading than useful. From 8 to 12 tons per acre for roots, and from 15 to 20 tons for potatoes, are general dressings, along with artificial manures, which may cost from 25s. to 60s. per acre additional. In certain cases the allowance of dung would be less, and in other instances more.

Dunging Often and Lightly.—As a rule it is the best plan to dung often, and in moderate quantity at each time. As to this point, Mr Gilbert Murray says: "If the land is worked on the six course, I should divide the farmyard manure into three portions. One I should apply to the root break, supplemented by artificials—phosphates and nitrogen—a second would be spread on the young seeds immediately after the separation of the crop, and the third I should apply to the wheat stubble on the separation of that crop and in preparation for the next cereal.

"I have long been convinced of the folly of applying the whole of the fold-yard manure to the root crop. Repeated doses at short intervals is the most effective system of applying dung."

Unsatisfactory Results from Excessive Dressings.—Mr Murray adds: "For the last twenty years I have carefully watched the effects of stable manure on a kitchen-garden devoted to the production of ordinary garden produce. The extent is under 4 acres. To this has been applied the summer and winter manure of thirty horses. The manure is drawn fresh from the stables, placed in heaps, watered, and turned several times until well rotted, when it is carted on to the land and covered in with a deep spit. I can scarcely conceive a more convincing proof of the unsatisfactory results to be obtained by heavy dressings of farmyard manure alone. The crops are not better than, if so good as, those gathered from the same land twenty years ago. It is true the potatoes grow more tops, and the cabbage and cauliflower are more open than formerly. Light dressings often applied are the most efficient.

"Cabbages and mangels as field crops are gross feeders, and pay for extra dressings."

Economical Use of Dung.—It seems to be well established that dung may be, as a rule, most economically used in moderate dressings, along with judicious mixtures of more quickly acting chemical manures.

Application of Artificial Manures.

In the application of artificial manures there is ample scope for good or bad management. By the use of these manures all the elements of plant-food may be supplied either together or separately, or as many of them given and as many withheld as may be considered desirable. The subject is therefore one of vast importance, placing in the hands of the skilful farmer far greater possibilities than were within his reach when farmyard dung was the only available manure.

It is especially necessary in the use of artificial manures, that the farmer should most carefully consider the character and composition of the soil, the nature and requirements of the crops, the rotation pursued, the climate of the district in which the farm is situated, and the character of the manure itself.

Elements Absorbed by Crops.—In the first place, it would be well to have in view the amounts of the various ingredients abstracted from the soil and atmosphere for building up the substance of the crops. These have already been shown—see p. 62, vol. i., and p. 90, vol. ii.

These substances are present in soils in various proportions, the quantity of each being dependent on the origin of the soil in the first instance; and secondly, on the prior growth of plants on its surface—the residue left by the decay of these having a considerable influence on the natural fertility of every soil. The majority of these constituents exist in all soils in excess of the quantities required to build up the substance of crops, no matter what system of cropping may be pursued; and therefore the farmer, in order to render his soil fertile, has to supply only those few elements which are deficient in the soil.

Elements to be Supplied in Manures.—The subject of manuring is thus reduced to the supply of an *uncertain deficiency* of one or more of the following substances—viz., nitrogen, phosphoric acid, lime, and potash.

The form, manner, time, and quantity in which these substances are to be applied will manifestly depend on the preceding considerations enumerated in the first paragraph under the above heading—considerations which we shall now examine in detail.

Character of Soil and Manuring.—The character of a soil depends on the proportion in which its proximate constituents, sand, clay, lime, or humus, may be present. If either of these preponderate, then the product is known as a clay, sandy, calcareous, or loam soil. These have all different textures, and consequently vary in their capability of retaining the more soluble manures. Sandy and open porous loams have less power of holding manure than clays or heavy loams. Then the relative fertility of all soils is regulated by the character and composition of the materials of which the soil is made up, whether this material owes its origin to the disintegration of the rock it overlies or is transported.

A Knowledge of Geology useful.—There are few studies that would give better paying results to the farmer than that of geology, as a knowledge of the character of the soils on the various rock-formations would correct many a blunder which occurs when a farmer changes to a new locality. Farm practice must always be modified by the relation of the soil to the underlying strata, and not only this, but the system of manuring must also in so far be regulated by the same considerations.

Manures for Different Soils.—The surface-soil and the general practice as to the application of manures may now be considered. On clay soils the best results are usually obtained from nitrogenous and phosphatic manures—the former having the greater influence; on loams, from phosphatic and nitrogenous manures—the former exercising the greater power; while on sandy soils a combination of nitrogenous, phosphatic, and potassic manures generally gives the best return. Soils intermediate between either of these groups will give results in proportion to the modification of the mixture of manures.

Form of Application for Different Soils.—Then, again, the form in which the manure is applied must depend on the composition of the soil. A sandy soil cannot retain a soluble manure: for it, therefore, it is safest to give nitrogen in the form of fish guano, guano, or other organic matter; phosphates, as bone-meal or slag; and potash, as kainit. Loamy soil will usually give the most satisfactory results from nitrogen in the form of sulphate of ammonia and nitrate of soda mixed, and one of bones to two of superphosphate; whilst clay will respond most freely to nitrate of soda, and superphosphate, three parts—one of bones and two of slag.

Evidence of the Soil.—But the only evidence which is absolutely reliable as to the immediate manurial wants of a soil is that of the soil itself, as expressed, not in chemical analysis, but in various crops carefully arranged so as to test the available supplies of the different elements of plant-food contained in the land. As to how this evidence may be procured, refer to Ville's remarks on pp. 91-93, and to "Farmers' Experiments," on p. 93, in this Division.

Caution in Applying Bones.—In the application of bones, care must be taken that carbonate of lime is not present in too great a proportion, as, if it is so, the carbonic acid present in the water, instead of attacking the tribasic phosphate of lime, will combine with the carbonate of lime, and form a bicarbonate; also, if the carbonate of lime is deficient, the soluble phosphate will not precipitate, and will escape into the subsoil, or it will combine with iron and form phosphate of iron, which does not readily yield up its phosphoric acid to the plant.

Tillage and Manuring.—In applying artificial manures, it should be borne in mind that the natural source of plant-food is the soil, and that manure is merely supplemental. The farmer should therefore, by careful cultivation, endeavour to prepare these soil ingredients so as to render them available to the plant. The quantity of manure required may thus be, to a considerable extent, influenced by the care bestowed on the tillage operations. With efficient and timely cultivation, a certain amount of manure will produce better crops than would be obtained from twice as much manure with bad, ill-timed tillage. One of the most noteworthy facts demonstrated in the Rothamsted experiments is the great influence which perfect tillage and the keeping down of weeds exercise on the productive power of a soil. Indeed, the application of manures cannot possibly be profitable to the farmer unless the soil be moderately well cultivated, as well as efficiently drained.

Return of Manure on Exhausted Land.—It is often remarked by practical farmers that no soil responds more freely to the application of artificial manure than one which had been previously neglected and partially exhausted. The cause of this is obvious. By the repeated cropping without receiving an adequate return in the shape of manure, this soil becomes exhausted of certain of the elements of fertility, while by the decay of the roots of the crops other elements of plant-food are stored up in increasing quantity. Then, when the neglected land is well tilled and the deficient elements supplied in a suitable manure, the store of fertility is called into action, and the result is a bountiful crop.

Manures for Different Crops.—The form and quantity of manure must be carefully adapted to the requirements of the crop.

Limited Guidance of Experiments.—Many experiments have been carried out for the purpose of determining the best form, kind, and quantity of various fertilisers for the different farm crops; but, as has already been stated, the local circumstances of soil and climate and the customs of farming vary so greatly that the results and lessons of these experiments are not, as a rule, to be relied on as guides beyond the respective districts and conditions in which they have been conducted. The results attained at Rothamsted have most certainly been of great benefit to the agriculture of this country, yet it is well to bear in mind that the circumstances under which these have been carried out differ substantially from the conditions surrounding ordinary rotation farming such as prevails throughout the country. It is thus obvious that farmers cannot with safety resort to these experiments for specific directions as to the manuring of their land.

Value and Uses of Experiments.—With a full knowledge and intelligent conception of his own local surroundings—of the character and condition of the soil, the requirements of the crops to be grown, and the climate of the district—the farmer may unquestionably derive valuable aid in his practice of manuring, by careful study of such experiments as have been carried on at Rothamsted and elsewhere. We have taken care to provide him with convenient means of studying the results of several of the more important sets of experiments conducted in this country; and here we would specially commend the farmer to peruse the contributions to this volume by Mr Warington, on the Rothamsted experiments; by Mr Jamieson, on the experiments in Sussex and Aberdeenshire; and by Dr Aitken, on the Highland and Agricultural Society's experiments.

Manures for Slow and Fast Growing Crops.—It is important in the practice of manuring that the habit of growth of the different crops should be carefully considered. A slow-growing crop, for instance, should receive different manurial treatment from that which is best adapted to fast-growing crops. A slow-growing crop requires a mixed manure, partly soluble, and the balance coming slowly into action. Wheat, which occupies the ground for a comparatively long period, will, as a rule, be able to obtain from the soil all its mineral ingredients, and therefore a supply of readily available nitrogen seems to be all that is required. Barley, on the other hand, is a plant of more rapid growth, and being shallow-rooted, must have its food ready, and near the surface, to ensure a large produce. Then, the leaf-surface is also important, for a plant is dependent on the soil or the atmosphere for its increase, in proportion to the extent of its foliage.

Soil, Climate, and Manuring.—But a still more important consideration is the bearing of soil and climate upon the weight of the crop. For example, in a dry climate 12 to 15 tons is a very general yield of roots; while in a moist climate and favourable soil the produce per acre will be nearly 30 tons, often indeed as much as 40 tons. Now it would be manifestly absurd to apply the same quantity of manure in these two cases. To the consideration involved here is due the diversity and misunderstanding which frequently arises as to the practice of manuring. About 3 cwt. of superphosphate per acre is usually found a suitable quantity to allow for roots in the south of England, where the yield is generally under 20 tons per acre; but in the north of Scotland, where much heavier crops of roots are grown, this quantity may be increased, with economical results, to at least 5 cwt. per acre, besides, perhaps, some bones and nitrogenous manure.

Rainfall and Artificial Manures.—And the climate, particularly the rainfall, should also influence the form in which a manure is to be applied. Every farmer must have noticed that in a dry season the effect produced by artificial manures is very slight indeed, the more soluble showing better results than insoluble manures. From this it may be concluded that soluble manures are most suitable for a dry climate, whilst the less readily available kinds will give better results over a rotation of crops in a moist one.

These remarks are fully borne out by the practice pursued in different localities. In the north and east, where the climate is moderately moist, the application of artificial manure ranges from 5 to 6 cwt. per acre; while in the west and south-west, where the climate is wet, 7 to 9 cwt. per acre would be nearer the average; 3 to 4 cwt. being usual quantities in the dry climate of the south of England.

Manures for Different Rotations.—The length of the rotation must also be considered in determining the form of manure to be applied. For instance, three years' grass will necessitate a larger application of phosphates in the form of bone-meal or slag. For long rotations the slow-acting manures are employed.

More Frequent Manuring.—But many farmers now consider that it is a mistake to apply to the turnip or other green crop the entire quantity of manure required for a rotation of crops. When one considers the solubility of most of the artificial manures now in use, one can readily understand that the spreading of the manure over the crops of the rotation would result in less loss of fertilising matter, and lead to a more reliable increase of crops on an average of years. Again, the insoluble manures, by their greater specific gravity, must speedily find their way to the subsoil, where they are beyond the reach of the plant at its first period of growth. These considerations would lead the farmer to infer that a moderate dose of soluble phosphates, applied along with the seed, would be most suitable for green crops;

and if nitrogenous manure were considered necessary, then sulphate of ammonia or nitrate of soda could be given with the seed or after singling, or guano might be applied at the time of sowing.

Grass seeds then might receive an application of soluble and insoluble phosphates, along with nitrogenous manure—the mixture being varied according to the intended duration of the grass, whether two, three, four, or more years. Then, again, the corn crops after lea would require another top-dressing of phosphates and nitrate of soda. This method would be specially suitable in a climate subject to heavy rainfall, while as a rule it would be safe and economical for average conditions in this country.

Ratio of Different Ingredients.—On account of the diversity of conditions and influences which have been noticed, it is considered unsafe to attempt to prescribe definite doses of manure. But it may be stated approximately that the *ratio* of the manurial elements for green crops should be about 4 of phosphoric acid to 1 of nitrogen; for oats and barley, 2 of phosphoric acid to 1 of nitrogen; for wheat, 2 of nitrogen to 1 of phosphoric acid; and for grass, 1 of nitrogen to 2 of phosphates and 1 of potash.

Time of Application.—Until recently, artificial manures were generally applied along with the seed. Slow-acting nitrogenous manures may be thus applied, but nitrate of soda, as a rule, gives the best results when not sown till after the braird appears. When a heavy dressing of nitrate of soda is to be given, one-half the quantity should be sown then, and the balance held over for later application.

Nitrate of Soda is the most quickly acting of all nitrogenous manures, and is therefore the best adapted for a late dressing to push on a dragging crop. But in a late wet climate, or rainy season, it may not be advisable to apply nitrate of soda, for it has a tendency to force up a rank growth of straw, thus perhaps making the harvest too late, and so endangering the yield of grain.

Sulphate of Ammonia would be more suitable in these circumstances. Indeed, as a rule, in wet districts, or very rainy seasons, sulphate of ammonia gives better results than nitrate of soda. In dry seasons, and on dry soils, exactly the reverse is usually the case. But sulphate of ammonia is not nearly so well suited for top-dressing as nitrate of soda. A safe method of applying sulphate of ammonia is to mix it with dry fine soil (not ashes, as these might cause loss of ammonia), sow broadcast, and plough in immediately.

Mr Warington remarks that *top-dressing* with nitrogenous manures is especially to be avoided when the soil contains any considerable amount of lime, as loss of ammonia might then occur.

Phosphates may be sown any time during winter or early spring. The usual practice of sowing in the drill, when applied to green crops, has until lately been considered satisfactory; but new ideas have sprung up, and the action of soluble phosphates has become better understood. Yet until further information is obtained as to the benefits derived from a change of practice, farmers would do well not to rashly abandon a custom which has long been pursued with fairly satisfactory results. Farmers might advantageously experiment for themselves on this point. They might make trials of different times of application, and the result would guide them as to the best method to adopt.

Sowing Manure in Drills.—In sowing artificial manures in the drills the following plan is found to work well, the manure, as we have already seen, being conveyed to the land in carts: The loads ought each to contain 20 bushels, and thus in, say, a 20-acre field 8 loads are to be applied. The width of the field is, say, 240 yards, and we divide it into breadths of 60 yards. Two carts full of manure are unloosed in each breadth; and the sowers, one to each drill-plough, are started with a weighed quantity to sow along the drill so many yards. If the drills are 27 inches wide, then to sow 6 cwt. per acre, 21 lb. will sow one drill 200 yards. After the sower ascertains the quantity to take in the hand to effect this, he will have no difficulty in applying the quantity correctly, and he will always have a check when each pair of carts are emptied.

The reason for having the carts in pairs is to save the carrying of manure long distances. The sower can load-up himself, as the space he will thus have to travel will not be too great. In a field, say, 20 chains long, the carts will be placed, one 5 chains from the top, the other 5 chains from the bottom, about 20 yards away from the face on the prepared land, not in the drills.

Another Method.—Another method, still more precise, is conducted as follows: The manure is sown with a machine, which does three drills at once, and is riddled just before being used, so that there may not be any lumps to interfere with even distribution in sowing. The length of the drills is measured to ascertain the number required for an acre. The quantity for each drill is calculated, and the quantity necessary to sow three drills put into one of the artificial manure bags and weighed on a weighing-machine. A bag for each three drills is laid down at each end of the field, making it very convenient to put into the machine without loss of time, and each three drills in this way get their own exact quantity of manure. The weighing of the bags takes up very little time. They are filled to sight as near the quantity as can be guessed, then lifted on to the machine and adjusted to the required quantity according to the rate per acre.

This system may be considered unnecessarily precise, but the result on the crops has proved that it is worth more than the additional labour, which indeed is very little, when properly conducted.

Sowing Manures by Machines.—The practice of sowing artificial manures by machine is much preferable to sowing by hand, and it is fast coming into

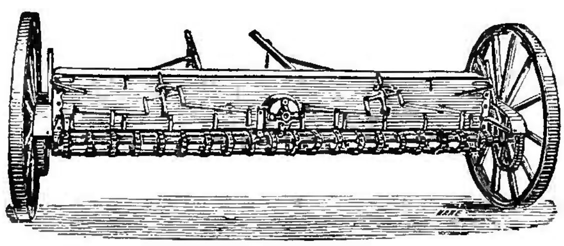


Fig. 254.—*Broadcast manure-distributor.*

favour. By an efficient machine a more even distribution can be secured, and the importance of this is not easily overestimated. Careful consideration certainly shows it to be greater than most farmers seem inclined to regard it. Unless the manure is evenly distributed, its full benefit cannot be obtained, and to secure this, the cost of an efficient manure-distributor would be a good investment. There is still scope for ingenuity in the devising of machines for this purpose, although there are already some very good distributors in existence. One of the best is that made by Ben. Reid & Co., Aberdeen, represented in fig. 254.

The hand-sower "Little Wonder," fig. 263 (p. 195), is also well adapted for sowing dry manures, and so also is Strawson's very ingenious air-power distributor.

Farmers to Judge for themselves.—It might perhaps have been expected that more precise prescriptions would have been given as to the doses of manure to apply for the various crops. Practical farmers, however, know only too well that any attempt to lay down hard-and-fast rules in manuring would be liable to do more harm than good. Doses which give good results on one farm may be quite unsuitable for another.

It has therefore been considered advisable rather to present in a convenient form such information as will enable farmers to become acquainted with the character, purchase, preparation, and application of the various manures, and thus, with a careful study of this information, be qualified to judge for themselves, and adjust their practice to suit their own peculiar plans, circumstances, and environments.

ROTHAMSTED EXPERIMENTS.

Rothamsted has become a household word wherever science is applied to agriculture. In 1834 Sir (then Mr) John Bennet Lawes succeeded to the estate of Rothamsted, Hertfordshire, and soon after began to conduct experiments with different manuring substances, first with plants in pots, and afterwards in the field. In 1840 and 1841 somewhat extensive field trials were carried out, and in 1843 the experiments were begun upon the comprehensive and systematic form which they have ever since maintained. The foundation of the Rothamsted Experimental Station is therefore usually dated from 1843.

The experiments, the most elaborate and comprehensive of the kind ever attempted in any country, have from the first been maintained entirely by Sir John Bennet Lawes, Bart., LL.D.; and with munificent liberality and public spirit he has set apart the handsome sum of £100,000, besides certain areas of land, to ensure to British agriculture the benefits and guidance derivable from the perpetual continuation of the Rothamsted experiments. The unique and splendid inheritance which the country is thus to receive from a private citizen is of priceless value.

Since 1843, Dr J. H. Gilbert has been associated with Sir John Lawes in the conduct of the experiments, and has had the direction of the laboratory. Since 1850, one, two, and sometimes three chemists have been employed in the laboratory; and, as indicating the vast amount of chemical work undertaken, it may be mentioned that in 1887 there were more than 40,000 bottles of samples of experimentally grown vegetable produce, of animal products, of ashes, or of soils, stored in the laboratory.

Besides the experiments upon crops and manures, many interesting points connected with the feeding of farm livestock have been experimentally investigated, and much of the valuable information thereby acquired has been incorporated in different parts of this work.

For the following sketch of the general scope of the investigations with manures, of the detailed experiments with wheat under different manurial treatment, of the behaviour of manurial substances in the soil, and of the loss of plant-food in drainage-water, we are indebted to Mr R. Warington, who has long been engaged in chemical work at Rothamsted.

The Soil.—Rothamsted adjoins the village of Harpenden. The land lies mostly about 400 feet above the sea. The average rainfall is about 28 inches. The surface-soil is a heavy loam, containing many flint stones; the subsoil is a pretty stiff clay, resting on chalk. The chalk is usually about 9 feet from the surface, and affords a good natural drainage. The land does not bear a high rent. The soil is a fair one for wheat, but would not be considered as specially suited for barley; it is still less suited for turnips. No sheep are kept on the farm. Dairy cows and bullocks are kept on the permanent pasture. The arable land is largely devoted to corn crops.

Scope of the Manurial Experiments.—Different fields on the farm have been set apart for the study of individual crops; thus one has been devoted to wheat, one to barley, one to roots, &c. In each of these fields the crop has, as a rule, been grown continuously for many years without the intervention of fallow or any other crop.

In the early years of the experiments trials were made with various miscellaneous manures, and the same plot of land did not each year receive the same manure, but after a little while the present systematic treatment was adopted. In nearly every case farmyard manure has been annually applied to one portion of the experimental field, while another portion has been left entirely without manure. The other plots have received the various chemical constituents of manure, either singly, or in mixture with each other. The substances applied have been generally—ammonia salts, nitrate of soda, superphosphate of lime, sulphate of potash, sulphate of magnesia, and sulphate of soda. The object has been to supply the various constituents of plant-food (see p. 57) in their most soluble and active form, and thus obtain their greatest effect. By employing substances of known composition, it is also possible to calculate how much of each constituent has been applied to the land.

Each plot of land has, during the later systematic portion of the experiments, received each year, as a rule, the same manure. The system pursued has in fact been to grow the same crop for many years on the same land with the same manure. By this plan trustworthy averages of the amount of produce yielded under each condition of manuring are obtained, and also ample information as to the influence upon the produce of seasons of different character. The permanent or temporary effect of the manures is also shown.

By long-continued treatment of this kind the soil of the experimental field, which was at first practically the same throughout, has been altered, so that the different plots now represent extremely different conditions of food-supply. On certain plots the crop now grows in soil specially exhausted of nitrogen, or phosphates, or alkalies, to an extent which can very rarely occur in farm practice; while in the soil of other plots abundance of these constituents has accumulated.

The work has not been confined to a determination of the amount of produce obtained from each manure; the crops have themselves been analysed at the Rothamsted laboratory. Information has thus been obtained as to the proportion of the manure that is recovered in the increase of the crop; and also respecting the alteration in the composition of the crop brought about by the differences in the composition of the soil, and the character of the season.

Soil and Drainage-water Investigations.—The investigation has further extended to the soil. After applying the same manure to the same land for many years, it becomes possible to learn by soil analysis what accumulation or exhaustion has taken place, and the depth to which manure has penetrated. In one of the fields the drainage-waters are collected and examined: the nature and amount of the soluble matters lost by drainage, under various conditions of manuring, are thus indicated. The investigations relating to the soil are, from the difficulty of the subject, in a less advanced stage than those relating to the effect of manures on crops.

Scientific Character of the Trials.—It will be seen from the above sketch that the object of the investigations has been purely scientific. It has not been the aim to discover the most economical manuring for each crop. None of the experiments have been designed with a view to a money profit; on very few of them would there be any profit if conducted on a large scale. The whole in vestigation, therefore, stands condemned by the so-called "practical" man as a mere scientific amusement, from which he has nothing to learn. He, indeed, may learn little, but it will be because he lacks the elementary knowledge which is necessary for an appreciation of the results.

The mode of investigation adopted is, however, one which must add largely to our true knowledge of crops, manures, and soil. This knowledge will be turned to practical account in a number of ways by a skilful farmer; but to provide him with practical rules has not been the object of the investigation. To have made the practical result the chief object, would have cramped the whole inquiry, and defeated its highest purpose.

EXPERIMENTS ON THE CONTINUOUS GROWTH OF WHEAT.

The experiments on wheat are among the oldest of those at Rothamsted. Broadbalk field has been under arable culture for at least two or three centuries. It grew its last turnip crop in 1839: this was followed by barley, peas, wheat, and oats. The last four crops were without manure.

The continuous growth of wheat commenced in 1844, and has since proceeded without interruption, so that the present crop (1889) is the 46th. The cultivation of the land has been that usual in the district; there has been no deep ploughing. The seed used in the first 5 seasons was old Red Lammas; then followed Red Cluster (4 seasons), Red Rostock (29 seasons), Square Head (8 seasons). The area of the full-sized plots (*a* and *b*) is 6-10ths of an acre; there are some half plots. All the artificial manures are sown broadcast, screens being carried on each side of the sowers to prevent the manure falling on other plots. The wheat is drilled in October, 2 bushels of seed being used. In the spring and early summer great care is taken to remove weeds. The luxuriance of weeds, in the absence of fallow crops, will always prove a practical objection to the continuous growth of corn, and especially of winter corn.

Without Manure.

In Table I. is shown the average produce per acre on Plot 3, without manure, in four succeeding periods of ten years, and during the last five years.

[TABLE I.

TABLE I.—PRODUCE OF WHEAT WITHOUT MANURE, FORTY-FIVE YEARS, 1844-88.

	Dressed Corn.		Total Produce.
	Quantity.	Weight per Bushel.	
	bush.	lb.	lb.
Ten years, 1844-53	15¾	58.3	2711
" 1854-63	16½	57.6	2728
" 1864-73	12¾	59.0	1924
" 1874-83	10¼	58.3	1614
Five years, 1884-88	12½	59.7	1648
Mean of forty-five years	13⅝	58.5	2178

If all the seasons had been perfectly alike, the produce of the unmanured land would doubtless have fallen steadily throughout the experiment—more rapidly at first, and very slowly afterwards. The very variable character of the seasons in our climate prevents any such regularity in the produce. The course of change is best seen by looking at the amounts of "total produce."

The average produce of forty-five years of continuous wheat-growing without manure is seen to be 13⅝ bushels. It is interesting to note that this amount is quite equal to the average yield of the principal wheat-producing countries of the world. Thus, the average yield of the United States is 12 bushels, of Australia 11 bushels, and of India 10 bushels.

With Farmyard Manure.

Ordinary yard manure, at the rate of 14 tons per acre, has been annually ploughed in in October on Plot 2; the produce is shown in Table II.

TABLE II.—PRODUCE OF WHEAT WITH FARMYARD MANURE, FORTY-FIVE YEARS, 1844-88.

	Dressed Corn.		Total Produce.
	Quantity.	Weight per Bushel.	
	bush.	lb.	lb.
Ten years, 1844-53	27	59.8	4828
1854-63	37¾	60.3	6355
" 1864-73	35¼	60.8	5797
" 1874-83	29⅝	60.1	5086
Five years, 1884-88	36¼	62.0	5778
Mean of forty-five years	32⅝	60.4	5546

Plant-food in Dung.—The amount of plant-food supplied is much larger than on any other plot in the field. The fourteen tons of farmyard manure are estimated to contain 201 lb. nitrogen, 235 lb. potash, 35 lb. magnesia, 31 lb. lime, and 78 lb. phosphoric acid, with a number of other substances, including a large amount of silica, which is at present supplied to no other plot in the field. In consequence of this large supply there has been a great accumulation of manurial matter in the soil, which is now far richer than that of any other plot in the field.

Limits to High Manuring.—The

table shows a considerable rise in the produce during the earlier years of the experiment, owing to the accumulation of food in the soil. This rise afterwards ceases. Everything, indeed, in nature tends to come to an equilibrium. On the unmanured land the crop falls, till its demands equal the annual supply from soil and atmosphere. On the dunged plot the produce rises, till here, too, the crop equals the annual supply of assimilable food. With very high manuring we meet with another limit, that of season. A larger crop cannot be produced by manure than the character of the season will admit of.

The average produce with farmyard manure in forty-five years has been 32⅝ bushels; the highest produce was 44 bushels in 1863.

Nitrogen in Dung.—Notwithstanding the richness of the soil, the farmyard manure plot very seldom yields the highest produce in the field, both nitrate of soda and ammonia salts proving more effective. The nitrogen in farmyard manure is in fact principally combined with carbon, and exists as nitrogenous humic matter; only a limited portion of this is each season oxidised, the nitrogen forming nitrates, and thus becoming available to the crop.

Mechanical Influence of Dung.—Not a few of the advantages attending the use of farmyard manure are due to its improvement of the physical condition of the soil. In the present case the soil, while becoming less heavy, has also become more retentive of moisture, and the crop thus suffers less in time of drought (*Jour. Royal Agric. Soc.*, 1871, p. 91). The produce of this plot is more even, and less affected for good or evil by the vicissitudes of season than the other highly manured plots in the field.

With Ash Constituents.

When water has been removed, the constituents of a plant may be classed under two heads—the combustible and the incombustible.

The *incombustible* portion is very small; in wheat grain it is about 1.7 per cent, in wheat straw about 4.6 per cent. It consists of the phosphates, potash, lime, magnesia, silica, &c., derived from the soil.

The *combustible* part is made up of the carbon, oxygen, and hydrogen derived from the atmosphere and rain, and of the nitrogen derived from the atmosphere and soil. The quantity of the principal ash constituents, and of nitrogen, contained in a wheat crop of 30 bushels, has been already given on p. 63.

Of the substances present in the ash, six—potash, lime, magnesia, iron, phosphoric and sulphuric acid—are quite indispensable for plant-growth.

Mineral Theory.—At the time when the Rothamsted wheat experiments commenced, chemists had a very exaggerated notion of the amount of ammonia annually supplied by rain. Liebig, owing to this mistaken idea, taught in 1843 that the ashes of a manure contained its true active ingredients; that where the necessary ash constituents of a crop were supplied by manure, the crop would have no difficulty in obtaining all the nitrogen it required from the atmosphere. This view was known as the "mineral theory." The state of opinion at the time must be borne in mind in considering the Rothamsted field experiments, as they were planned to a considerable extent to test the truth of the mineral theory.

In the first season of the wheat experiments (1843-1844), one plot received 14 tons of farmyard manure, and a second plot the ashes from another lot of 14 tons, with the following result:—

	Dressed Corn.	Total Corn.	Total Produce.
	bush.	lb.	lb.
Farmyard manure, 14 tons	20½	1276	2752
Ashes of ditto	14½	888	1992
Unmanured.	15	923	2043

The plot receiving the ashes thus yielded no more produce than the plot entirely without manure.

Various systematic experiments have since been made with the ash constituents of wheat; these have been supplied in abundance, and the crop left to obtain its carbon and nitrogen from the natural resources of the soil and air.

One plot has received superphosphate of lime only; one a mixture of the sulphates of potash, soda, and magnesia; and one these sulphates together with superphosphate. The latter mixture is termed by Lawes and Gilbert the "mixed mineral" manure. It has generally consisted of 3½ cwt. superphosphate, 200 lb. sulphate of potash, and 100 lb. each of sulphate of soda and magnesia, per acre.

The mixed sulphates of potash, soda, and magnesia, applied for thirty-two years (Plot 1), have not increased the produce at all. Superphosphate of lime applied alone (Plot 0) has, on an average, increased the corn by 3 bushels, and the straw by 2 cwt. The mixture combining both manures (Plot 5) has given an increase of about 2 bushels of corn, and 1¾ cwt. of straw over the produce of the unmanured land.

Nitrogen of the Soil and Atmosphere Insufficient.—As these manures have supplied all the ash constituents of the wheat crop (excepting silica, which we shall presently see to be non-essential), it is quite evident that the amount of the other necessary elements of plant-food supplied by the soil and atmosphere was insufficient to produce a full crop of wheat. The crop grown with a full supply of ash constituents on Plot 5 has contained, on an average, about 20 lb. of nitrogen per acre per annum. This quantity represents the average amount furnished by the soil and atmosphere without the aid of manure.

We shall presently see that the growth of wheat on these plots was really limited by the small quantity of nitrogen at the disposal of the crop. When nitrogen is supplied, phosphates and potash become important elements in producing growth.

Ammonia Salts with Ash Constituents.

The ammonia salts employed have been a mixture of equal parts sulphate and chloride: 200 lb. of this mixture are estimated to contain about 43 lb. of nitrogen. The systematic experiments with ammonia salts did not begin, in several cases, till 1852. We shall therefore take the average produce after this date as the basis of our comparison:—

TABLE III.—PRODUCE OF WHEAT VARIOUSLY MANURED, AVERAGE OF THIRTY-SIX YEARS.

Plot.		Average Produce, 36 Years, 1852-87.				Average Total Produce.		
		Dressed Corn.		Straw and Chaff.	Corn to 100 Straw.	First 18 Years, 1852-69.	Second 18 Years, 1870-87.	Second 18 Years, per 100 of first 18.
		Quantity.	Weight per Bushel.					
		bush.	lb.	cwt.		lb.	lb.	
3	No manure	13	58	11	66.5	2421	1669	68.9
5	Mixed ash constituents	15⅛	58⅞	12⅝	66.9	2786	1944	69.8
6	Do., and ammonia salt, 200 lb.	24	59⅝	21⅞	61.6	4480	3449	77.0
7	Do. do. 400 lb.	32¾	59¾	33¼	56.0	6295	5300	84.2
8	Do. do. 600 lb.	36½	59⅝	40¼	51.5	7152	6518	91.1
10a	Ammonia salts, 400 lb.	20½	57¼	18¾	61.8	4018	2788	69.4
11	Superphosphate and ammonia salts, 400 lb.	25¾	57⅞	24¼	60.1	4936	3758	76.1
2	Farmyard manure, 14 tons	33¾	60¼	31⅝	60.4	6066	5299	87.4

Table III. shows, that whereas the continued use of ash constituents alone increased the crop by only 2⅛ bushels, the addition of 200 lb. of ammonia salts gave a further increase of 8⅞ bushels, the addition of 400 lb. of ammonia salts an increase of 17⅝ bushels, and the addition of 600 lb. an increase of 21⅜ bushels. The produce with ash constituents and 400 lb. ammonia salts (Plot 7) nearly equals in corn, and exceeds in straw, the produce from the annual application of 14 tons farmyard manure; while the produce with 600 lb. of ammonia salts (Plot 8) considerably exceeds both in corn and straw that yielded by the dung. The far greater effect produced by the nitrogen of the ammonia than by the nitrogen of the dung is very evident, 86 *lb. of nitrogen as ammonia being on a long series of years nearly equal to* 201 *lb. applied as dung.*

Organic Manures Unnecessary.—These results throw a flood of light on the conditions required for producing good wheat crops. The manure applied to these ammonia plots has been purely inorganic, it has contained no carbon; yet the produce has been large, and in favourable seasons very large. In 1863 the yield of corn on Plot 7 amounted to 53½ bushels per acre. About 1 ton of carbon is contained in the average crop of Plot 7, and still more in that of Plot 8. All the carbon assimilated by these crops has been derived from the atmosphere. *The atmospheric supply of carbon is apparently sufficient for the largest cereal crops.* Such crops may be obtained in favourable seasons by the use of purely inorganic manures.

Silica Unnecessary.—The results are equally conclusive as to the uselessness of applying silica in manure. The composition of cereal crops given on page 63 shows silica to be by far the largest constituent of the ash of straw, and to its presence the stiffness of the straw has been too hastily attributed. German experiments have shown that silica is not an indispensable constituent of cereal crops; that fully developed plants can be obtained without it; and that in these plants the straw does not show any want of stiffness.

At Rothamsted, wheat crops, above the average produce of the country, have been continuously obtained for forty years with manures supplying no silica. The produce with these manures has indeed been larger than that yielded by farmyard manure which supplies silica. To make the test still more complete, one-half of several of the plots received for four years an application of soluble silicates, and in the succeeding twelve years the straw of the crop was returned to the land. The half plots thus treated have not shown any increase of produce, save in those cases where the straw was helpful by supplying potash; nor has the wheat-straw any greater power of standing in rough weather than that grown without silica in the manure.

Artificial Supply of Nitrogen essential for Wheat.—The evidence afforded by these experiments with ammonia salts shows unmistakably the great need of the wheat crop for an artificial supply of nitrogen, if full crops are to be continuously obtained. The assimilable nitrogen furnished by the air and rain is quite insufficient for the production of a full cereal crop. The annual application of 86 lb. of nitrogen per acre, in the form of ammonia, has raised the average produce from 15⅛ bushels to 32¾ bushels per acre.

Manures best for Cereals.—The manures which experience has proved to be most effective for wheat, barley, or oats, are those which, like guano, nitrate of soda, and sulphate of ammonia, supply nitrogen in a form readily assimilated by plants. The enrichment of the surface-soil with nitrogen is also the main effect of a variety of agricultural methods commonly employed to render land fit to produce good crops of cereals.

Excessive Dressings Unprofitable.—It will be noticed that the application of 200 lb. of ammonia salts per acre gave an average increase of nearly 9 bushels of corn, and 9¼ cwt. of straw. The addition of a second 200 lb. of ammonia salts gives a further increase of nearly 9 bushels of corn, and 11⅜ cwt. of straw. The 400 lb. of ammonia salts was thus not an excessive dressing. With a further addition of 200 lb. ammonia salts, however, the return is greatly diminished, the increase only amounting to 3¾ bushels of corn, and 7 cwt. of straw. It is plain, therefore, that 600 lb. was not an economical dressing.

For thirteen years, 1852-64, as much as 800 lb. of ammonia salts were applied to one of the plots. The average produce of different amounts of ammonia during these thirteen years was as follows:—

TABLE IV.—PRODUCE OF WHEAT WITH VARIOUS QUANTITIES OF AMMONIA SALTS, AVERAGE OF THIRTEEN YEARS, 1852-64.

Plot.	Manuring.	Dressed Corn.		Straw and Chaff.	Corn to 100 Straw.
		Quantity.	Weight per Bushel.		
		bush.	lb.	cwt.	
5	Mixed ash constituents .	18¼	58⅛	16⅝	62.6
6	Do. with ammonia salts, 200 lb.	28½	58⅞	27⅛	58.8
7	" " " 400 lb.	37⅛	58¾	38⅛	54.6
8	" " " 600 lb.	38⅞	58¼	42¾	51.2
16	" 800 lb.	39½	58	46⅝	47.8

We have here a successive increase of 10¼, 8⅝, 1¾, and ⅝ bushels of corn, and 10½, 11, 4⅝, 3⅞ cwts. of straw for each additional 200 lb. of ammonia salts.

High Manuring and Wet Seasons.—It will be noticed that though the crops are larger in this shorter experiment, the return for the second and third addition of ammonia is less than in the longer series of trials. We shall see presently that the nitrogen of the ammonia is liable to be removed as nitrates in the drainage-water in wet seasons. When this happens, the plots receiving an excessive manuring will suffer least; as, notwithstanding their loss, they may retain enough to carry the crop. The explanation of the difference in the two series is therefore apparently to be found in the large number of wet seasons during the latter part of the last thirty-six years.

Corn and Straw from High Manuring.—It will be observed that there is a much larger increase of straw than of corn with the heavier dressings of ammonia salts; the proportion of corn to straw diminishes, indeed, with each addition of ammonia.

The quality of the corn is improved by the use of 200 lb. and 400 lb. of ammonia salts, but with further additions of ammonia the weight per bushel begins to decline.

Ammonia Salts alone.

We come now to Plot 10*a*, which has received annually 400 lb. of ammonia salts, without any supply of phosphates, potash, magnesia, lime, or other ash constituents (saving the sulphuric acid and chlorine in the ammonia salts). This treatment has dated from 1845. The average produce in thirty-six years has been 20½ bushels and 18¾ cwt. of straw; or 7½ bushels and 7¾ cwt. of straw over that of the unmanured land.

Natural Supplies of Ash and Nitrogen.—While the crop on Plot 5 was entirely dependent upon natural sources of nitrogen, the crop on Plot 10*a* has been wholly dependent upon natural sources for its ash constituents. The supply of ash constituents from the soil has clearly been insufficient, for the same amount of ammonia salts, when aided by a manuring of ash constituents (Plot 7), has produced a much larger crop than on Plot 10*a*.

The natural supply of ash constituents, though insufficient, is, however, more effective than the natural supply of nitrogen; for while, on Plot 5, the natural supply of nitrogen only produces 15⅛ bushels, the natural supply of ash constituents is equal to the production of 20½ bushels.

Soils better Supplied with Ash than with Nitrogen.—The fact just stated is one that holds true in general agricultural experience. A purely nitrogenous manure will, in a vast majority of cases, produce a greater effect on wheat or other cereals than any manure supplying ash constituents; not because the latter are less necessary for the growth of the crop, but because the soil is generally far better supplied with available ash constituents than it is with available nitrogen.

It must be recollected also, that the average results obtained in these Rothamsted experiments with purely nitrogenous manures, are by no means so good as would be obtained in ordinary practice. The soil on Plot 10*a* is now in fact exhausted of ash constituents by forty-four successive wheat crops, removing, at least 900 lb. of potash and 500 lb. of phosphoric acid per acre. In the earlier years of the experiment the ammonia salts applied alone gave a much better result than they do at present.

Importance of Ash Constituents.—The importance of ash constituents when nitrogen is supplied is strikingly shown by comparing the produce of the exhausted soil on Plot 10*a* with that of the soil of Plot 7, which has annually received an abundance of ash constituents, with the same amount of ammonia. The average produce with ash constituents and ammonia is 12¼ bushels greater than with the same quantity of ammonia applied alone. *As nitrogenous manures are by far the most costly that a farmer purchases, it is important to remember that economy in their use depends a great deal on there being a sufficient supply of available phosphates and potash in the soil.*

Ammonia with Individual Ash Constituents.

On Plot 11 the 400 lb. of ammonia salts have been continuously applied with superphosphate. The average produce is 25¾ bushels, and 24¼ cwt. of straw; or 5¼ bushels and 5½ cwt. of straw more than that given by the ammonia salts alone. Thus, on a phosphate exhausted soil, superphosphate becomes a paying manure for wheat if nitrogen is not deficient.

The produce on this plot is, however, far below that on which *all* the necessary ash constituents are applied. The *superphosphate* has increased the produce of the ammonia by 5¼ bushels, but the *mixture of ash constituents* applied on Plot 7 increases the produce by 12¼ bushels. The mixed ash constituents include potash, soda, and magnesia.

A series of experiments has been made in which the sulphates of potash, soda, and magnesia have been used separately, each with ammonia salts and superphosphate. Unfortunately, previously to the commencement of this trial in 1852, the whole three plots had received during five or six years heavy dressings of potash. It has therefore required a considerable time for the want of potash to affect the amount of produce. Taking, however, the average of the last five seasons, 1884-88, the effect of the special manuring is tolerably apparent, as will be seen from Table V.

TABLE V.—PRODUCE OF WHEAT VARIOUSLY MANURED, AVERAGE OF FIVE YEARS, 1884-88.

Plot.	Manured with Ammonia Salts and Superphosphate.	Total Corn.	Straw and Chaff.	Corn to 100 Straw.
		lb.	lb.	
11*b*	Alone	1323	2019	65.5
12*b*	With soda	1777	2721	65.3
14*b*	With magnesia	1848	2810	65.8
13*b*	With potash	1983	3108	63.8
7*b*	With soda, magnesia, and potash	2130	3322	64.1

The *sulphate of potash* thus yields the largest crop, and its excess over the soda and magnesia will doubtless become more marked as exhaustion of potash proceeds on these plots.

Relative Importance of the Ash Constituents.—*Phosphoric acid* and *potash* are the ash constituents of the greatest importance to the wheat crop, and indeed to every other crop. *Magnesia* is a less important ash constituent of wheat, and is usually found in sufficient abundance in the soil. *Soda* is found to a very small extent in the mature crop; but soda salts have some effect as manure: they probably act by liberating potash in the soil. *Lime* scarcely occurs in wheat grain, and to only a small extent in the straw; the natural supply is quite sufficient.

Effect of Autumn and Spring Applications of Ammonia Salts.

Up to the year 1872, the whole of the manures, with the exception of nitrate of soda, were applied to the land in autumn at the time of wheat-sowing, and ploughed in.

With the season 1872-73, an experiment commenced on the comparative effect of autumn and spring applications of ammonia salts. For five years (1873-77) Plot 15 received 400 lb. of ammonia salts as a top-dressing at the end of March or beginning of April, while Plot 7 received the same amount when the wheat was put in in October. For the autumn of 1877 the manuring was reversed, Plot 15 now received the ammonia salts in the autumn, and Plot 7 received them in the spring. Both plots had at all times a complete autumn manuring with ash constituents.

The comparative results in ten years of autumn and spring manuring are shown in Table VI.

TABLE VI.—COMPARATIVE EFFECT OF AUTUMN AND SPRING SOWING OF AMMONIA SALTS.

	Rainfall.		Drainage, 5-ft. Gauge.		Total Produce, Corn and Straw.		
	Autumn Manuring to Spring Manuring.	Spring Manuring to end of July.	Autumn Manuring to Spring Manuring.	Spring Manuring to end of July.	Autumn Manuring.	Spring Manuring.	Spring + or − Autumn.
	inches.	inches.	inches.	inches.	lb.	lb.	lb.
1872-73	18.53	6.92	11.45	0.42	3344	5031	+1687
1873-74	7.05	7.93	2.89	0.58	7094	4588	−2506
1874-75	10.55	13.55	5.21	3.86	5110	4915	− 195
1875-76	12.17	7.58	10.14	1.94	3793	4083	+ 290
1876-77	22.01	8.18	15.78	1.18	3048	4795	+1747
1877-78	11.17	12.96	8.11	6.02	4486	7017	+2531
1878-79	15.05	17.10	13.09	6.76	1275	4063	+2788
1879-80	5.78	10.82	3.37	1.58	6309	6155	− 154
1880-81	15.20	6.16	12.75	0.25	3489	3917	+ 428
1881-82	10.34	14.73	7.62	4.48	5948	7981	+2033
Mean	12.79	10.59	9.04	2.71	4390	5255	+ 865

Spring Sowing preferable.—It appears that, out of the ten seasons, there was one (1874) in which the autumn sowing of the ammonia salts gave decidedly the best result; there were four in which the difference between autumn and spring sowing was very small; there were five in which the spring sowing gave much the best result. The average result was thus decidedly in favour of spring sowing.

Rainfall and Time of Sowing Manure.—When we turn to the other columns in the table, it is plainly seen that the advantage or disadvantage of autumn sowing depends on the amount of the rainfall. The autumn application of ammonia salts is advantageous only when a dry winter follows their application. *This is owing to the fact that ammonia is converted into nitrates in the soil; and the soil, having no power of retaining nitrates, they are liable to be washed into the subsoil by heavy rain, and to be carried in drainage-water beyond the reach of the roots.* This is what happens during a wet winter.

In the table, the quantity of rain, and the amount of drainage-water passing through 5 feet of uncropped soil (60-inch drain-gauge), in each season, is given.

It will be noticed that a wet winter, in some cases (1880-81), does little harm to the autumn-sown ammonia salts. In these cases the wet winter is followed by a dry summer, and the crop is able to draw up from the soil the solution of nitrates which had passed downwards.

The worst results of autumn manuring are when a wet winter is followed by a wet summer (1877-78, 1878-79, 1881-82). In these cases the nitrates washed below are kept down by the subsequent spring and summer rainfall.

In consequence of these results, the time for applying the ammonia salts to the experimental plots in the wheat-field has been altered. For 1878-83, the ammonia was (save on Plot 15) applied entirely in the spring. Since then 100 lb. of ammonia salts have been applied in autumn and the remainder in spring.

With Nitrate of Soda.

The trials with nitrate of soda commenced in 1852, but the quantities of manure used did not become constant till 1855. We shall therefore quote the results from the latter year. As one object of the experiment was to compare the effect of nitrogen in the two forms of *ammonia* and *nitric acid*, the quantity of nitrate of soda employed was arranged to supply the same weight of nitrogen (86 lb.) as 400 lb. of ammonia salts. The quality of the ammonia salts employed has since improved, so that in later years the quantity of nitrogen supplied as ammonia has probably exceeded by 3 or 4 lb. that supplied as nitric acid. The nitrate of soda has always been applied as a top-dressing at the end of March or beginning of April. The ammonia salts on the comparative plots were applied in autumn, till the season 1877-78.

TABLE VII.—PRODUCE OF WHEAT WITH NITRATE OF SODA AND AMMONIA SALTS, AVERAGE OF THIRTY YEARS, 1855-84.

Plot.	Manure.	Average Produce, 30 Years, 1855-84.				Average Total Produce.		
		Dressed Corn.		Straw and Chaff.	Corn to 100 Straw.	First 15 Years, 1855-69.	Second 15 Years, 1870-84.	Second 15 Years, per 100 of first 15.
		Quantity.	Weight per Bushel.					
		bush.	lb.	cwt.		lb.	lb.	
3	No manure	13	58¼	10⅞	66.9	2390	1670	69.9
5	Mixed ash constituents	15⅛	59⅛	12⅜	68.5	2695	1964	72.8
7	Do., ammonia salts, 400 lb. . .	33	59⅞	33¼	56.6	6284	5350	85.1
9*a*	Do., nitrate of soda, 550 lb. .	37½	59¼	43	49.3	7368	7026	95.3
10*ab*	Ammonia salts, 400 lb.	21¾	57¾	19⅞	62.3	4271	2947	69.0
9*b*	Nitrate of soda, 550 lb.	23½	56⅞	24⅝	53.7	4971	3489	70.2

Nitrate of Soda excels Ammonia Salts.—The nitrate of soda applied alone has given 1¾ bushels more corn and 4¾ cwt. more straw than the corresponding plot receiving ammonia salts. Where an abundance of ash constituents is supplied, as on Plot 9*a*, the advantage from the use of nitrate of soda is still more marked, the excess over the corresponding ammonia plot reaching 4½ bushels and 9¾ cwt. of straw.

As the nitrate of soda, from its well-known solubility, has always been applied in the spring, and the ammonia salts have, in most years of the experiment, been applied in the autumn, the comparison may be thought hardly fair to the ammonia. In Table VIII., the produce by nitrate of soda is compared with that given both by autumn and spring dressings of ammonia salts during ten years, each manure supplying approximately the same quantity of nitrogen, and the land receiving in every case a full supply of ash constituents in the autumn. It will be seen that, on an average, the spring-sown ammonia was 4⅛ bushels better than the autumn sown, and the nitrate of soda 4⅞ bushels better than the spring-sown ammonia. With the straw, the spring-sown ammonia is 5⅜ cwt. better than the autumn sown, and the nitrate 10 cwt. better than the spring sown.

Influence of Rainfall.—Ammonia salts and nitrate of soda compare, however, very differently in different seasons; there are seasons in which the nitrate is immensely superior, and there are some seasons in which the ammonia salts give an equal or better result. With a dry spring and summer the nitrate is generally much superior to a spring dressing of ammonia salts, the nitrate being immediately available to the plant, while the ammonia has to undergo the process of nitrification, which in dry weather is not speedy. On the other hand, in a wet spring, the nitrate is subject to immediate loss by drainage, while the ammonia is not lost till it is nitrified, and thus for a few weeks partially escapes the losses which the nitrate is undergoing. In Table VIII., the comparative effect of nitrate of soda and ammonia salts is given for the ten seasons of which the rainfall and drainage have been already given in Table VI.

TABLE VIII.—PRODUCE OF NITRATE OF SODA, AND OF AUTUMN AND SPRING SOWN AMMONIA SALTS, IN VARIOUS SEASONS.

Season.	Ammonia Salts, 400 lb.				Nitrate of Soda, 550 lb.	
	Autumn Sown.		Spring Sown.		Spring Sown.	
	Corn.	Straw.	Corn.	Straw.	Corn.	Straw.
			bush.		bush.	cwt.
1872-73	22	18	32⅝	27½	35¾	35⅛
1873-74	39½	41½	29⅛	24¾	38¼	44¾
1874-75	25⅞	30½	25½	28½	30½	42⅜
1875-76	23½	19¾	25½	21¾	33¼	32
1876-77	19⅞	16⅜	33⅛	24⅞	40⅛	34⅜
1877-78	22⅛	27⅜	31¼	44¼	37¼	50¼
1878-79	5⅜	8⅛	16¼	26⅞	22	38⅞
1879-80	36¼	36	34½	35¾	34	39¼
1880-81	25¼	17⅝	26⅝	19⅝	35½	32½
1881-82	29	36½	35¾	51⅛	31⅞	56
Mean	24⅞	25⅛	29	30½	33⅞	40½

It would require a detailed discussion of the character of each season, month by month, if we were to attempt to explain all the differences between the crops; we can only refer to the most striking instances. In 1874, 1876, 1877, and 1881, the nitrate crop exceeds the spring-sown ammonia crop by 7 to 9 bushels, and 10 to 20 cwt. of straw; these are all years in which the spring and summer rainfall are on the whole conspicuously deficient. In 1882 the spring-sown ammonia yields 4 bushels more than the spring-sown nitrate. This year is seen by Table VI. to have had the wettest spring and summer in the series, with the exception of 1879. In 1882, however, a large excess of rain occurred in April; while in 1879 the great excess did not commence till May; the nitrate not yet taken up by the crop thus probably suffered a greater loss in the former season than in the latter. In two seasons, 1874 and 1880, the autumn-sown ammonia salts beat the nitrate in yield of corn. These two seasons have a very dry winter, as well as a dry spring; the rain from spring sowing to the end of June in those two years was but 5.12 and 5.56 inches respectively. The weather during spring was apparently too dry for the nitrate to attain a proper diffusion in the soil. The nitrates from the autumn-sown ammonia were better diffused, and gave the larger produce.

Practical Conclusions.—It is evident from the facts now mentioned that nitrate of soda will give a better return than spring applications of ammonia salts in a dry climate. In a very dry climate the nitrate should be applied very early, or ammonia salts should be employed in the autumn instead. Where the spring months are usually wet, the nitrate should be applied in two dressings, or recourse had to ammonia salts. When a late dressing is needed, nitrate of soda should be preferred to ammonia salts, as its nitrogen is immediately available. Very late dressings produce straw rather than corn.

Proportion of Corn to Straw.

In Tables III. and VII. will be found the proportion of corn to 100 straw in the produce of the various manures we have considered. The proportion of corn is highest in the produce of the unmanured land, and on that receiving only the ash constituents of the wheat crop.

The addition of any manure producing luxuriance of growth increases the proportion of straw; thus, by the continuous application of farmyard manure, the proportion of corn to 100 straw falls from 66 to 60.

With increasing quantities of ammonia salts, applied with ash constituents, the proportion of corn gradually falls, being 61.6, 56.0, and 51.5, with 200, 400, and 600 lb. of ammonia salts. This considerable increase in the proportion of straw with the higher amounts of ammonia is not, however, entirely due to the ammonia, as on Plot 10*a*, with 400 lb. of ammonia salts alone, the proportion of corn is 61.8; and on Plot 11, with the same quantity of ammonia with superphosphate, the proportion is 60.1 to 100. The increase in straw is clearly due in great part to the potash supplied on Plots 6, 7, and 8, which helps largely to form straw when the nitrogen necessary to nourish the crop is present.

The proportion of straw is much greater with nitrate of soda than with ammonia salts (Table VII.) Here, too, the effect of the ash constituents is seen, for while the nitrate alone gives 53.7 of corn to 100 straw, the proportion when phosphates and potash are added is 49.3 to 100.

Diminution in Produce.

In Tables III. and VII. we have given the total produce of the various plots during the first and second half of the period of experiment. In every instance there is a diminution of produce in the more recent years. The plots receiving the most abundant manuring, as 2, 7, 8, 9*a*, are those which have suffered least in the second period; the diminution in their case varies from 5 to 16 per cent. The smallest diminution takes place on Plot 9*a*, receiving nitrate of soda and ash constituents. In these cases we may probably assume that the decline in produce is due to the inferiority of the seasons in later years.

The produce of other plots, as 3, 5, 10, and 9*b*, shows a diminution of about 30 per cent in the second period. We have here, besides the effect of bad seasons, the still greater effect of the gradually progressing exhaustion of the soil.

Influence of Season.

The 45 successive wheat crops in Broadbalk field at Rothamsted, grown for the most part under the same conditions as to manuring every year, afford splendid material to the statistician for indicating the varying produce of the country in different seasons. We cannot in this place regard them in this wide aspect. The produce of each plot, and the character of each season, during 40 years, will be found in two papers by Messrs Lawes and Gilbert, in *Jour. Royal Agric. Soc.*, 1864, 93; 1884, 391. To these papers, and to a paper, "Our Climate and our Wheat Crops," *ibid.*, 1880, 173, we must refer for full details. We have here to regard the influence of season as a condition affecting the fertility of soil and the action of manures.

Every farmer knows that the effect of season is greater than the effect of manure. A season may be so bad that the best soil and manure may yield a miserable produce, and it may be so good that moderate manuring may nearly equal in result a liberal treatment. A suitable manuring will, however, assert itself in a large majority of cases, redeeming a bad season from utter loss, and securing from a good season the grand return which it is capable of yielding.

Influence of Light and Heat.—No large crop can be obtained without a sufficient amount of light and heat, as the assimilation of carbon from the atmosphere only occurs with suitable light and temperature. The formation of seed especially requires heat. A bulky crop in June will produce abundance of corn in July, if this month is warm, and not too wet; but it will remain a crop of straw if July is cold and rainy. The corn produced in a cold wet summer is also imperfectly developed; it contains less starch, and a larger proportion of albuminoids and ash constituents, than well-ripened grain, and has a low weight per bushel. The same defect in the corn may be brought about by premature ripening, occasioned by sudden heat and drought; but this will seldom happen upon a clay soil like that at Rothamsted.

Autumn and Winter Weather.—The popular view of the character of a wheat season is confined to the meteorological conditions of spring and summer. Winter is taken into account only when frost or floods have injured the plant. We have already seen, however, when considering the very different results of the autumn and spring application of ammonia salts, that the dryness or wetness of the autumn and winter is a most important factor in determining the character of the next summer's crop. In a wet winter, the nitrates produced in the soil since the last cropping, or resulting from autumn applications of nitrogenous manure, may be removed almost entirely in the drainage-water, and the soil reduced to an impoverished condition by the time the growth of wheat commences in the spring. A dry winter is thus essential if a full wheat crop is to be harvested throughout the country.

The farmer who applies nitrate of soda, ammonia salts, or guano as a spring dressing, may of course make himself independent of the character of the winter; but if the winter has been wet, he must apply more of those expensive manures to produce the wished-for effect.

Conditions Favourable to Large Crops.—The years of greatest total produce during the Rothamsted experiments have been 1863 and 1854. These seasons had dry winters, and in the case of 1863 the winter was also mild. There was also during spring and summer a deficiency of rain, though enough fell at critical times to prevent any check to growth. The summers were not unusually hot, indeed that of 1854 was decidedly cool; there was thus no premature ripening of the produce.

These are the conditions favourable to large produce on every description of soil, manured or unmanured. The dry weather between autumn and spring retains in the soil all the nitrates belonging to it; dry mild weather during winter and spring also occasions a maximum development of root; the plant is thus enabled to levy contributions from a considerable depth of soil. If moderately dry weather continue, the plant is afterwards fed with a concentrated solution of plant-food. The moderate warmth of the season allows full time for the collection of food from the soil. There is finally a somewhat late harvest, and a most abundant produce.

High Temperature.—A different class of good seasons are those with high temperature, and (generally) an early harvest; such seasons were those of 1857, 1868, and 1870. The produce in corn, though very good, is not equal to that of the longer and cooler seasons; and the produce in straw is much less.

Bad Seasons.—The worst possible season is that in which a wet winter is followed by a cold, wet, cloudy summer, as in 1879. Under these circumstances the soil is robbed of soluble food; the whole plant, roots included, is scarcely developed, and, fed with a copious supply of rain-water, a miserable crop is the inevitable result. The most liberal manuring is the one that under these circumstances yields the best return.

The seasons 1853, 1860, 1867, 1871, 1873, 1875, 1876, were bad seasons for the production of wheat, but none were nearly so bad as 1879.

Ash Constituents and the Seasons.—The beneficial effect of giving a good supply of ash constituents with the ammonia salts or nitrate is generally very conspicuous in a season of low vitality, or in one of premature ripening. The bulk of the produce is not affected so adversely by the season, and the grain has a higher weight per bushel where the soil is well supplied with ash constituents.

Effect of Residues of Manures.

As only a portion of every dressing of manure is taken up by the crop in the season in which it is applied, it becomes an important practical question whether the unused portion of the manure remains in the soil in such a condition as to yield a supply of food to subsequent crops. The subject has recently received additional importance, as, under some circumstances, a farmer has now a property in the unused residues of the manures which he has applied.

The Rothamsted experiments supply numerous illustrations of the influence of the residues of previous manuring. We will, in this place, refer to a few of the most important experiments on this subject occurring in the wheat field. We will consider first the results showing the effect of residues of ash constituents.

Residues of Ash Constituents.—One half of Plot 10, designated 10*b*, received in 1847, and again in 1849, a liberal manuring of ash constituents, containing in all about 300 lb. of potash and 130 lb. of phosphoric acid. The other half of the plot, named 10*a*, did not receive this manure. For the season 1851, and since, both halves of the plot have received annually 400 lb. of ammonia salts without ash constituents.

As manuring with ammonia salts alone is the treatment which produces the most rapid exhaustion of the ash constituents of the soil, it is naturally an excellent means of bringing into view any store of ash constituents which the soil contains.

Table IX. shows the average produce per annum of the two half plots since 1852.

TABLE IX.—AVERAGE PRODUCE OF WHEAT ON PLOTS 10*a* AND 10*b* DURING THIRTY-TWO YEARS.

	Dressed Corn.			Total Produce.		
	Plot 10*a*.	Plot 10*b*.	Excess on 10*b*.	Plot 10*a*.	Plot 10*b*.	Excess on 10*b*.
	bush.	bush.	bush.	lb.	lb.	lb.
Eight years, 1852-59	22¾	27½	4¾	4055	4885	830
" 1860-67	24	27¼	3¼	4076	4563	487
" 1868-75	19	20⅛	1⅛	3060	3264	204
" 1876-83	16⅝	18⅛	1¾	2618	2935	317
Thirty-two years, 1852-83	20½	23¼	2¾	3452	3912	460

The figures show an average annual excess of 2¾ bushels on the plot which received in early years the dressings of ash constituents. The excess was most considerable in the first years, but was still perceptible in 1888.

In thirty-six years the residue of ash constituents on 10*b* has produced in all ninety-one bushels of corn! This is a very striking fact. It must, however, be recollected, that the effect of this *residue of potash and phosphoric acid* is made apparent only by following a treatment very exhaustive to the land, and that such an exhaustive system is very wasteful, and one that it would never pay a farmer to follow. Had ash constituents been regularly applied to Plot 10*b* during the thirty-six years, the same quantity of ammonia would have yielded 340 bushels more corn!

Residue of Ash and Ammonia Salts.—Our next illustration will show not only the effect of residues of ash constituents, but also the effect produced by a previous manuring with ammonia salts. The manures on Plots 17 and 18 have alternated each year since 1852. In each year one plot receives the usual full dressing of ash constituents, and the other plot 400 lb. of ammonia salts. In the following year the manuring is reversed, the plot that had received ash constituents now receives ammonia, and the one which had received ammonia now receives ash constituents. There is thus each year a crop by ammonia salts, plus a residue of ash constituents, and a crop by ash constituents, plus the residue from the ammonia.

The average effect of these annual residues is shown in Table X.

TABLE X.—EFFECT OF ANNUAL RESIDUE OF ASH CONSTITUENTS, AVERAGE THIRTY-SIX YEARS.

	Dressed Corn.	Total Produce.
	bush.	lb.
Ammonia and residue of ash constituents	30½	5258
Ammonia alone, Plot 10*a*	20½	3403
Excess, due to residue of ash constituents	10	1855

EFFECT OF ANNUAL RESIDUE FROM AMMONIA SALTS, AVERAGE THIRTY-SIX YEARS.

	Dressed Corn.	Total Produce.
	bush.	lb.
Ash constituents and residue of ammonia	15¼	2500
Ash constituents alone, Plot 5	15	2365
Excess, due to residue of ammonia .	¼	135

The abundant residue of ash constituents remaining from the preceding year has proved its effectiveness, by raising the produce by 10 bushels per year.

We turn now to the result produced by the residue of the ammonia. It has yielded, according to the table, an increase of but ¼ bushel per year!

Of the 86 lb. of nitrogen contained in the ammonia salts, not more than 43 lb. would be contained in the crop obtained by its use; what then has become of the remaining 43 lb.? It is quite clear that the missing ammonia is not present in the soil ready for use in the next season, for it produces no effect on the crop.

We shall see presently that there is much evidence to show that the unused ammonia has been in great part lost as nitrates in the drainage-water.

We have one more instance to give of the effect of residues of ammonia. Plot 16 received for thirteen years (1852-1864) 800 lb. of ammonia salts per annum, with ash constituents. This was the largest amount of ammonia salts applied to any plot in the field. The average produce during these thirteen years was 39½ bushels of corn. From 1865-1883 the plot was left unmanured. The excess of produce in these nineteen years over the produce of the permanently unmanured land is shown in Table XI.

TABLE XI.—EXCESS OF PRODUCE ON PLOT 16 OVER PLOT 3, IN NINETEEN YEARS.

	Dressed Corn.			Total Produce.		
	Plot 3.	Plot 16.	Excess of 16 over 3.	Plot 3.	Plot 16.	Excess of 16 over 3.
	bush.	bush.	bush.	lb.	lb.	lb.
1865	13¼	32⅜	19⅛	1861	5007	3146
1866	12⅛	17⅜	5¼	2046	3081	1035
1867	8⅞	14⅝	5¾	1505	2512	1007
1868	16⅝	22¾	6⅛	2027	3503	1476
Average—four years, 1869-72	12¼	15¼	3	1943	2493	550
" eleven " 1873-83	10½	11¾	1¼	1613	1821	208

It will be noticed that in the first year after the cessation of the ammoniacal manuring on Plot 16, there was on this plot a considerable crop, exceeding by 19⅛ bushels that of the permanently unmanured land. This considerable excess must be attributed to a residue of the preceding abundant nitrogenous manuring remaining in the soil. In the second, third, and fourth years, the excess of crop on the previously manured soil is only 5 or 6 bushels. After this time the excess rapidly diminishes, averaging in the last eleven years only 1¼ bushel per annum.

It is probable that only the excess of the first year was due to an unused residue of nitrogenous manure. The excess of the later years, we shall see presently, was probably rather due to a gradual oxidation of the accumulated organic matter in the soil.

Practical Conclusion.—We learn, then, that residues of phosphoric acid or potash remain available for future crops, but that no effective residue remains in the soil, even from abundant applications of ammonia salts. The use of such salts is apparently attended with a considerable waste of nitrogen.

EXAMINATION OF THE SOILS.

It may be assumed that, at the commencement of the experiment, the soil of the various plots in Broadbalk field was of a fairly uniform composition, though the subsoils would then, as now, be more or less irregular in character. As on some plots of the field no manure has been applied, while on other plots there have been long-repeated applications of particular manures, the composition of the soil is now of the most varied description. On some of the plots the land is now extremely rich in phosphoric acid and potash, on others it is exhausted of these constituents to an extent which could hardly occur in ordinary farm practice. On some plots nitrogen has accumulated, on others the soil is impoverished.

1. *Contents in Cinereal Plant-food.*

Little has been done in the way of mineral analysis of the soil. Hermann von Liebig examined the soils of some of the plots collected in 1865, and determined the amount of various constituents soluble in dilute hydrochloric and in dilute acetic acid, and the amount of phosphoric acid soluble in nitric acid. His results for the unmanured soil are given in Table XII.

TABLE XII.—SOME CONSTITUENTS IN 100 PARTS OF UNMANURED SOIL (PLOT 3) IN BROADBALK FIELD, 1865.

	Soluble in Dilute Hydrochloric Acid.	Soluble in Dilute Acetic Acid.		
	First 9 inches.	First 9 inches.	Second 9 inches.	Third 9 inches.
Lime	2.298	2.065	.377	not determined
Magnesia	.092	.028	.013	not determined
Potash	.085	.015	.018	.011
Soda	.066	.012	.013	.014
Sulphuric acid	.015	trace	.002	.003
Silica	.434	.065	.080	not determined
Phosphoric acid, soluble in dilute nitric acid	.075	.075	.047	.043

The lime in the surface-soil at Rothamsted is principally due to ancient dressings of chalk. The phosphoric acid originally present in the surface-soil, at the commencement of the experiments, is estimated by H. Liebig as .084 per cent. This he considers as below that necessary for a good wheat soil. He concludes, from his analyses of the soils and subsoils of other plots, that the phosphoric acid which had been applied as manure, and not removed in the crops, was still present in the soil, chiefly in the first 9 inches, but some also in the second 9 inches. Of the potash applied, he found some in the first 9 inches; but a large quantity was not found. He thought it most probable that it had really entered into some insoluble combination which was unattacked by his weak acid. The sulphuric acid, and the soda applied in the manures, had apparently not been retained by the soil.

2. *Contents in Total Nitrogen.*

The soils and subsoils of the various plots have been on several occasions carefully sampled, and the nitrogen which they contained determined. The last and most complete examination was made on soils collected in October 1881. The amount of nitrogen found in some of the principal plots is given in Table XIII.

TABLE XIII.—NITROGEN FOUND IN FIRST 9 INCHES OF SOILS FROM BROADBALK FIELD, 1881.

Plot.	Manuring.	Average Total Produce per Acre, 1852-81.	Nitrogen in Dry Soil.		
			Per Cent.	Per Acre.	Excess over Plot 5 per Acre.
		lb.		lb.	lb.
3	No manure .	2108	0.1045	2404	...
5*a*	Ash constituents .	2394	0.1012	2328	...
6*a*	Do. and ammonia salts, 200 lb.	3954	0.1153	2652	324
7*a*	" 400 "	5710	0.1264	2908	580
8*a*	" 600 "	6778	0.1320	3036	708
9*a*	" and nitrate of soda, 550	6903	0.1253	2883	555
9*b*	Nitrate of soda, 550 "	4293	0.1106	2543	215
10*a*	Ammonia salts, 400 "	3450	0.1074	2471	143
10*b*	Ammonia salts, 400	3923	0.1077	2476	148
11*a*	Superphos. and ammonia salts, 400 lb.	4387	0.1164	2676	348
2	Farmyard manure, 14 tons	5696	0.1957	4502	2174

The first thing that strikes one in looking at the figures is the smallness of the alteration in the nitrogen of the soil produced either by exhaustive cropping or by very liberal treatment with artificial manures.

Slow Exhaustion of Soil-nitrogen.—On Plots 3 and 5 no nitrogen has been applied; the crop has drawn its nitrogen entirely from the soil and atmosphere. On Plot 5 production has been stimulated as far as possible by liberal manuring with the ash constituents of wheat. In this condition of nitrogen hunger, all the nitrogen has been taken from the soil that could be taken; yet at the end of twenty-nine years the soil still contains 2300 to 2400 lb. of nitrogen in the first 9 inches. The amount of nitrogen lost in twenty-nine years of continuous wheat-cropping without nitrogenous manure is probably not more than one-fifth of the amount originally present in the soil.

The *slowness* with which the nitrogenous matter in the soil is oxidised, and made soluble and available to the plant, is a great natural safeguard against the complete exhaustion and sterilisation of the soil which might else speedily occur under bad treatment.

Small Increase of Soil-nitrogen by Ammonia or Nitrates.—On the other hand, the liberal manuring with ammonia salts, or nitrate of soda, which many of the plots have received, and which has resulted in large crops, has not produced any considerable increase in the nitrogen of the soil. We have already seen that these *nitrogenous manures, though very active in the season in which they are applied, leave no residue in the soil available for the next season; they, in fact, feed the crop but not the soil.*

Soils Enriched in Nitrogen by Heavy Crops.—Though, however, ammonia and nitrates do not themselves permanently enrich the soil, it will be seen, on comparing the average total produce of the plots during nine years with the nitrogen found in the soils at the end of this period, that there is a distinct relation between the two. *The nitrogen of the soil rises or falls as the previous cropping has been abundant or not.* Thus the same amount of ammonia has been applied on Plots 7 and 10. The former plot, having been well supplied with ash constituents, has yielded a good crop; the latter, having no ash constituents, has given a much smaller produce. The soils now reflect, not the quantity of ammonia applied to them, which has been alike, but the amount of produce grown upon them, the soil of Plot 7 containing considerably more nitrogen than the soil of Plot 10. The soil has in fact been *enriched*, not by the manure, but by the *residue of roots, stubble, and weeds* left in it at the end of each harvest. That this is the case is further proved by the fact that the proportion of carbon found in the various soils rises or falls with the proportion of nitrogen.

The permanence of the percentages of nitrogen and carbon in the soil thus depends on the permanence of the amount of produce. We shall expect a further decline in nitrogen in the soils of Plots 3, 5, 9*b*, 10, and 11, because the crops on these must still further diminish in consequence of their imperfect nutrition; but we do not expect any further decline in Plots 6, 7, 8, 9*a* (unless there should be a series of seasons below the average), because the nutrition on these plots is complete, and the amount of crop and crop residue should remain fairly constant.

Effect of Exhaustive Treatment.—Plot 16, which is not mentioned in the table, affords a striking instance of the rapidity with which a soil falls out of condition when it passes from a liberal to an exhaustive treatment. As already stated (p. 142), this plot received up to 1864 a larger amount of ammonia salts, with ash constituents, than any other plot in the field, and surpassed every other plot in the amount of its total produce. In 1865 the soil was sampled. It then contained in the first 9 inches 2907 lb. of nitrogen per acre, a quantity larger than that found in any other plot (save Plot 2) at that date. From 1864 the soil has been unmanured; the crop, as we have already seen (Table XI.), speedily fell to nearly that of the permanently unmanured soil. In 1881 the soil was analysed again, and found to contain not more than 2557 lb. of nitrogen per acre. The soil had thus lost at least 350 lb. of nitrogen in 16 years, or about 22 lb. per annum.

Residue of Dung.—The soil of Plot 2, receiving farmyard manure every year, is in very different circumstances from those manured with ammonia salts or nitrates. There is here a very large accumulation of nitrogen and carbon in the soil, due, not to crop residues, but to large residues of manure. The amount of nitrogen in the soil is shown by Table XIII. to be much larger than in any other plot in the field. It is indeed nearly double that found on Plot 5, receiving no nitrogenous manure. On Plot 2 the crop for some time steadily increased from year to year (Table II.) This increase of crop has now ceased, and the increase of the nitrogen in the soil has also ceased, or is at least proceeding but slowly. The annual oxidation of organic matter in the soil is now, apparently, about equal to the annual receipt.

In the first 9 inches of soil, manured for 38 years with farmyard manure, the proportion of nitrogen to carbon was found to be 1 : 11. On the other plots in the field the proportion was about 1 : 10. By comparing these proportions with those shown by the original materials supplied to the soil, we see in a striking manner the character of the oxidation which takes place in the soil. In moderately rotted farmyard manure the proportion of nitrogen to carbon is about 1 : 19; and in the roots and stubble of cereal crops 1 : 43. The carbon is thus first oxidised, and a residue of nitrogenous humus remains in the soil.

Nitrogen in the Subsoil. — The second and third 9 inches of the various soils have been examined. They are fairly uniform in their percentage of nitrogen throughout the field, being apparently little affected either by manure or crop residue. They lie, indeed, to a great extent, out of the sphere of accumulation or oxidation. The percentage of nitrogen in the soil of the second

9 inches is usually 0.07, and the amount per acre about 1900 lb. In the third 9 inches the percentage of nitrogen is about 0.06, and the amount per acre 1600 lb. The proportion of carbon to nitrogen diminishes as we descend, being about 1 : 9 in the second 9 inches, and 1 : 8 in the third 9 inches.

Soil-nitrogen unsuitable for Wheat.—One fact plainly taught by the results given in this section is the uselessness of the ordinary nitrogen of the soil for the wheat crop. The unmanured land contains, to a depth of 27 inches, about 5700 lb. of nitrogen per acre, yet the wheat on this land can barely appropriate 20 lb. per annum, and suffers from nitrogen hunger! *The form of nitrogen that practically acts as food for wheat is nitric acid. The growth of the wheat crop is limited (ash constituents being present) by the amount of nitrates present in the soil.*

3. *Contents in Nitric Acid.*

Determinations of nitrogen present as *nitrates* in the various soils and subsoils of Broadbalk field were made in the samples collected October 10 to 18, 1881. The results are described here, as they fall naturally under the head of soil; but the reader is advised to peruse the next section, on drainage-waters, before considering these results, as the subject will become clearer by so doing.

The composition of the drainage-waters of Broadbalk field proves that nitrates are absent, or nearly absent, during summer time in the soils of those plots which receive no excess of nitrogen in their manure. The same fact is shown by the analysis of various soils at Rothamsted, taken from wheat and barley fields immediately after harvest. At this time, unless heavy rain has lately fallen, the soils are nearly destitute of nitrates. After harvest, nitrates generally appear in considerable quantities in the drainage-waters, the amount depending on the richness of the soil in nitrogenous matter, and the abundance of the rainfall, and is much increased by ploughing. In soils containing an excess of ammonia or nitrates beyond the power of the crop to assimilate—either from the largeness of the application, as on Plot 8, or from the fact that the ash constituents necessary for the assimilation of nitrogen are absent, as on Plots 9*b*, 10, and 11—nitrates are found in the drainage-waters, when the drains run, both in summer time and at harvest.

TABLE XIV.—THE NITROGEN AS NITRATES IN THE DRAINAGE-WATERS OF THE PLOTS IN BROADBALK FIELD, FROM MARCH 1881 TO JANUARY 1882, IN PARTS PER MILLION.

Plot.	March 5, 6, 7, Mixed.	August 30.		Sept. 25.	Oct. 14.	Oct. 23.	Nov. 25.	Nov. 27.	Dec. 7.	Dec. 17, 18, 20, 21, Mixed.	Jan. 9.
		A.M. 6.30.	P.M. 2.3.								
2	5.1	...	...	...	...	...	18.9 [1]	7.1	...	5.8	...
3 & 4	3.4	1.2	0.9	4.7	6.3	8.7	5.4	7.0	5.1	4.1	3.5
5	3.6	1.5	1.4	6.0	8.1	9.5	6.0	7.3	6.3	5.0	3.9
6	3.9	...	1.9	7.0	12.3	13.3	8.5	8.8	7.8	6.2	6.2
7	3.9	...	4.1	...	...	18.5	9.8	11.7	10.9	7.3	7.2
8	5.3	...	...	...	...	23.0	17.1	18.2	16.8	11.2	10.2
9	5.2	...	...	...	...	21.8	12.3	...	13.8	9.4	10.0
10	5.9	20.3	16.1	20.6	21.0	16.2	11.2	14.5	14.0	9.3	9.1
11	5.4	9.0	6.8	10.7	12.6	19.6	12.6	14.9	13.7	9.4	9.4
12	4.8	...	2.3	7.2	9.3	15.2	10.5	11.6	10.2	7.6	7.4
13	4.5	...	2.4	...	9.0	14.5	9.8	11.1	9.3	6.8	6.5
14	5.1	...	...	...	...	15.0	9.7	12.1	9.4	6.8	6.7
15	11.6	...	...	...	...	13.1	66.6 [2]	40.5	34.8	26.4	22.4
16	3.1	...	0.3	...	7.4	8.6	5.1	6.3	4.1	3.4	2.9
17	3.9	1.0	0.4	8.8	9.6	10.7	5.4	6.8	5.6	4.1	3.7
18	3.9	...	...	...	...	11.6	7.5	9.0	7.1	5.6	4.9
19	12.1	...	...	...	...	14.9	19.6 [3]	19.2	10.0	15.6	...

[1] Farmyard manure applied October 27. [2] Ammonium salts applied October 27.
[3] Rape-cake applied October 28.

Nitrates in the Drainage.—Table XIV shows the amount of nitrogen as nitrates in the drainage-water from each plot in Broadbalk field immediately before and after the sampling of the soil. A blank in the table signifies that no water ran from the pipe: drainage would, however, actually occur in such cases. The thick line indicates the interval at which soil-sampling occurred. The drain-pipes did not run from March 7 till after harvest. The ammonia salts and nitrate of soda were applied to their respective plots on March 12. The spring and summer months were dry. The wheat was cut August 8-11. Immediately after followed a deluge of rain, amounting during the whole month to 5.82 inches. The land was scarified early in September, and ploughed towards the end of the month. The soil was sampled between October 10 and 18, the operation being interrupted by heavy rain on the 14th.

It will be seen that on the first running of the pipes after harvest, the drainage-waters from the plots receiving no nitrogenous manure (3 & 4, 5, 16, 17) contained on an average 1.0 per million of nitrogen as nitric acid; those receiving ammonia salts, with a complete or fair supply of ash constituents (6, 7, 12, 13), contained 2.7 per million; while that receiving ammonia with incomplete ash constituents (11) gave 7.9; and that receiving ammonia with no ash constituents (10) 18.2 per million.

In the first division of plots we may safely conclude that no appreciable amount of nitric acid existed in the upper soil at harvest. In the second division the amount, if any, was very small. In the third division a considerable amount of nitric acid had remained unassimilated all through the summer. Of the plots that did not afford drainage-water in August or September, we may class 9*a*, 14, 15, 18 in the second division, and 8 and 9*b* in the third division.

It is clear that after the soil became saturated with water active nitrification commenced, as with each running of the drains the proportion of nitrates in the water is increased, the maximum being reached on October 23.

Nitrates in the Soil and Subsoil.—We now turn to the amount of nitrogen as nitrates found in the soil: this was determined in the first, second, and third 9 inches. The results yielded by the principal plots is shown in Table XV.

Table XV.—Nitrogen as Nitrates in Wheat Soils variously Manured, October 1881, in Pounds per Acre.

Plot.	Manuring.	First 9 inches.	Second 9 inches.	Third 9 inches.	Total 27 inches.	Excess over Plots 3 and 4.
		lb.	lb.	lb.	lb.	lb.
3	No manure, thirty-eight years	9.7	5.3	2.8	17.8	...
4	No manure, thirty years	9.2	4.0	1.8	15.0	...
16*a*	No manure, seventeen years	10.6	5.0	2.3	17.9	1.5
5*a*	Ash constituents, thirty years	12.6	7.1	4.6	24.3	7.9
17*a*	Do. do., one year	10.3	7.5	3.4	21.2	4.8
6*a*	Do. and ammonia salts, 200 lb.	16.5	7.5	4.7	28.7	12.3
7*a*	Do. do., 400 lb.	22.8	11.3	5.7	39.8	23.4
8*a*	Do. do., 600 lb.	21.1	13.9	7.8	42.8	26.4
9*a*	Do. and nitrate of soda, 550 lb.	19.7	10.0	8.2	37.9	21.5
9*b*	Nitrate of soda, 550 lb.	16.3	20.1	17.7	54.1	37.7
10*a*	Ammonia salts, 400 lb.	14.2	11.9	7.3	33.4	17.0
11*a*	Superphos. and ammonia salts, 400 lb.	17.9	9.3	3.6	30.8	14.4
19	Rape-cake, 1700 lb.	14.1	13.0	7.1	34.2	17.8
2	Farmyard manure, 14 tons	30.0	15.4	6.8	52.2	35.8

It must be recollected in discussing these results, as in all other results of soil analysis, that the figures can only approximately represent the truth, owing to the impossibility of obtaining a sample of soil that shall exactly represent the whole of the plot.

The first point calling for attention is the preponderance of the nitrates in the surface soil. Taking the mean of all the plots, save 9*b*, the proportion of nitrates in the first, second, and third 9 inches is as 100, 59, and 31. This is owing to the fact that *nitrification takes place chiefly near the surface*, where the soil is richest in nitrogenous matter, and most freely exposed to air. After a continuance of rainy weather, the nitrates would be found much more evenly distributed.

On Plot 9*b*, manured with nitrate of soda only, the nitrates are most abundant in the subsoil. Here a considerable part of the nitrate applied in spring has not been assimilated by the crop, owing to the poverty of the soil in ash constituents: it has remained in the soil all the summer, and reached by drainage and diffusion a lower depth than the nitrate newly formed after harvest.

Nitrates in Soil without Nitrogenous Manure.—The three unmanured plots yield an average of 16.9 lb. of nitrogen as nitric acid per acre in 27 inches of soil. With a liberal supply of ash constituents this is increased to 22.8 lb. It is now known that phosphates favour nitrification; their effect will only be perceived by comparison with a soil exhausted of phosphates.

Nitrates, where Ammonia Applied.—With an annual dressing of 200 lb. ammonia salts, with ash constituents, the nitric nitrogen rises to 28.7 lb. When the ammonia is doubled, or an equivalent quantity of nitrogen as nitrate of soda is employed, the nitric nitrogen becomes 39.8 and 37.9 lb.

With an excess of ammonia salts (600 lb.) the nitric nitrogen reaches 42.8 lb. With an excess of nitrate of soda it is 54.1 lb. The plot receiving ammonia without ash constituents shows a comparatively small amount of nitrates in the surface-soil, the crop and weed residue here being relatively small.

Nitrates from Farmyard Manure.—The largest amount of nitrification in the surface-soil occurs on the plot receiving farmyard manure. The first 9 inches contains 30 lb. of nitric nitrogen per acre; in 27 inches the total is 52.2 lb. The large amount of nitrogen in this soil has been already noticed in the preceding section.

Sources of the Nitrates in the Soil.—Before leaving this section we will recapitulate what has been already said in various places as to the sources of the very considerable amounts of nitrates found in these wheat soils. The nitrates are in some cases (Plots 3, 4, 16, 5, 17, 6) entirely derived from the oxidation of the nitrogenous organic matters of the soil, consisting primarily of crop and weed residues, and the dead bodies of insects and other animals; for it should not be forgotten that the soil of our fields is a burial-ground. On other more highly manured plots the nitrates are mainly derived from a similar source (which in many cases is much more considerable, as the growth on the land has been much greater), but there is, in addition, more or less nitrate which has resulted directly from the ammonia or nitrate applied, and which has existed as nitrate all through the summer. There is, farther, on Plots 19 and 2, but especially on the latter, nitrate derived from the oxidation of organic manure.

The quantities of nitrates found in October in these Broadbalk soils must be considered as decidedly above an average, the large rainfall in August producing a specially early and vigorous nitrification.

Losses by Autumn and Winter Drainage.—As an example of the serious losses which soil may suffer from autumn and winter drainage, it may be mentioned that before the spring of 1882 there had been removed in drainage from these plots of Broadbalk field a quantity of nitrates equal to from one-half to three-quarters of that shown by the analyses in Table XV

DRAINAGE-WATERS AND THE NITRATES OF THE SOIL.

In order to understand fully the facts shown by the drainage-waters, we must say a word, in the first place, as to the composition of the rain falling on the soil.

Rain-water.—The rain is collected at Rothamsted in a gauge having an area of 1-1000th of an acre. The nitrogen as ammonia which it contains amounts to 2.4 lb. per acre per annum; the nitrogen as nitric acid to barely 1 lb. The chlorine is 14.4 lb., equal to 24 lb. of common salt. The sulphuric acid is equivalent to 17.3 lb. of sulphuric anhydride per acre per annum. The amount of organic nitrogen has been determined in some samples of Rothamsted rain-water by Dr E. Frankland. If we take this amount as expressing the average composition, the total combined nitrogen in the rain-water becomes a little over 4 lb. per acre per annum. The nitrogen in rain is thus small in quantity, while the chlorides and sulphates are rather considerable, and equal or even exceed the amounts present in most farm crops.

The Drain-gauges.

Since 1870, the amount of drainage has been determined at Rothamsted by means of three drain-gauges, of the respective depths of 20, 40, and 60 inches, and of the area of 1-1000th of an acre. The soil which they contain is in its natural state of consolidation, the gauges having been constructed by cutting under the soil, and then isolating the block of soil by building round it with brick and cement. The soil has been kept free from weeds. No manure has been applied.

Evaporation and Drainage.—The proportion of the rainfall which passes through a soil depends, if there is no surface drainage, entirely on the amount of evaporation that takes place from the surface. The amount of drainage is, in fact, the amount of rainfall minus the amount of water evaporated. The evaporation is of course much greater in summer than in winter. It is also much greater from a soil covered by a crop than from bare soil.

Periods of Drainage.—In an average season comparatively little drainage occurs in the seven months March to September. The period of active drainage is the five months October to February. With land bearing a crop the amount of summer drainage will be still further reduced, and the autumn drainage commence somewhat later.

Chlorides in Drainage.—Since May 1877, the amount of chlorine, and the amount of nitrogen as nitrates, have been systematically determined in the mixed drainage of each month. Average results for 11 years are given in Table XVI.

TABLE XVI.—THE AMOUNT OF DRAINAGE, AND THE NITROGEN AS NITRATES IN THE DRAINAGE-WATER, FROM UNMANURED BARE SOIL, 20 AND 60 INCHES DEEP, AVERAGE OF ELEVEN YEARS.

	Rainfall.	Amount of Drainage.		Nitrogen as Nitrates.			
				Per Million of Water.		Per Acre.	
		20-Inch Gauge.	60-Inch Gauge.	20-Inch Gauge.	60-Inch Gauge.	20-Inch Gauge.	60-Inch Gauge.
	inches.	inches.	inches.			lb.	lb.
March	1.60	0.78	0.88	7.5	9.0	1.33	1.80
April	2.31	0.82	0.90	8.2	8.9	1.53	1.82
May	2.50	0.69	0.70	9.0	10.3	1.40	1.63
June	2.40	0.66	0.66	9.5	9.7	1.42	1.45
July	2.50	0.52	0.45	15.4	13.3	1.81	1.35
August	2.67	0.85	0.76	15.9	14.0	3.05	2.40
September	2.88	1.07	0.91	17.8	13.5	4.32	2.78
October	3.26	1.97	1.77	14.1	12.1	6.30	4.83
November	3.26	2.48	2.36	11.8	11.4	6.64	6.13
December	2.48	1.97	1.96	9.4	10.6	4.19	4.72
January	2.14	1.82	1.98	7.3	8.7	3.00	3.91
February	2.31	1.99	1.87	7.6	9.0	3.41	3.80
March–June	8.81	2.95	3.14	8.5	9.4	5.68	6.70
July–September	8.05	2.44	2.12	16.6	13.6	9.18	6.53
October–February	13.45	10.23	9.94	10.2	10.4	23.54	23.39
Whole year	30.31	15.62	15.20	10.9	10.6	38.40	36 62

The amount of chlorides found in the water from the drain-gauges, when calculated as pounds per acre, is found to be practically identical with that furnished by the rain. The soil in the drain-gauges has thus apparently been thoroughly washed out, and all residues of soluble manure removed.

Nitrates in Drainage.—The quantity of nitrates in the water from the drain-gauges is very large, amounting in the drainage from 20 inches of soil to 38.4 lb., and in the drainage from 60 inches of soil to 36.6 lb. per acre per annum. Of this quantity only about 4 lb. could possibly be supplied by the rain; the remainder has come from *the oxidation of the nitrogenous organic matter of the soil.*

Nitrification and Bacteria.—Nitrification in soil is now known to be accomplished by the agency of a bacterium. This requires for its action the presence of water; the ash constituents of plant-food; a salifiable base, as carbonate of lime, with which the nitric acid may combine; a suitable temperature; and the presence of sufficient oxygen in the surrounding atmosphere. Ammonia is apparently the substance which is oxidised into nitric acid.

The first stage in the nitrification of the nitrogenous humic matter of soil is probably the production of ammonia. This production of ammonia is also apparently the work of bacteria, but whether of the same species which produces nitrification is at present unknown.

Consistently with these conclusions, based on laboratory experiments, it is found that nitrates are produced most abundantly in moist soils, during warm weather, and that the production is greatly increased by tillage, and that ammonia salts, when mixed with a fertile soil, are rapidly converted into nitrates.

Discharge of Nitrates in different Months.—On looking at the amounts of nitrogen as nitrate found in the monthly drainage from the soils of the drain-gauges, it will be seen that the smallest amount is found in March. After this month the strength of the drainage-water slowly rises. In July a great stride is made, and the drainage-water in this month has sometimes the maximum strength for the year, though on an average the maximum is a little later. The largest quantity of nitrates is not, however, discharged till the season of active drainage commences in October. After November the amount discharged in the drainage-water diminishes, the soil being gradually washed out.

Nitrification does indeed continue during winter time (probably not in actual frost), but with far less activity than in summer. From the 20-inch drain-gauge, 61 per cent of the nitrates annually discharged are expelled in the drainage of five months—October to February. The proportion for the same period with the 60-inch gauge is 64 per cent.

Total Production of Nitrates in the Soil.—The 36-38 lb. of nitric nitrogen discharged on an average each year from the drain-gauges, may be regarded as representing the average annual production in the soil. The rate of production is apparently diminishing, the easily oxidised nitrogenous matter contained in the soil becoming slowly exhausted. We shall see, by-and-by, that the rate of production in a manured soil, or in a bare fallow subject to tillage, is considerably greater.

Loss per Acre.—The significance of these results is at once apparent, when we recollect that *the amount of nitrogen as nitrates present in a soil represents the amount of nitrogen available as plant-food for most crops.* These nitrates are annually produced in the soil, and they are lost with great ease by drainage. The money value of nitrogen in nitrate of soda is, at the present price of this salt (£11 a ton), 7½d. a pound. The 38 lb. annually lost by the uncropped soil of the drain-gauge are thus worth 24s. an acre, and this sum would have to be spent in manure to replace the waste by drainage, if the fertility of the soil is to be maintained.

The Nitrates in Fallow Soils.

As the soils of the drain-gauges represent a bare untilled fallow in an exhausted soil, it will be most convenient to mention here the amounts of nitrogen as nitrates found in ordinary farmed soils at Rothamsted at the end of a season of bare fallow. Three analyses of soil, taken in September or

October, from different fields, in fair agricultural condition, showed 56.5, 58.8, and 59.9 lb. of nitrogen as nitrates per acre, in 27 inches from the surface. When the preceding summer had been dry, the principal part of this nitrogen (40 lb.) was found in the first 9 inches.

In bare fallows, on unmanured and exhausted land, 33.7 and 36.3 lb. of nitrogen as nitrates were found.

All these amounts represent the quantity left in the soil at the end of fourteen or fifteen months fallow. If we estimate the probable amount lost by drainage during the seasons in question, it will appear that about 80 to 90 lb. of nitric nitrogen had been produced per acre in the better soils during the period of fallow.

The Nitrates in Cropped Soils.

The determinations of nitric acid in soils that have just grown a cereal crop show a very small amount existing in the soil. On permanently unmanured wheat land there was found, after harvest in 1878, only 2.6 lb. of nitrogen as nitric acid in the first 9 inches, and no determinable quantity in the second 9 inches. The same land was sampled again in March 1881 (it had been left unploughed through the winter)—it then contained in the first 27 inches 14.5 lb. of nitric nitrogen.

In September 1877, after a good crop of barley, grown with nitrate of soda, 15.7 lb. of nitric nitrogen were found in the first 9 inches of soil, but in 45 inches below this depth only 6.2 lb. The nitrate at the surface had probably been formed in great part since the active growth of the crop had ceased.

The nitrates found in the wheat plots of Broadbalk field have been already noticed in detail; in this case the sampling of the soil did not take place till the middle of October, after heavy rain, and the ploughing of the land, had caused vigorous nitrification to take place.

The Drainage-waters of Broadbalk Field.

The principal plots of Broadbalk field consist of two "lands," each 4⅛ yards wide, and forming the two halves, *a* and *b*, of the plot. The length of the plots is 352 yards. Under the furrow, in the middle of each plot, is a drain-pipe, laid in 1849, at from 2 to 3 feet below the surface. Since 1866 the lower end of each pipe has discharged into a small pit, so that the drainage-water can be collected from the end of the pipe. The series of pits are connected by a large cross-drain which keeps them free from water. There is no means of gauging the quantity of water discharged from each plot, nor would any measurement give a correct idea of the amount of drainage, as much drainage must occur through the soil itself.

Run of Water in different Months.—There is no continuous run of water from these pipes. The discharge ceases soon after the cessation of rain. The dates on which each pipe has run since 1866 have been recorded. As an example of the distribution of the discharge throughout the year, we will take the case of the pipe from the unmanured land, Plots 3 and 4. This pipe has discharged in July, August, and September, only on nine, six, and eight days respectively during twenty years. In October active drainage commences, 35 daily runnings occurring in twenty years. In November the runnings reach 59, and in December and January 60 and 61. In February there is a diminution, the total being 42. In March the runnings are only 18, and the monthly total still further diminishes as summer is approached.

Heavy Crops and Drainage.—On those plots which bear the heaviest crops the runnings are less frequent in spring and summer, and begin somewhat later in autumn.

Farmyard Manure and Drainage.—The drain-pipe from the plot receiving farmyard manure runs less frequently than any other. This is apparently due (at least in part) to the greater power of retaining water possessed by the soil of this plot. Determinations made in January 1869, when the soil of the field was saturated with water, showed that in the first 3 feet, the soil continuously manured with dung contained 214 tons more water per acre than the permanently unmanured land.

1. *Ash Constituents lost in Drainage.*

Several series of drainage-waters collected in 1866-68 were analysed by Dr

Voelcker. Other series, collected in 1868-73, were analysed by Dr E. Frankland. Since 1876, determinations of the nitrates and chlorides have been made at the Rothamsted laboratory, in nearly every running, or in mixtures of the runnings, of every pipe. The subject is a large one. We can only here dwell on the points of greatest practical importance; further details will be found in *Jour. Royal Agric. Soc.*, 1874, p. 132; 1881, p. 1.

We will, in the first place, call attention to some facts shown by the analyses of Voelcker and Frankland. The following table gives the mean of five analyses by Voelcker and five by Frankland, of the drainage-waters from the principal plots.

TABLE XVII.—MEAN OF TEN ANALYSES OF BROADBALK DRAINAGE-WATER BY VOELCKER AND FRANKLAND, 1866-73, IN PARTS PER MILLION.

Plots.	Total Solid Matter.	Lime and Magnesia.	Chlorine.	Nitrogen as Nitrates.
3 & 4	228	99	10.4	3.9
5	330	132	10.7	4.7
6	450	171	23.5	9.0
7	542	207	33.9	15.9
8	615	222	44.8	20.2
9	406	126	12.4	16.0
10	442	173	37.1	17.6
11	490	197	38.6	19.4
2	367	123	19.4	11.5

Unmanured Plot Drainage.—The drainage from the permanently unmanured plots, 3 and 4, is seen to have contained 228 of solid matter per million of water; the principal constituents of this solid matter are lime salts, chiefly the carbonate.

Ash Constituents Plot Drainage.—The superphosphate, and the sulphates of potash, soda, and magnesia applied to Plot 5, considerably increase the contents of the drainage-water, the solid matter rising to 330 per million. The sulphate of lime in the superphosphate, and the sulphate of soda, are the chief constituents of the manure which appear in the drainage-water. The sulphates of potash and magnesia do not appear directly in the drainage-water, but by acting on the lime in the soil, they contribute a further quantity of sulphate of lime to the drainage.

Ammonia Salts and Drainage.—When ammonia salts are applied to the land, the quantity of matter removed in the drainage-water is much increased. Thus the application of 400 lb. of ammonia salts alone to Plot 10 raises the solid matter to 442 per million. When ammonia salts are added to the ash constituents applied on Plot 5, the solid contents of the drainage-waters rise in proportion to the quantity of ammonia salts added. Thus in the drainage-waters from Plots 6, 7, and 8, to which 200, 400, and 600 lb. of ammonia salts are applied, the proportion of total solid matter is respectively 450, 542, and 615 per million.

The ammonia salts used in these experiments are composed of equal parts sulphate and chloride. The solid matter which they remove from the soil consists chiefly of the *sulphate*, *chloride*, and *nitrate of lime*.

Ammonia Salts robbing a Soil of Lime.—The whole of the sulphuric acid and chlorine contained in the ammonia salts probably combines with the lime of the soil. The nitric acid produced by the oxidation of the ammonia will also unite with lime, and if not appropriated by the roots of the crop, the nitrate of lime will also appear in the drainage-water. This action of ammonia salts in impoverishing a soil of lime must be borne in mind whenever their application to a soil poor in lime is in question.

Nitrate of Soda and Lime.—The nitrate of soda applied on Plot 9 has apparently little or no influence in increasing the proportion of lime in the drainage-water. As only one-half the plot receives ash constituents, the amount of lime applied as manure is one-half that received by Plot 5. Although receiving some lime in the manure, the quantity present in the drainage-water is considerably less than in the water from Plot 10, receiving ammonia salts without lime.

Lime and Magnesia lost in Drainage.—For the purpose of illustrating the annual losses of lime and magnesia[1] which the soil suffers by drainage, we will assume that the average annual drainage in Broadbalk field amounts to 10 inches (2¼ million lb. per acre), and that it has the composition shown in Table XVII. The lime and magnesia annually lost by the unmanured Plots, 3 and 4, will then be 223 lb.; by Plot 5, receiving only ash constituents, 297 lb.; by Plot 9, receiving nitrate of soda and half a dressing of ash constituents, 284 lb.; by Plot 10, receiving 400 lb. of ammonia salts alone, 389 lb.; by Plot 11, receiving 400 lb. of ammonia salts with superphosphate, 443 lb.; and by Plots 6, 7, 8, receiving, on an average, the same manure as Plot 11, with the sulphates of potash, soda, and magnesia in addition, 450 lb. per acre. As the quantity of lime and magnesia in the annual dressing of ash constituents is only 104 lb., the amount lost is greatly in excess of that applied to the land.

These results are good examples of the losses of lime occurring both on unmanured and on manured land. The necessity of restoring lime to many soils after a number of years is well known.

Phosphoric Acid in Drainage.—The amount of phosphoric acid found by Dr Voelcker in the drainage-waters was very small; the average of all the determinations is 0.93 per million. With 10 inches of annual drainage, this would amount to a loss of 2.1 lb. per acre.

Potash in Drainage.—The drainage-water from six plots receiving no potash in their manure contained, on an average, 1.6 of potash per million; the waters from eight plots receiving potash contained an average of 4.2 per million.

[1] The magnesia shown in Voelcker's analyses is small in amount, generally 4 to 5 per cent of the lime.

The former proportion would, with the drainage previously assumed, correspond to a loss of 3.6 lb., and the latter to a loss of 9.5 lb. per acre per annum.

It must be recollected, however, that both potash and phosphoric acid would, in the absence of drain-pipes, be retained in great part by the subsoil.

Soda in Drainage.—Soda is shown by Voelcker's analyses to be present in much larger quantity in the drainage-water. The water from six plots receiving no soda as manure contained a mean of 6.1 of soda per million. The water from five plots receiving 100 lb. of sulphate of soda, gave 11.6 per million. Where 366½ lb. of sulphate of soda are applied (Plot 12), the amount became 24.6 per million. Where 550 lb. of nitrate of soda were used (Plot 9), the soda is increased to 56.1 per million.

These results illustrate the well-known fact that soil has a far less retentive power for soda than for potash. The soda in the drainage from the unmanured land was probably derived from rain.

Chlorine and Sulphuric Acid in Drainage.—The chlorine and the sulphuric acid in the manures are not retained by the soil, but appear freely in the drainage-waters.

Drainage from Dunged Plot.—The scanty drainage from the farmyard manure plot (2), though much stronger than that from the unmanured land, is by no means so concentrated as that from many plots receiving artificial manure. It is, according to Voelcker, specially rich in sulphuric acid.

2. *Nitrates Lost in Drainage.*

We turn now to the part of the subject which, in recent years, has been most thoroughly investigated at Rothamsted—namely, the loss of nitrates in the drainage-waters.

Not only the nitrates, but also the *chlorides* removed in the drainage have been determined. From the results relating to chlorides many valuable facts have been learnt. Indeed, without the information which they afford, our interpretation of the course of action which takes place would be uncertain or imperfect. We shall here, however, confine ourselves as far as possible to the results relating to nitrates.

Unmanured Plot.—We take first the case of the wheat land which is left permanently without manure. Table XVIII. shows the average monthly proportion of nitrogen as nitrates, and of chlorine present in the drainage-waters.

TABLE XVIII.—NITROGEN AS NITRATES AND CHLORINE IN THE DRAINAGE OF UNMANURED WHEAT LAND, AVERAGE OF EIGHT YEARS, 1878-86.

	Runnings of Drain-pipes (Days).	Per Million of Water.		Nitrogen to 100 Chlorine.
		Nitrogen as Nitrates.	Chlorine.	
March	7	2.0	4.5	43.5
April	10	1.9	4.3	
May	6	0.8	3.3	12.7
June	8	0.1	2.9	
July	4	0.0	1.7	5.2
August	6	0.2	2.4	
September	5	3.9	9.0	50.8
October	20	4.9	9.3	
November	25	3.2	6.7	61.1
December	26	5.0	6.8	
January	14	3.2	4.8	67.3
February	34	4.1	6.1	
March–May	23	1.6	4.1	39.3
June–August	18	0.1	2.4	4.5
September–November	50	4.0	8.0	49.8
December–February	74	4.3	6.1	69.6
Whole year	165	3.4	6.0	55.8

Loss of Nitrates Checked by Crop.—The nitrates in the drainage-waters from the uncropped soil of the drain-gauges increased in proportion as the spring advanced, and the waters attained their maximum strength between July and September. Here, on the land bearing an unmanured wheat crop, the nitrates diminish as the spring advances, and soon entirely disappear. In fact, out of the 18 collections of drainage-waters made during eight years in June, July, and August, there were only two which contained any nitrate.

The nitrates are thus entirely removed from the upper 2½ feet of soil (the depth above the drain-pipes) during the period of active growth of the crop.

Loss Resumes when Crop is Removed.—After the crop has been removed from the land, the first drainage-water collected is sure to contain nitrates. The proportion rapidly increases, and, if the season is wet, a maximum is reached in October. Nitrification diminishes in energy as the weather becomes colder, and the amount of nitrate in the water diminishes to some extent, but is fairly maintained till after February, when the nitrate is once more taken up by the new crop.

The course of change shown in the table is not regular, because in some of the seasons drainage did not commence till winter, and the maximum strength of the water was consequently postponed.

The *chlorine* in the drainage-water is derived from rain. It is permanently assimilated by the crop to only a small extent. The relation of nitric nitrogen to chlorine thus serves to indicate the formation or removal of nitrates in the soil.

Dung Plot.—The nitrates in the drainage from the plot annually manured with farmyard dung show the same course of change that we have just noticed. The average results of fifty runnings during eight years were as follows.

The farmyard manure is ploughed in in October:—

TABLE XIX.—NITROGEN AS NITRATES IN THE DRAINAGE OF WHEAT LAND RECEIVING FARMYARD MANURE, AVERAGE OF EIGHT YEARS, 1878-86.

	Runnings of Drain-pipes (Days).	Nitrogen as Nitrates, per Million.
March–May	4	2.9
June–August	5	1.2
September–November	15	8.2
December–February	26	5.8
Whole year	50	5.8

The drainage is seen to be considerably richer in nitrates than that from the unmanured land, but it is by no means as rich as we should expect from the very large amount of nitrogenous manure applied. We shall refer to this point again.

Ammonia Salts.—We turn next to the behaviour of ammonia salts. These, as used at Rothamsted, are a mixture of equal parts chloride and sulphate. When these salts become mixed with the soil they are speedily decomposed, the chlorine and sulphuric acid combine with the lime of the soil, forming soluble salts which can be removed by rain, while the ammonia is retained near the surface in combination with the hydrous silicates, the humus, and the ferric oxide of the soil.

If, therefore, drainage occurs immediately after the application of the ammonia salts, much chlorine and sulphuric acid are found in the drainage-water, with some ammonia, but there is no considerable increase in the quantity of nitric acid. After a few days the nitric acid in the drainage is much increased, while the chlorides have begun to diminish.

We may quote, as an illustration of what we have been saying, some analyses of the drainage-water of Plot 15 made in the autumn and winter of 1880-81. 400 lb. of ammonia salts were applied to this plot on October 25, 1880, and then ploughed in. Heavy rain occurred on the night of the 26th, and the drain-pipe was found running the next morning. The analyses of the drainage-waters are given in Table XX.

TABLE XX.—COMPOSITION OF THE DRAINAGE-WATER OF PLOT 15 BEFORE AND AFTER THE APPLICATION OF AMMONIA SALTS ON OCT. 25, 1880, IN PARTS PER MILLION.

Date of Collection.	Nitrogen as Ammonia.	Nitrogen as Nitrates.	Chlorine.	Nitrogen as Nitrates to 100 Chlorine.
1880, October 10	none	8.4	22.7	37.0
1880, October 27, 6.30 A.M.	9.0	13.5	146.4	9.2
" " 1 P.M.	6.5	12.9	116.6	11.1
" " 28	2.5	16.7	95.3	17.5
" 29	1.5	16.9	80.8	20.9
November 15, 16	none	50.8	54.2	93.7
" " 19, 26	"	34.6	47.6	72.7
" December 22, 29, 30	"	21.7	23.2	93.5
1881, February 2, 8, 10	"	22.9	19.4	118.0

The occurrence of ammonia in the Rothamsted drainage-waters is unusual. It is only present in any distinct quantity when, as in this instance, heavy rain follows immediately after applying the ammonia salts.

It will be observed that the nitric acid began to rise in the drainage-water forty hours after the application of the ammonia salts, and in three weeks it reached its maximum proportion. After the middle of November the nitrates steadily declined, but not so rapidly as the chlorides. The proportion of nitrogen to chlorine thus continued to increase throughout the winter.

When ammonia salts are applied as a top-dressing in spring, they are, from the drier character of the season, less liable to the rapid removal of their constituents into the drainage-water.

Relation of Manure to Loss of Nitrates.—The relation of the character of the manuring to the contents in nitrates of the drainage-waters from the principal plots in Broadbalk field, is shown in Table XXI., which gives the average composition of the drainage-waters in four seasons of the year. The first period is from the top-dressing of the ammonia salts and nitrate of soda in March till the end of May. The second period is from the beginning of June till harvest. The third is from harvest to the autumn sowing of the wheat, when farmyard manure and rape-cake are ploughed in on their respective plots, and ammonia salts applied to Plot 15. The fourth period embraces the winter months, from autumn sowing to the spring top-dressing.

Table XXI.—Nitrogen as Nitrates in Drainage-waters from variously Manured Wheat Land, Average of Five Years, 1878-83, in Parts per Million.

Plots.		Spring Sowing to end of May.	June to Harvest.	Harvest to Autumn Sowing.	Autumn Sowing to Spring Sowing.	Whole Year.
3 & 4	Unmanured	1.7	0.1	5.6	3.9	3.5
5	Ash constituents	1.7	0.2	5.6	4.5	3.9
6	Do., ammonia salts, 200 lb.	8.1	0.7	7.3	4.8	5.0
7	" " 400 lb.	16.3	1.4	8.3	5.2	6.4
8	" 600 lb.	21.5	4.0	14.7	7.3	9.3
9*ab*	" nitrate of soda, 550 lb.	48.4	9.1	14.3	6.8	12.3
10	Ammonia salts, 400 lb.	28.6	11.4	11.5	6.3	9.9
11	Superphosphates, ammonia salts, 400 lb. .	19.5	5.8	9.2	7.1	8.5
15	Ash constituents, ammonia salts, 400 lb.	5.7	2.9	7.4	26.4	19.4
19	Rape-cake .	4.7	0.5	8.2	12.5	10.1
2	Farmyard manure	2.7	1.4	7.4	7.3	5.6

Only fairly general runnings of the drain-pipes are taken into account, so that the comparison between the plots may be as accurate or possible. The numbers given for Plots 2 and 19 are, however, the average of but 45 and 53 analyses respectively, in place of 78 to 87 in the case of the other plots, as the drain-pipes of the two plots first named ran but seldom.

The general change in the amount of nitrates with the season of the year has been already discussed in the case of the drainage-water from the unmanured plot. We may now confine ourselves to the influence of manure.

With the application of *ash constituents* to the soil (Plot 5) there is some increase in the proportion of nitrates over that produced without manure, but no change in the general character of the drainage.

Looking next at Plots 6, 7, and 8, which receive rising quantities of *ammonia salts* with ash constituents, we see that they are all liable to suffer loss of nitrates in the spring period, after the top-dressing of the ammonia salts in March, the loss being greatest on Plot 8, where most ammonia is applied. Notwithstanding the very considerable amount of nitrate produced from the ammonia salts, it is usually found to have disappeared entirely from Plot 6, and to have disappeared, or have been reduced to a very small quantity, from Plot 7, when the drains run in summer time. Plot 8 receives nitrogen in excess of what the crop can assimilate. The nitrates here do not disappear in summer, though the quantity is greatly diminished.

In a very mild early spring, as that of 1882, the nitrates may disappear from Plot 6, and be reduced to little more than a trace on Plot 7, by the first week in May. In other seasons a similar diminution may not occur till June or July.

When the drains commence running after harvest, Plot 8 shows signs of the existence of nitrate that has remained unused through the summer; but the excess of Plots 6 and 7 over Plot 5 is but small.

The winter drainage shows a surprising equality, the amount of nitrates removed from Plots 5, 6, and 7 being more equal than the total nitrogen contained in their surface-soils.

Excess Nitrogen Lost in Drainage.—The results afforded by Plots 10 and 11 are most instructive. The same quantity of ammonia salts is applied here as on Plot 7, but on Plot 10 without ash constituents, and on Plot 11 with superphosphate only. The result is that on these plots, and particularly on 10, the crop is unable to assimilate the nitrogen supplied. The nitrates consequently are found in considerable quantity all through summer, and a distinct residue remains after harvest. *The winter drainage, however, generally removes all excess, and the crop starts the next spring no richer for the unused nitrate of the previous year.*

Winter Application of Ammonia Salts Ruinous.—On Plot 15 the ammonia salts which are applied on Plot 7 in the spring are here applied in October; the salts are not top-dressed, but ploughed in. The winter drainage is here extremely rich in nitrates, and as no crop is then growing, the losses are often extremely heavy. On an average of five years, the drainage-water has contained for the whole year 19.4 per million of nitric nitrogen, as compared with 6.4 in the case of Plot 7, where the ammonia is applied in March.

Practical Conclusions.—These results furnished by the drainage-waters explain in a striking manner the results already shown by the crops. We have now no difficulty in understanding why a spring dressing of ammonia salts is in most seasons superior to an autumn dressing. The reason why the unused nitrogen of an abundant application of ammonia salts produces no effect on the crop of the following season is equally manifest. In both cases the conversion of the nitrogen of the manure into soluble nitrates, and their removal from the soil in the drainage-water, affords an ample explanation.

Nitrate of Soda.—There is but one plot (9) on which we have the results of the direct application of nitrates. The numbers given for the nitric nitrogen should be compared with the mean of Plots 7 and 10, since one half of Plot 9 receives ash constituents and compares with 7, and the other half receives none and compares with 10. Thus viewed, the loss of nitric nitrogen on Plot 9 is seen to be much greater than that of ammonia salts applied at the same time. It is evident, indeed, that the nitrate is ready for removal directly it is applied, while in the case of ammonia, time must be allowed for nitrification.

For this reason *nitrate of soda* is always *applied in spring* to a growing crop, which can at once commence the assimilation of the manure. Notwithstanding, however, the larger loss to which nitrates are liable, so active is the manuring power of nitrate of soda, that, as we have already seen, it actually produces more effect upon the crop than the same quantity of nitrogen applied as ammonia.

A part of the efficacy of nitrate of soda is doubtless due to the fact that it leaves an alkali in the soil, while ammonia salts leave an acid.

Nitrogenous Organic Manures.—The composition of the drainage-waters from Plots 2 and 19, to which organic nitrogenous manures (farmyard manure and rape-cake) are applied, does not fairly compare with the results given by the other plots, as these drain-pipes run much less frequently. These organic manures, from their slower nitrification, accumulate nitrogen in the soil during the earlier years of their application.

The soil thus enriched with nitrogenous matter produces nitrates more evenly throughout the year than soils to which ammonia salts are applied once in the season. This, however, will scarcely prove an advantage when land is cropped with cereals, as nitrates will be freely produced in autumn and winter when there is no crop to appropriate them.

The *rape-cake* contains nearly the same amount of nitrogen as 400 lb. of *ammonia salts.* According to the figures in the table, the drainage-water contains for the whole year an average of 10.1 of nitrogen per million. This is much less than the autumn-sown ammonia salts, which give 19.4, but more than the spring-sown ammonia salts, which show 6.4 or 9.9, according as ash constituents are applied or not.

The *farmyard manure* plot shows a much smaller quantity of nitrates in the drainage-water than we should expect from the large amount of nitrogen in the manure, and especially from the large amount of nitrate found in the soil in autumn by direct analysis (Table XV.)

Nitrogen Evolved as Gas.—It seems very probable that a considerable part of the nitrates produced on the farmyard manure plot are afterwards destroyed, and the nitrogen evolved as gas. This action is now well known to agricultural chemists. It takes place in soils rich in organic matter, and ill provided with air. It will thus chiefly occur when the soil is for some time saturated with water.

3. *Do Drain-pipes Increase the Loss?*

In concluding this survey of the losses suffered by drainage, it may fairly be asked: Would the losses have been as considerable if the field had not been provided with drain-pipes, especially with pipes so near to the surface as 2½ feet? The amount of water passing downwards through the surface-soil would, of course, be the same whether pipes were present or not. All that the pipes have done is to remove a portion of the drainage-water before it had passed below 2½ feet of soil. If the nitrates that have passed below 2½ feet of soil may afterwards be of service to the crop, then the action of the drain-pipes has tended to diminish the food-supply, and increase the amount of waste.

Influence of Subsoil Nitrates.—The influence of subsoil nitrates on the crop must depend very much on the character of the spring and summer. If these are warm and fairly dry, the crop becomes vigorous, extends its roots, and evaporates through its leaves much more water than is then supplied to it by rain. Under these circumstances a part of the nitrates that have passed into the subsoil in winter will move upwards, and be consumed by the crop. This recovery of nitrates undoubtedly takes place in seasons in which the period of drainage has been short, and the depth to which the nitrates are carried is therefore not considerable.

On the other hand, the recovery, after long-continued rain, must be very small, the nitrates being carried below the possible action of the roots.

Thus in good seasons the drain-pipes may rob the crop to some extent, while in very wet seasons they do not really diminish the supply of soluble food, while they make the crop more vigorous by removing the excess of water.

Nitrates in Deep-well Waters.

We can only here just refer to an investigation concerning the drainage-water which exists at great depths in the soil—namely, in deep wells. The chalk-well waters at Rothamsted and Harpenden have been subjected to a monthly examination, extending over two or three years. The unpolluted well-water, at depths from 60 to 140 feet below the surface, is found to be of nearly uniform composition. *It contains 4.4 of nitrogen as nitrates, and 10 to 11 of chlorine per million of water. This is the final result of the drainage from a large area of land under pasture and arable.* Analyses of 109 pure well and spring waters, from various geological formations, gave Dr E. Frankland a mean of 3.8 nitric nitrogen and 16.5 of chlorine.

Taking the higher figure of 4.4, the loss of nitrogen will be 1 lb. per acre for each inch of drainage. With the lower figure of 3.8, the loss will be 0.86 lb. per inch. Assuming the average drainage for England, excluding the extreme western counties, as 8 inches per annum, we have 8 lb. of nitrogen as the annual loss by drainage, according to the evidence of the chalk wells, and 6.9 lb. as the loss calculated from Frankland's analyses. The loss from arable land will be, of course, much greater than this, while that of pasture will be less, the figure given being clearly a mean of all.

The average loss of nitrogen by drainage is thus distinctly greater than the amount supplied to the land by rain, but it is probably less than the whole atmospheric supply, including the amount absorbed by soil and crop.

NITROGEN STATISTICS—THE SUPPLY, AND WHAT BECOMES OF IT.

The nitrogen contained in the crops removed from the Rothamsted wheat-field is approximately known. The quantity of nitrogen applied as manure is also known. We have also information as to the nitrogen in the soil, and as to the nitrogen removed in the drainage-waters. Is it possible, putting these facts together, to tell what has been the supply of nitrogen to the unmanured crops, and what has become of the nitrogen applied as manure? The problem is one of the highest interest, and Messrs Lawes and Gilbert have attempted to answer it.

Unfortunately the data at command are in part insufficient. The gains and losses of the soil are not exactly known. The composition of the water from the drain-pipes does not certainly indicate the general composition of the water percolating through the soil. The amount of drainage in Broadbalk field is also uncertain, save during the winter months. The figures, therefore, that we have to give, must be taken only as probable estimates, founded upon the facts at command.

Wheat without Nitrogenous Manure.—The unmanured wheat crop has in thirty years contained an average of 18.6 lb. of nitrogen; the estimated loss of nitrogen by drainage is 10.3 lb.; or 28.9 lb. in all have been removed from the land each year. On Plot 5, receiving only ash constituents, the average nitrogen in crop is 20.3 lb., and in drainage 12 lb.; total, 32.3 lb. On these plots the nitrogen in the soil has considerably diminished; the estimated diminution in the case of Plot 5 is about 20 lb. per annum. There is thus left about 10 lb. of nitrogen to be supplied annually by the seed, the rain, and by direct absorption from the atmosphere. If any reduction of nitrates to nitrogen gas has occurred, the supply from the atmosphere would have to be proportionately increased.

Wheat with Ammonia.—The plots receiving ammonia salts all show an unaccounted for loss of nitrogen. The simplest case is that of Plot 7. The ammonia salts have supplied 86 lb. of nitrogen. Assuming, as above, 10 lb. of nitrogen from seed, rain, and air, we have in all 96 lb. to account for. The average nitrogen in the crop has been 46 lb.; the estimated loss in drainage 31 lb.; the total is thus 77 lb., leaving about 19 lb. not accounted for.

This is a simple case, as there is no evidence of any serious change in the nitrogen of the soil during the experiment. The quantity shown as unaccounted for is very probably below the truth, as with a larger crop we should expect an increased supply of nitrogen from the atmosphere.

On Plot 8 and on Plot 10, where the ammonia is present in excess of the capacity of the crop to assimilate it, and the quantity of nitrate passing downwards is very considerable, the quantity of nitrogen unaccounted for in crop and drainage is much larger than on Plot 7.

Wheat Annually Dunged. — The farmyard manure annually applied to Plot 2 is estimated to contain 201 lb. of nitrogen. The average crop during thirty-eight years would contain about 46 lb. of nitrogen. The amount lost by drainage is very uncertain, but it is probably not more than 17 lb. There is further to be taken into account a large gain in the nitrogen of the soil, amounting to perhaps an average of 42 lb. per annum; much more in the earlier years, and much less in the later ones. We have here an average of at most 105 lb. of nitrogen accounted for out of 201 lb., plus that contributed by seed, rain, and air received. The average loss thus appears to be about 106 lb. per annum; much less in the early years of the application, and much more in recent years.

Nitrogen Disappearing.—It will be observed that where nitrogenous manure is applied, there is generally a considerable proportion of the nitrogen which is not accounted for, either in the crop, the soil, or the drainage-water. It is quite possible that the estimates of the loss by drainage are too low. It is difficult, however, to believe that there is not some other source of loss, an action, in fact, which reaches its maximum on the plot annually receiving farmyard manure.

This action is most probably the reduction of nitrates to nitrogen gas.

The serious losses of nitrogen which attend the continued abundant use of farmyard manure is a fact of great practical importance.

The waste of manure with high farming must always be proportionately greater than when smaller crops are aimed at.

In addition to the fruitful investigations thus reported upon by Mr Warington, many important experiments have been conducted at Rothamsted. Amongst the other subjects experimented upon are the manuring of other farm crops, the feeding of stock, the manurial value of foods, the practice of ensilage, and other matters of interest to the farmer. In various parts of this work we have drawn freely upon the great stores of knowledge which have been accumulated by Sir John Lawes and Dr Gilbert, and which they have with characteristic public spirit placed so fully at the service of their fellow-agriculturists.

The results of the experiments on barley, roots, potatoes, and leguminous crops will be referred to when we come to treat of these respective crops. Here it may be useful to present the following summary of some of the

Practical Conclusions

which may be drawn from, or are further confirmed by, the investigations at Rothamsted as to the behaviour of various manures in the soil, and the loss in drainage-waters of nitrates and other elements of plant-food.

That when nitrates—which are formed by the agency of a bacterium—exist in an uncropped soil, they are very liable—indeed in a wet season certain—to be washed away in drainage-water.

That nitrates are produced most abundantly in moist soils, and during warm weather, their production being greatly increased by tillage.

That nitrification—the production of nitrates—continues, though less actively, during mild weather in autumn and winter, ceasing in times of frost.

That there is little danger of serious loss of nitrates in drainage-water while the soil is covered with vegetation.

That it is therefore found advantageous, when there is any considerable residual nitrogen in the soil, to sow some forage crop, such as rye, in the autumn after the removal of a cereal crop, so that the growth of the plants may absorb the soluble nitrates; this forage crop being, perhaps, pastured by sheep, and ploughed down in spring.

That, for the above reasons, the system of bare fallow facilitates the loss of nitrogen in drainage.

That lime and magnesia are liable to be washed out of soils in drainage-water.

That the action of ammonia salts tends to impoverish a soil of lime.

That neither phosphoric acid nor potash is liable to serious loss in drainage.

That soils have a far stronger retentive power for potash than for soda.

That the chlorine and sulphuric acid supplied in the manure are not retained in the soil, but freely pass away in the drainage-water.

That the continued application of farmyard manure tends to lessen the discharge of water from drains by increasing the capacity of the soil to retain moisture.

That the loss of nitrates is prevented by a growing crop.

That immediately on the removal of a crop, any surplus nitrates remaining in the soil, and the nitrates resulting from fresh nitrification, begin to pass away in the drainage-water.

That this washing away of nitrates will go on till the soil is robbed to a great extent of its available nitrogen.

That when ammonia salts are mixed with the soil they are speedily decomposed, the chlorine and sulphuric acid, combining with the lime of the soil, forming soluble salts, which can be removed by drainage-water, while the ammonia is retained near the surface in combination with the hydrous silicates, the humus, and the ferric oxide of the soil.

That, therefore, if drain-water begins to flow immediately after the application of ammonia salts, much chlorine and sulphuric acid and some ammonia are washed away, and that after a few days the rate of loss of nitric acid on drainage becomes very serious.

That when ammonia salts are applied

as a top-dressing in spring, they are, owing to the drier season, less liable to the rapid removal of their constituents in the drainage-water.

That when more nitrogen is applied than can be assimilated by the crop to which it is given, the whole of the excess nitrogen remaining in the soil in the form of nitrates, after the removal of the crop, is generally washed away in winter drainage, so that the next crop starts in the following spring no richer for the unused nitrates of the previous year.

That, in wet seasons, it is ruinous to apply ammonia salts in winter.

That ammoniacal manures should be applied in spring, so as to be speedily used by the crop.

That nitrate of soda is even more liable to rapid loss by drainage than ammonia salts, for the former is ready for removal directly it is applied to the soil.

That, therefore, nitrate of soda should always be applied in spring to a growing crop which can at once commence to assimilate the manure.

That farmyard manure and rape-cake enrich the soil with nitrogenous matter.

That this, however, is not entirely advantageous, as from this store of nitrogen nitrates are freely produced, and washed away in drains in autumn and winter, after the removal of the crop.

That nitrates washed into the subsoil by rain-water, are only partially serviceable to the crop.

That the seed of grain, rain-water, and the atmosphere, contribute to an unmanured wheat crop about 10 lb. of nitrogen per acre per annum.

That where nitrogenous manure is applied there is generally a considerable proportion of the nitrogen which is not accounted for either in the crop, the soil, or the drainage-water.

That the missing nitrogen most probably passes away into the atmosphere in the form of nitrogen gas.

That there is from this cause a serious loss of nitrogen where farmyard manure is applied abundantly.

That the risks of loss are reduced to a minimum, by giving only as much nitrogen as will supply the wants of the crop to which it is to be given, and by applying the manure when the crop is ready to commence the assimilation of it.

That with excessive or abundant manuring the waste of manure will always be proportionately greater than with moderate manuring.

EXPERIMENTS ON PHOSPHATIC MANURING.

Their History, Development, and Results.

In 1875 there were at Rothamsted no experiments showing the relative effect of different forms of phosphates; and, other subjects fully engaging attention, the question has not there been taken up, or at least not largely, to the present time. Yet the annual expenditure for phosphatic manurial matter was then, as now, very great indeed, while the many forms of phosphate available varied greatly in price. It was a source of great national and individual loss if the most effective and economical form was not the one generally used, and unfortunately no distinct information existed as to the relative values of the different forms.

Unless, however, private enterprise took the matter in hand, it seemed that nothing would be accomplished. The private station at Rothamsted was fully engaged with other matters. There were, no doubt, two large and wealthy agricultural societies—the Royal Agricultural Society of England, and the Highland and Agricultural Society of Scotland; but they also were fully engaged on other matters, more in sympathy with the views of their members—such as competition in cattle-rearing, and in implements for mechanical cultivation—and these societies were not encouraged to enter upon elaborate experiments by the fact that the little which had been done in that direction had not fulfilled expectation.

That such experiments did not come up to expectation was due to a want of the development and continuance of the experiments: they were too limited, and too desultory to reach the profitable point. Work that had no outward show, and in its first stages no tangible benefit, could hardly be expected to appeal to those with whom the whole subject was not only more or less a mystery, but was indeed looked at rather with suspicion. This suspicion was engendered both by the feeling that artificial manure was a departure from the old-fashioned idea of substantial and solid manuring in the form of dung, and also by the feeling that the result of artificial manuring was evanescent, if not positively hurtful. This, in fact, farmers had probably actually experienced, not being all so well trained in agricultural science as to distinguish between suitable and unsuitable manure, nor to perceive that perfect artificial manure is natural plant-food, and that while there were evanescent and hurtful forms, there might also be more reliable and economical forms.

It was not therefore surprising that all appeals made by advanced members of these societies that experiments should be performed, fell on unsympathetic ears; while there was also a tendency to point to Rothamsted as already doing all that was necessary, although, as has been stated, the points were actually not touched there which the farmer really required to know.

ABERDEENSHIRE EXPERIMENTS.

It was under these circumstances that an effort was made in Aberdeenshire to deal with the question. The work was taken up successfully and carried on continuously for seven years, by the Aberdeenshire Agricultural Association, which in 1882 was developed by the addition of a farm, laboratory, museum, &c., under the name of the Agricultural Research Association for the North-Eastern Counties of Scotland.

At the request of the Editor of this edition of *The Book of the Farm*, Professor Thomas Jamieson, F.I.C., chemist to the Association, who has all along had the active management of the experiments, has kindly furnished the following account of the progress and results of these historical experiments.

The experiments were commenced in 1875. They had been framed with great care, scrutinised and amended by several gentlemen familiar with the various aspects of the question, chiefly by Mr J. W. Barclay, M.P., who was familiar with the manure trade and with farming, and had given close attention to the scientific aspect of the question; by Mr John Milne, Mains of Laithers, farmer, manure manufacturer, and holder of the Highland Society's diploma; by Mr Ranald Macdonald, factor on the Cluny estates; and by the chemist to the Association. The scheme of experiments, provisionally made, was thus scanned from all aspects, and was then laid before the committee (presided over by the Marquis of Huntly), fully discussed, and finally adjusted. It will thus be seen that its scientific accuracy and direct practical bearing were well assured.

The Experimental Stations.—Five different sites were fixed upon, at altitudes varying from 1 to 400 feet above sea-level; at distances from the sea varying from 2 to 30 miles; and representing soils of different characters and different degrees of fertility; the depth of mould varying from 8 to 36 inches; while the subsoils represented crumbling granite, gravel, and sand, yellow clay, bluish clay, and stiff red clay.

Size of Plot.—Each site was about two acres in size, and was enclosed by a substantial fence. This area gave space for a large number of plots, of the size that had been so highly recommended by the late Professor Anderson, chemist to the Highland and Agricultural Society—viz., $\frac{1}{112}$th part of an acre.

It may be mentioned in passing, that Professor Anderson arrived at this size after much experience with experiments on a larger scale. It may also be mentioned that the same experience was got in Aberdeenshire; preliminary experiments on $\frac{1}{10}$th and on $\frac{1}{20}$th acre plots having been made, while along with the large number of $\frac{1}{112}$th acre plots, a large field was divided into ¼th acre plots. This experience gradually led to a clearer discernment of the objectionable features of large plots, and to a distrust in their results; while Professor Anderson's opinion was abundantly confirmed, that the $\frac{1}{112}$th acre plot is a most suitable size for field experiments, while it is also very convenient for calculation, as every pound of manure applied, or of crop reaped, represents the same number of cwts. per acre.

Discussion as to Size of Plot.—It is only what is to be expected that this subject of size of plot will crop up every now and again; familiarity with work on large areas engendering a leaning towards large experimental plots, while greater familiarity with actual experimenting leads to the small plot, as ensuring uniformity of soil, as well as identical cultivation under the same climatic conditions, and hence fair comparison. The $\frac{1}{112}$th acre plot is indeed too large; but it is probably as small as can be adopted, unless the soil is actually taken up, and thoroughly mixed, and returned in equal quantities to the former position. Under such arrangement the $\frac{1}{1000}$th acre plot will be found in the highest degree satisfactory.

It is interesting to notice how steadily opinion grows in favour of small plots, and how constantly the above experience is repeated—namely, that every beginner, especially if associated or influenced, directly or indirectly, with practice on the large scale, begins with large plots, and gradually works towards the smaller ones.

Duplicated Plots.—Especial care was taken to have each experiment duplicated, a feature too often neglected in experiments. It is indeed desirable that they should even be triplicated.

In the experiments having reference specially to phosphate applied with and without nitrogen, special care was taken that there should be no hindrance to the action of these essentials by the absence of other materials understood to be essential. This was prevented by the application, all over the plots, of a mixture consisting of 3 cwt. potassic chloride, 1 cwt. magnesia sulphate, and ½ cwt. common salt. Each plot was surrounded by a deal-board nine inches deep, driven edgewise into the soil.

Adjusting the Manures.—The soils were subjected both to chemical and mechanical analyses. The manures were also analysed, and care taken that equal quantities of the ingredients were used. In the earlier experiments, however, the proportion of insoluble phosphate was a half more than soluble phosphate, an adjustment considered necessary in order that the two phosphates might be fairly compared, assuming that the finer division or greater distribution of the soluble phosphate would give it undue advantage in a fair trial of the relative powers of the two substances. Possibly this adjustment was unnecessary; the probable effect was to provide a larger quantity of phosphorus in the case of the insoluble form than was necessary. In the later experiments, therefore, equal quantities were adopted, with about the same result as had previously been got in the crop. In the first instance, also, the soluble phosphates were exactly a half soluble (*i.e.*, in commercial terms about 20 to 26 per cent superphosphate). In the later experiments, however, the highest practicable degree of solubility was sought—viz., about 35 per cent soluble.

On singling the plants (turnips) it was sought to have an equal number in each plot—namely, about 200; but that number, from various causes, which will be easily understood by those engaged in practice, was seldom maintained to the end of the season. Attacks by insects, weakly plants, frost, drought, &c., frequently reduced the number.

None of the operations on the plots were allowed to go on, nor weighing of the crop, except in the presence of the chemist who directed the experiments.

It may thus be seen that the most scrupulous care and attention were given to the whole work.

First Year's Conclusions.

At the end of the year the numerous and duplicated results of this large series of experiments were tabulated, and presented such a varied and confirmed series of results as probably had not previously been available. They were carefully considered by the individuals above mentioned, and others taking part in the direction, and finally the following conclusions were adopted:—

1. That *phosphates of lime* decidedly increase the turnip crop, but that farmers need not trouble themselves to know whether the phosphates are of animal or of mineral origin.

2. That soluble phosphate is not superior to insoluble phosphate to the extent that is generally supposed.

3. That nitrogenous manures have little effect on turnips used alone, but when used along with *insoluble* phos-

phates increase the crop; that the addition of nitrogen to *soluble* phosphates does not seem to increase the solids or dry matter in crop; that there is no material difference between the effects of equal quantities of *nitrogen* in nitrate of soda and in sulphate of ammonia.

Note.—Pure sulphate of ammonia contains about 5 or 6 per cent more nitrogen than nitrate of soda.

4. That fineness of division seems nearly as effective in assisting the braird and increasing the crop as the addition of nitrogenous manures. Hence the most economical phosphatic manure for turnips is probably insoluble phosphate of lime, from any source, ground down to an impalpable powder.

Condensed Results.—It would occupy too much space to give the results in detail. It may suffice to give a few condensed results—namely, a few results from the station that responded best to the action of phosphate, and therefore showed the relative action of the different forms most clearly; and also the results of the five stations averaged:—

		Aboyne. Turnips. Tons per acre.	Average of 5 Stations. Turnips. Tons per acre.
Group I.	No phosphate given	5	10
	Insoluble phosphate (ground coprolite)	19	16
	Soluble phosphate (superphosphate)	22	18
Group II.	Insoluble phosphate and nitrate of soda	21	18
	Soluble phosphate and nitrate of soda	26	21
Group III.	Insoluble phosphate and sulphate of ammonia	23	20
	Soluble phosphate and sulphate of ammonia	24	20
Group IV.	Raw bone-meal	16	16
	Steamed bone-powder	23	20

Insoluble Phosphates as Plant-food.—From the point of view of new information, the first and last groups are by far the most important. Formerly coprolite was deemed of no manurial value until rendered soluble by sulphuric acid; and in placing a money value on a dissolved manure, no value was attached to the insoluble portion it contained. The above results indicated that this position was untenable. They led the Aberdeenshire Association to say decisively that insoluble phosphate in the form of ground coprolite was directly effective on plants, and to add the statement that the superiority of the soluble form is not so great as is generally supposed. It was thought well to limit expression to the latter general and tentative statement, reserving a definite statement till further results were obtained.

The fourth group indicates the excellent results got by using phosphate in a fine state of division, and led to the fourth conclusion stated above.

It may be remarked that these opinions are now generally accepted. No doubt there may constantly be heard dissentients from these doctrines. That is only what may be expected, when the subject concerns so large a body as the whole agriculturists of a kingdom. But no responsible person will now be found to take up an opposite position.

The bearing of the New Doctrine.—At this stage there ought to be prominently brought forward the real bearing of this new doctrine on agricultural practice.

What is the actual effect of the knowledge that the natural coprolite, merely ground, is able directly to feed the plant with phosphate? Being decidedly the cheapest form of phosphate, does it follow that it should be employed to the exclusion of all other phosphates? Assuredly not, when it is so clearly brought out that although it produces 16 tons per acre, other forms produce 18 tons, and others 20 tons per acre. Assuredly not again, when it is stated that greater assistance is given to the plant in the early stage, by more finely divided phosphate, or by soluble phosphate. So long as the latter two phosphates are not charged a higher price, as compared with coprolite, than is compensated by the larger crop, they should be used. So soon, however, as the price advances much beyond that point, the agriculturist can fall back on coprolite, which is found abundantly in many parts of the world, and requires no more manufacture than simple grinding.

It is thus wholly and solely a matter of price. And herein lies the important practical bearing of the new doctrine. It is well to grasp fully the significance of the knowledge that coprolite may be used directly. Put in few words it is this—*that it provides a check to the undue raising of the price of manufactured phosphates.*

Experiments of Subsequent Years.

It would go beyond the limits of this article to explain the many points that engaged the Aberdeenshire Association during the following six years—viz., till 1882—during which the experiments of the first year were continued and repeated, providing altogether many hundreds of results. The proceedings of the Association, for that period of seven years, form a large volume, replete with tables, diagrams, and photographs, which provide the critic with full details, while at the same time the main points are clearly brought out for the general reader. It may suffice to say that the following points were very fully entered into :—

1. The *specific gravity of turnips*, which was found to give no reliable indication of their quality.

2. The *proportion of water in turnips*, which was found to be increased both by nitrogenous, and, to some extent, by soluble phosphatic manures.

3. "*Finger and toe*" *disease* was investigated; farmers' opinions regarding it widely ascertained; many experiments conducted to ascertain the effect of manures in giving rise to the disease; and other experiments with the view of finding a remedy. Speaking generally, it was found that whatever weakened the plant predisposed it to disease, and rendered it an easy prey to its natural fungoid enemy, which then produced the disease. But while many influences, both mechanical and climatic, caused weakness, it was found, in a very remarkable and unmistakable manner, that soluble phosphate produced this effect in a very striking degree. Nor was this effect confined to phosphate rendered soluble by sulphuric acid, but sulphur in various forms seemed more or less to have a similar effect. As to a remedy, the disease seemed lessened by whatever ensured healthy growth, or a condition of soil uncongenial to fungoid growth, as well as such lapse of time between the two turnip crops as would reduce the natural food of the fungus, while a heavy dose of lime markedly lessened the proportion of disease.

4. The *variation in weight on oat grain by storing;* the solid nourishing matter in oats differently manured; and the proportion of husk to kernel.

5. *Different methods of storing turnips* during winter were tried, and the method of storing in pits of two or three loads, and covered with three or four inches of earth, was found to answer best; while the result was not greatly different whether or not the roots or leaves, or both, were cut off previous to storing.

The first series of experiments was, as mentioned, on turnips, and turnips were grown on the same ground successively for five years.

But in the second year of the experiments, the original experiments were repeated on new ground at each station, and the effect of the various manures ascertained over a rotation.

Relative Value of Phosphates and Nitrogen.

At the end of seven years it was considered that the subject that had been carefully avoided up to that time might then be approached—viz., to fix the relative agricultural value of phosphates and nitrogen. This was done, not by attaching a money value, which might vary every year, but by fixing on some large natural source of phosphate, and a similar source of nitrogen, and adopting these each as a standard, to be referred to by the figure 10. The standard adopted for phosphate was ground coprolite of the usual commercial degree of fineness, which was called 10; while the standard chosen for nitrogen was nitrate of soda, the value of which was also called 10.

It may be necessary later on to make these standards more definite, by specifying more distinctly the precise state of mechanical division; and obviously the finer the division chosen for the standard, the less will be the difference between it and the forms standing above it. But for the immediate purpose the commercial forms were deemed sufficient.

The values thus carefully arrived at for phosphate were :—

Phosphate of iron . .	0
Phosphate of alumina (redonda)	3
Tribasic phosphate of lime in bone	10
Tribasic phosphate of lime in insoluble mineral	10
Monobasic phosphate of lime in soluble phosphate . . .	12
Bibasic or tribasic phosphate of lime in precipitated form	13
Tribasic phosphate of lime in steamed bone flour	14

While the values for nitrogen were as follows :—

Nitrate of soda .	10
Sulphate of ammonia	10
Guano .	10
Nitrogen (only) in bones (supplemented with dried blood) .	8

At the same time the conclusions originally framed were more specifically drawn out as follows :—

Final Conclusions.

1. Non-crystalline phosphate of lime, ground to a floury state, applied to soil deficient in phosphate, greatly increases the turnip crop, and also, though to a less extent, the cereal and grass crops, but always with equal effect, whether it be derived from animal or mineral matter.

2. Soluble phosphate is not superior in effect to insoluble phosphate if the latter be in finely disaggregated form—*e.g.*, disaggregation effected by precipitation from solution, or by grinding bones after being steamed at high pressure. In such finely divided conditions, the difference is in favour of the insoluble form, in the proportion of about 12 for the soluble to 13 and 14 for the above insoluble forms respectively. In less finely divided form (such as mineral phosphate impalpable powder), insoluble phosphate is inferior to soluble phosphate in the relation of about 10 to 12.

3. Nitrogenous manures used alone have little effect on root crops, unless the soil is exceptionally poor in nitrogen, and rich in available phosphate.

Nitrogenous manures used with phosphate on soils in fairly good condition give a visible increase of root crop, but this increase is due mostly, and often entirely, to excess of water in the bulbs.

Nitrogenous manures greatly increase cereal crops, and the increase in this case is not due to excess of water.

As to the relative efficacy of different forms of nitrogen : the ultimate effect of nitrogen in sulphate of ammonia, in guano, and steamed bone flour, is nearly identical, whether used with soluble or insoluble phosphate. Nitrate of soda, when used with soluble phosphate, is also identical with the above forms, but is of less efficacy when used with insoluble phosphate.

4. Fine division (or perfect disaggregation) of phosphates assists the braird nearly as much, and with more healthy results, than applications of nitrogenous manures.

The most economical phosphatic manure is probably non-crystalline, floury, insoluble phosphate of lime ; the cheapest form being mixed with an equal quantity of the form in which the highest degree of disaggregation is reached.

(At present these two forms are respectively, ground mineral phosphate (coprolite), and steamed bone flour.)

Duplicate Trials in England.

It remains only to say, that it having been argued that while these results might apply to soil in Scotland, poor in lime, and not to soils in England, generally richer in lime, it was considered desirable to ascertain whether or not the results had only this limited application.

A station was therefore established in Huntingdon, and another in Kent, while later on a large number of experiments were established in Sussex, and carried on by the Sussex Association for the Improvement of Agriculture, under the same chemical direction as the Aberdeenshire experiments. These experiments in England showed, that while in soil actually on the chalk formation soluble phosphate showed to more advantage than on all the other soils tried, yet in the other soils in Sussex and in Huntingdon, where the soil was not so purely chalky, but yet contained the ordinary quantities of lime, the results were practically the same as those got in Aberdeenshire.

Outside Confirmation.

The value of these experiments in Aberdeenshire and Sussex would be uncertain unless confirmed not only in other places, but by other and independent experimenters. The importance of the question, however, was widely recognised; and after some time, both the Highland and Agricultural Society of Scotland, and the Royal Agricultural Society of England, established experiments on the same subject, as did also a number of private experimenters, all of whose results pointed more or less conclusively in the same direction.

Still the march has been slow, if we judge its progress by the amount of coprolite applied, or by the small effect on the superphosphate trade. But for this there are two obvious explanations; first, as already explained, that the effect is not to be looked for in the direction of the greater use of coprolite, but rather in the reduction of the prices of superphosphate and other phosphates—and this reduction has indeed taken place to a very marked extent; and, second, that the interest of the trade is more than able to cope with the agriculturist, who at the present day is hardly so skilled in the intricacies of manure as in a few years he is likely to become.

Scope of the Sussex Experiments.

Allusion has been made to the experiments conducted in Sussex under the name of the Sussex Association for the Improvement of Agriculture. As these experiments have been going on for eight years, in eight different sites throughout the county, representing the chalk formation, the weald clay, Hastings-beds and greensand, it will be evident that the amount of work and number of results thus ascertained are too extensive to admit of satisfactory treatment here. It may be mentioned however, that, beginning with experiments testing not only phosphorus but also nitrogen and potassium in different forms, on which a great amount of both interesting and useful information has been obtained, attention has been directed latterly to the means of improving old pasture, and to the laying down of new pasture in such a way as to ascertain the effect of different seeding, different manuring, liming, draining, &c.

HIGHLAND AND AGRICULTURAL SOCIETY'S EXPERIMENTS.

In the year 1878, a series of field experiments was inaugurated by the Highland and Agricultural Society of Scotland. For the following account of these experiments we are indebted to Dr A. P. Aitken, chemist to the Society, under whose care they were conducted:—

Object of the Experiments.—The object of these experiments was to test the accuracy of many views then prevalent regarding the efficacy of the various light manures in use among farmers, to discover what was the agricultural or crop-producing values of these substances, and to see how far these values corresponded with the prices at which the substances were being sold in the market.

It was believed by many advanced farmers that large sums of money were annually being spent in the purchase of manurial substances, whose efficacy as manures was entirely out of harmony with their market prices, and that nothing short of an extended series of experiments, performed upon an agricultural scale over two rotations, would be capable of uprooting old prejudices, and of enlightening farmers regarding the true value of the substances in which so much of their capital was being invested. It was believed that such a series of experiments would not only determine, in a practical and reliable manner, what was the real value of manures, but would also supply much-needed information regarding the special utility of the various ingredients of manures, the forms in which they could be most profitably employed, and the most rational and economical methods in which to apply them.

The Stations.—For this purpose the Society rented two fields—one at Harelaw, in East Lothian, and one at Pumpherston, in West Lothian. At each station 10 acres were set apart and divided into forty plots of one rood each. The soil of the former, a rich deep loam near the sea-level, in a dry early district; and that of the latter a thin clayey loam, resting on the till or boulder clay, a somewhat wet and late district, 400 feet above the level of the sea.

No dung was applied to the stations during the course of the experiments, nor for four years previous to their commencement.

Manures tried.—The three classes of manures under experiment were phosphates, nitrogenous matters, and potash salts of the following kinds:—

Phosphatic Manures.

Mineral phosphates	Carolina land phosphate. Canadian apatite. Curaçoa phosphate. Aruba phosphate, &c.
Of remote animal origin	Phosphatic guano. Coprolites.
Of recent animal origin	Bones, in various forms. Bone-ash.

These were applied in a finely ground state, and also after having been dissolved in sulphuric acid.

Nitrogenous Manures.

Soluble	Nitrate of soda. Sulphate of ammonia.	
Insoluble	Meat-meal Dried blood Horn-dust Keronikon Shoddy or wool-waste	of animal origin.
	Rape-cake dust Cotton-cake dust	of vegetable origin.
Guanos, &c.	Peruvian guano. Ichaboe guano. Fish-manure. Frey Bentos manure.	

Potash Manures.

Sulphate of potash.
Muriate of potash.

These manures were so applied that each plot received the same quantity of *phosphoric acid, of nitrogen, and of potash*, whatever might be the form in which these were applied, and irrespective of the gross weights of the substances, or of their market prices.

Cropping.—The cropping consisted of a four-course rotation of turnips, barley, beans, and oats.

Manures for Turnips and Beans.—When the crop was turnips or beans, the manures applied to these plots contained—

	lb. per acre.
Phosphoric acid	160
Nitrogen	40
Potash	120

Manures for Cereals.—When the crop was barley or oats, the manure contained—

	lb. per acre.
Phosphoric acid	80
Nitrogen	40
Potash	60

The plots on which the various *phosphatic manures* were tested, received, in addition, their proper quantity of potash in the form of a mixture of muriate and sulphate, and their nitrogen in the form of nitrate of soda.

The plots on which the various *nitrogenous manures* were tested, received, in addition, their proper quantity of phosphoric acid in the form of superphosphate, and their potash as mixed sulphate and muriate.

The plots on which the two *potash salts* were tested, received their proper quantity of phosphoric acid as superphosphate, and their nitrogen as nitrate of soda.

The great majority of the plots on the stations were thus fully manured; and in so far as the essential ingredients—phosphoric acid, ammonia, and potash—were concerned, they all fared alike. It was only the outward and accidental form and fashion of these substances that differed.

In order to form a starting-point or basis of comparison for the whole station, three plots received no manure whatever.

In order to measure the specific effects of each of the three essential ingredients, three plots received one of each and nothing else, while from other three plots each of the three essential ingredients respectively was withheld.

In addition to the two series of experiments on the stations, there were annually carried out a selected number of experiments on farms in various parts of the country to test the accuracy of the results obtained, and to acquire additional information regarding the action of manures when applied to different soils and under different climatic conditions.

Full reports of the experiments were published annually in the Society's *Transactions*, and the following is a general statement of the chief results obtained and observations made.

I. Results with Phosphatic Manures.

Produce of Dry Matter from Pumpherston.—During the eight years comprised in the two rotations, the total amount of dry vegetable matter per acre, in the form of roots, grain, and straw, removed from the plots to which *complete manures* had been regularly applied on that section of the station at Pumpherston devoted to the study of phosphatic manures was as follows:—

	Tons of Dry Matter, per acre.	
	Undissolved.	Dissolved.
Bone-ash	12.69	12.66
Ground coprolites	11.80	13.22
Bone-meal	11.32	13.80
Phosphatic guano	12.47	14.11
Ground mineral phosphates	11.66	14.16
Average	11.99	13.59

Conclusions. — The facts apparent from a mere glance at these figures are, that—

Soluble phosphates have produced about 13 per cent more actual fodder than insoluble phosphates.

Bone-meal, which is one of the dearest of the phosphates, has given the smallest return.

Dissolved mineral phosphate, which is just ordinary superphosphate, and made from the cheapest material, has given the largest return.

Among the insoluble phosphates, *phosphatic guano* and *bone-ash* are best.

Over a series of eight years, the amount of fodder raised by the application of different kinds of insoluble phosphates are not very different.

The following facts, although not apparent from a mere scrutiny of these figures, were attested from year to year during the course of the experiments:—

Insoluble Phosphates.—These vary in their efficacy far more than soluble phosphates. They are more dependent on moisture for their activity, and during dry seasons they are of very little use. Even during wet seasons they were found to be very capricious in their action. The phosphate which was the best one year might be the worst the next year.

Fineness of Grinding.—This uncertainty was found to be caused by the different *degrees of fineness* to which they happened to be ground. The finer they were ground, the more effective they were as manures.

A series of experiments made in 1886, on four plots of Pumpherston and on four Lowland farms, with the same mineral phosphate, in two slightly different degrees of fineness, showed uniformly a difference of about 11 per cent in favour of the more finely ground phosphate. The whole question of the efficacy of ground phosphates has been shown to turn on the point of the fineness to which they are ground.

Phosphatic Guano.—The reason why phosphatic guano is so effective a form of insoluble phosphate is presumably because it consists in great measure of very finely divided matter, and also because it contains from 5 to 10 per cent of precipitated or "reverted" phosphate which is in an infinitely fine state of division.

Bone-meal.—The reason why bone-meal is slowest in its action, is probably because it consists in large measure of very coarse particles.

Judged by the standard of fineness of division alone, bone-meal, which was enormously coarser than the other phosphates, should not have produced nearly so much vegetable matter. Its efficacy must therefore depend on other circumstances—notably its power of rotting in the soil, and of accumulating a store of phosphate, in no very long time becoming available as plant-food.

Soluble Phosphates.—Although the eight years' record shows that the soluble phosphates differ more widely in their efficacy than the insoluble ones, they have not varied up and down so much as the latter. Their action was much more steady and reliable. Nevertheless their relative order of activity did alter on some occasions.

Just as the undissolved phosphates differed from year to year in their fineness of grinding, so the dissolved phosphates differed from year to year in the fineness of their manufacture, or in their state of aggregation due to dampness, or the time during which they were kept in bags before being applied. Dissolved manures are liable to cohere into lumps from various causes, and the most careful riddling cannot restore the fine condition of a manure that has become lumpy.

Fine Powdery Condition essential.—Attention was early drawn to this circumstance during the course of the experiments, and observations made showed clearly that the efficacy of dissolved manures depends very much upon the more or less *powdery condition* in which they are applied. It is to this circumstance, more than to any other, that the variation in the amount of the produce from the application of different forms of soluble phosphate must be attributed, and from the results of these experiments the following affirmation may be made :—

Given two phosphates of somewhat similar composition, but of different degrees of fineness, the superiority will lie with the finer one, whatever be its origin or history, or by whatever name it may be called.

More Vigorous Growth from Soluble Phosphates.—On the plots to which soluble phosphates were applied the plants brairded sooner, the turnips came sooner to the hoe, and met sooner in the drills, and the cereals were ripe and ready for harvesting from a week to a fortnight earlier than on those plots manured with insoluble phosphates. These important advantages were especially noticeable during dry seasons.

Owing to the more vigorous growth on the plots manured with soluble phosphates, their crops were *less liable to disease*, and the land was always cleaner than on the other plots.

Harelaw Results.—The results obtained at the Harelaw station were very similar to those obtained at Pumpherston, but owing to the high state of fertility of the soil the differences were not so well marked.

Insoluble Phosphates for Mossy Land, &c.—A large number of experiments to determine the relative utility of soluble and insoluble phosphates were made on farms differing widely in their soil and climate, and it was found that insoluble phosphates produced their best results upon mossy land, and soils rich in organic matter in wet districts. In such circumstances they were a more economical manure than superphosphate.

Bones and Fineness of Grinding.—An extended series of experiments carried out on the stations, and on other farms, to test the relative manurial value of bone-meal of different degrees of fineness, showed that the finer ground bone-meals gave the best results during the season in which they were applied, and also during succeeding seasons where their after-effects were observed.

II. Nitrogenous Manures.

Produce of Dry Matter at Pumpherston. — The following are the amounts of dry vegetable matter removed from the plots at Pumpherston that were set apart to determine the relative efficacy of nitrogenous manures during the two rotations. The manures contained in each case the same amount of nitrogen, and there was given along with it a definite uniform amount of superphosphate and potash salts.

	Tons per acre.
Nitrate of soda	12.22
Sulphate of ammonia.	11.62
Horn-dust, shoddy, &c.	9.28
Dried blood	10.38
Rape-cake dust	10.96

As in the case of phosphates, so also in the case of nitrogenous manures, the most soluble substances produced the largest return.

Nitrate of Soda.—This is the most active and efficient of all the nitrogenous manures, and its action has been studied under a variety of conditions at the stations, and on other soils of very different character.

Its chief peculiarity is that it acts almost immediately on the crop, and produces a marked effect whether ploughed in with the seed or applied as a top-dressing during the growth of the crop.

When applied to land in good condition, or when it forms part of a complete manure, it causes the crop to braird vigorously, and is sometimes the saving of a crop whose youth is precarious. It is especially valuable in seasons of drought, as it enables the young plant to root rapidly and become less dependent on surface-moisture.

When applied to cereals it causes a more abundant growth of straw than any other manure. When applied with the seed or to the young braird, it not only increases the bulk of the crop, but it hastens its development and causes it to ripen sooner. If applied at a later period, it causes the plant to grow too much to stem and leaf, and it unduly prolongs the period of growth. When applied late as a top-dressing to cereals, it causes a disproportionate growth of straw, retards the period of ripening, and favours the production of light grain.

When applied to a thin sharp soil during a wet season its effect is transient, showing that much of it has been washed down through the soil and out of reach of the roots of the crop.

When applied too liberally on good land, it causes a rapid growth of ill-matured vegetable matter, and produces a crop which is too abundant, unable to ripen, of poor feeding value, and liable to accidents.

When applied to plants grown for their seed, nitrate of soda must be used more sparingly; for increase of stem or straw, if overdone, is secured at the expense of the seed, both in quantity and quality.

It may therefore be used with greater impunity to crops which are grown for the sake of their stem and leaf—chiefly and notably to grass of one or two years' duration.

When applied liberally to grass, it increases the growth of the grasses proper, but diminishes the amount of clover and other leguminous plants; therefore, when a good crop of clover is desired, nitrate should be used very sparingly.

Sulphate of Ammonia.—Sulphate of ammonia is slower in its action than nitrate of soda. It is therefore to be preferred as a nitrogenous manure for crops which have a prolonged period of growth. When applied as a top-dressing to cereals, it retards the time of ripening. A similar effect is produced when applied with the seed in dry districts or during seasons of drought. It does not fail to benefit the crop even upon thin soils and during wet seasons. It is therefore more appropriate than nitrate of soda for application in these circumstances.

Sulphate of ammonia can do little for the germinating seed in dry weather, as it is not in an immediately available form. Even after rain comes, it is some time before the sulphate of ammonia comes into action.

Sulphate of ammonia has been found to check the growth of clover more effectively than nitrate of soda if applied in excess, but in moderate quantity it is an excellent manure for old grass. It is not suitable for application to leguminous crops, which are intolerant of strong nitrogenous manures, especially after the first period of their growth.

Insoluble Nitrogenous Manures.

Insoluble nitrogenous manures are substances containing albuminoid matter. They are very suitable for wet districts, but none of them can be considered a manure until it is finely ground, or rotted, or dissolved.

Rape-cake Dust.—Among the insoluble nitrogenous manures rape-cake dust has produced the greatest amount of vegetable matter. It is very probable that this is due in some measure to the large amount of carbonaceous organic matter contained in it. It was also noticed that the plot to which this manure was applied was singularly free from disease, and that the texture of the soil improved under its application.

Dried Blood, Horn-dust, &c.—Dried blood was found to be a good manure for roots, especially when applied early, but too slow in its action for cereals.

The same remark applies to *horn-dust* and *keronikon*, which should be applied long before sowing. *Shoddy* was tried on only one occasion, and was found quite inoperative.

All these insoluble nitrogenous matters become, when dissolved in sulphuric acid, good quickly acting manures.

III. Potash Manures.

Potash salts are chiefly important on land that has not been dunged. On dunged land they frequently fail to produce any marked effect.

Sulphate and *muriate* of potash are nearly equal in their action. They are most effective when applied some months before sowing. The crops to which they are most beneficially applied are beans, clover, and leguminous crops generally.

When applied to cereals, they increase the amount of grain to some extent, and they make the straw more elastic and less liable to lodge.

Manuring Turnips.

The manurial constituents of greatest importance in raising a crop of turnips are phosphoric acid and nitrogen.

The relative importance to the turnip crop at Pumpherston of these two ingredients of potash, is seen by comparing plots manured as under during four years:—

No. of Plot.		Roots per acre. tons.	cwt.
22.	Potash	6	14
12.	Phosphate (bone ash)	9	2
18.	Nitrate	13	8
11.	Potash and nitrate	8	2
21.	Phosphate and nitrate	14	10
1.	Phosphate, nitrate, and potash	16	4

Effects of Manures on Turnips.— The chief effect of manuring on turnips is to increase the quantity per acre, but the quality of the turnip is also much affected by the nature of the manure.

Turnips manured with dissolved phosphate contain a higher percentage of ash than those manured with ground phosphates.

They also contain a somewhat smaller proportion of albumen, and upon the whole they have a wider ratio of albumen to carbohydrates, which means that they have not quite so high a feeding value.

The diminished percentage of albumen produced by the use of dissolved phosphate was counterbalanced by the increase in the total crop, so that the total amount of albumen per acre was somewhat in favour of the crop grown with soluble phosphate.

Dissolved phosphates when applied in April produced a better crop of turnips than when applied with the seed in June. The earlier manured turnips were denser, and produced more solid food per acre than the others.

Turnips manured early had more ash than those manured with the seed.

When the nitrogenous manure of turnips is given entirely in the form of nitrate of soda or of sulphate of ammonia, the latter has been found to produce a denser, sounder turnip.

The best way of applying potash to turnips is to apply it several months before sowing.

Potash manures cause an increase in the amount of turnip-tops, but retard the ripening of the bulbs.

An excess of potash manures decreases very materially the quantity of roots, and may greatly injure the crop.

It is scarcely possible to overdo the application of phosphates to turnips, so far as the health and feeding quality of the roots are concerned; but too liberal an application of nitrogenous manure unduly increases the tops and retards the ripening of the bulbs, and also increases their liability to disease.

General Observations on Turnips.

Turnips contain a smaller percentage of solids than swedes. The turnips at the stations contained from 7 to 9 per cent solids, and the swedes from 10 to 12 per cent.

The solid matter of the swedes contained 15 per cent more albuminoids than that of the turnip, and there was as much nourishment in 10 tons of swedes as in 13 tons of turnips.

Turnips contained in their dry matter nearly 8 per cent of ash, and swedes only about 5½ per cent. The latter were therefore less exhausting to the land.

Large turnips are not so economical as medium-sized ones in any way. They contain more water, and produce less solid matter per acre. The larger they are, the smaller is the proportion of true albumen in their solid matter; they are the less mature, and the less nutritious. They contain a higher percentage of ash, and are therefore more exhausting to the soil. They have a low specific gravity, and are usually spongy in the heart. They are more liable to rot, and do not keep so well when pitted. Turnips at their best are too watery a diet, but the larger they are the poorer the diet.

Small turnips, on the other hand, are not so profitable as *medium turnips*, because they do not produce so much solid food per acre, and although they contain a higher percentage of solids and a smaller percentage of ash, yet their solid matter consists largely of indigestible woody fibre, and is therefore less nutritious.

The nitrogenous matter in turnips is partly of a nutritive and partly of a non-nutritive kind. The former consists of albuminoid matter. The ratio of nutritive to non-nutritive nitrogenous matter varies extraordinarily in different turnips, and under different circumstances of weather and manuring.

Forced Turnips of Bad Quality.—Bulbs grown very rapidly, whether from excess of moisture or too liberal application of soluble nitrogenous manure, have a smaller proportion of their nitrogenous matter in the form of albumen.

Manures which unduly force the growth of turnips may increase the quantity of the crop; but the increase of quantity is got at the expense of quality, and the deterioration of quality is mainly expressed in the large percentage of water and the small percentage of albumen in the bulbs.

Manures for Rich Crops of Turnips.—In order to grow a large and at the same time a healthy and nutritious crop of turnips, such a system of manuring or treatment of the soil, by feeding or otherwise, should be practised as will result in the general enriching and raising of the condition of the land, so that the crop may grow naturally and gradually to maturity.

For that purpose a larger application of slowly acting manures, of which bone-meal may be taken as the type, is much better suited than smaller applications of the more quickly acting kind.

A certain amount of quickly acting manure is very beneficial to the crop, especially in its youth; but the great bulk of the nourishment which the crop requires should be of the slowly rotting or dissolving kind, as uniformly distributed through the soil as possible.

Manures for the Barley Crop.

The relative importance to the barley crop of the three manurial ingredients may be seen from a comparison of the results obtained on the plots manured as under for five years:—

No. of Plot.	Grain per acre. lb.
22. Potash	875
12. Phosphate (bone-ash)	1175
17. Phosphate and potash	1256
18. Nitrate	1287
21. Nitrate and phosphate	1706
11. Nitrate and potash	1814
13. Nitrate, potash, and phosphate	2596

Manures applied to the barley crop affect, in the first place, the quantity per acre both in grain and straw; in the second place, and to a much less extent, they affect the quality of both grain and straw, and they materially affect the time of ripening.

Nitrogenous Manure for Barley.—The most important constituent of a manure for the barley crop is nitrogen. In ordinary circumstances, it is the quantity of nitrogen in the manure or in the soil which determines the bulk of the crop.

In an ordinary rotation of cropping, in which barley succeeds turnips, the *phosphate and potash* required by the crop are relatively abundant in the soil, and a good crop can be obtained if only some nitrogenous manure is applied in sufficient quantity to enable the plant to take up its mineral food.

The kinds of nitrogenous manure most suitable for barley are those which are soluble and rapid in their action, such as sulphate of ammonia and nitrate of soda. *Sulphate of ammonia*, if applied as a top-dressing, and *nitrate of soda*, if so applied, much later than three weeks after the date of sowing, may increase the quantity of the crop both in grain and straw, but the quality of the grain, as indicated by the weight per bushel, will be lowered, and the time of ripening will be retarded.

A difference of three weeks in the time of ripening occurred among the experimental crops. The earliest were those which were manured with soluble phosphate, and whose nitrogenous manure was nitrate of soda applied with the seed. The latest were those which received no nitrogenous manure, an overdose of it, or too late a top-dressing.

Slowly acting nitrogenous manures are of no use to the barley crop, unless applied some months before the time of sowing.

A deficiency in the amount of nitrogenous manure applied to barley not only diminished the total amount of the crop, but it also diminished the percentage of albuminoid matter contained in the grain.

Barley, top-dressed with nitrate of soda, contained somewhat more albuminoid matter than that which had the nitrate applied with the seed.

The amount of albuminoid matter varied from 8½ to 11½ per cent. The former amount was contained in barley, from whose manure all nitrogenous matter was withheld, and the latter from barley top-dressed with nitrate.

Phosphatic Manures for Barley.—*Phosphatic manures* are next in order of importance for barley. The more speedy their action the better; therefore *superphosphate* is the most reliable form of phosphate.

The plots to which soluble phosphates were applied came to maturity ten days before those with insoluble phosphates.

Potash for Barley.—Potash manures somewhat increased the quantity of grain on the station where no dung was applied, and they strengthened the straw. But it was noticed that the grain was somewhat darker in colour than that to which no potash was appplied.

Manures for Oats.

The manures required for oats are quick-acting manures, to enable the crop to get a good hold of the soil before the nourishment contained in the seed is exhausted.

For this purpose superphosphate and nitrate of soda are peculiarly applicable.

Sulphate of ammonia, although a soluble manure, did not come into operation in time for the wants of the young plant during the dry season of 1885, and the crop which received that manure was a signal failure at both stations.

Potash manures, especially muriate of potash, had a very beneficial effect upon the oat crop, and considerably increased the yield of grain, and in a less degree the amount of straw.

The *general conclusions* to be drawn from the experiments with the oat crop are, that the treatment of the land should be such as to accumulate organic matter in it, to prevent too great a loss of moisture, and to provide the young plant with manures that come rapidly into operation.

When the young plant has safely passed the critical period of its growth it roots deeply, and lays hold of the moisture and nourishment contained in the subsoil.

Manures for the Bean Crop.

The usual practice in bean-growing districts is to apply dung to the bean break, and the opinion prevails that beans cannot be successfully grown without dung. But the experiments at Pumpherston station show that a full crop of beans may be grown with artificial manures upon land that has not been dunged for ten years.

The relative importance to the bean crop of the three chief constituents of a manure may be seen by comparing the produce of eight plots manured as follows for six years:—

No. of Plot.	Kind of Manure.	Bushels Dressed Grain per acre.
27.	No manure.	2½
12.	Phosphate (bone-ash)	5⅚
18.	Nitrate	6¼
21.	Phosphate and nitrate	5⅓
22.	Potash	26½
17.	Potash and phosphate.	42⅓
10.	Potash, phosphate, and nitrate	45½
38.	Potash, phosphate, nitrate, and gypsum	51

The characteristic ingredient of a bean manure is potash.

Without potash in the manure, the other two ingredients are of very little use, unless, indeed, the land be very rich in potash.

Potash salts alone may be a sufficient manure on land in good condition, and may even produce a fair crop on land that is in poor condition.

Phosphate, when applied along with potash salts, or when applied to land rich in potash, has a marked effect upon the crop.

Nitrogenous manures, even when of the most favourable kind, have very little influence in increasing the bean crop.

Lime, in the form of gypsum (or sulphate of lime), has a beneficial effect upon the crop.

Dissolved phosphate acts far more powerfully on the bean crop than ordinary ground phosphate.

Phosphatic guano was more effective than ground mineral phosphate, presumably for the reason that a small proportion of it was in an easily dissolved form.

The nitrogenous manures that are most beneficial to the bean crop are those whose action is rapid and soon over. In this respect nitrates are preferable to all other nitrogenous manures.

Nitrogenous manures should either be applied in very small quantity, or altogether withheld from the bean crop.

Nitrogenous manures that come into operation after the crop has made some growth have an injurious effect. Even sulphate of ammonia is too slow in its action, and retards the growth of the crop.

Nitrogenous manures should not be applied as a top-dressing to the bean crop.

Peruvian and other nitrogenous guanos are among the worst manures for the bean crop. They contain too much nitrogen and too little potash.

The muriate of potash has proved a more effective manure than the sulphate.

The beneficial effect of gypsum is to be ascribed, not to the sulphuric acid it contains, but to the lime, which, in combination with sulphuric acid, is a soluble manure, and has the power of liberating potash in the soil.

The general results of the experiments with different manures on the bean crop inform us that the bases potash and lime are the substances most required by the crop. The acids, phosphoric acid and nitric acid, are of secondary importance, and sulphuric acid is of no importance.

For land dunged in autumn—or for land in good condition—it would seem from the experiments at Pumpherston that the application of superphosphate, muriate of potash, and sulphate of lime, in equal parts, would be a very appropriate manure for the bean crop.

The composition of beans is very uniform whatever be the nature of the manures applied. It is the *quantity* of the crop, and not the *quality* of it, that is affected by the application of manures.

Lessons from Incomplete Manure Experiments.

The following are the amounts of dry vegetable matter yielded during eight years by those plots at Pumpherston from whose manures one or more of the three constituents—nitrogen, phosphoric acid, and potash—were withheld:—

	Tons per acre.
Nitrate and potash (no phosphate)	9.78
Nitrate and phosphate (no potash)	8.97
Potash and phosphate (no nitrogen)	7.65
Nitrate of soda alone	8.68
Bone-ash alone	6.50
Potash salts alone	5.35
Unmanured	5.40

From these figures it is evident that the manurial constituent most required for the production of the crops grown was *nitrogenous matter*, in the next place *phosphates*, and in the next *potash.*

Potash alone.—The plot to which potash salts alone were applied gave scarcely as much produce as the unmanured plot.

This plot went steadily from bad to worse, and was latterly the worst on the station, showing that the accumulation of potash was hurtful to most of the crops grown there.

There was one exceptional year, 1884, when the crop was beans, and then for the first time it threw up a crop five times as abundant as the neighbouring plot, to which no potash had been applied.

An Experiment for Farmers.—An experiment of the above kind—in which, along with a completely manured plot, there are arranged side by side a series of plots from which in turn one of the essential ingredients of a complete manure is withheld—forms a most instructive lesson for farmers, and should be applied by them to all the fields on their farm. It serves to show what is the ingredient in the soil or in the manure that is most deficient for the production of a crop, and thus guides the farmer in the selection of the light manures that are most appropriate for his purposes.

Manures for different Crops.

A review of the manurial requirements of a rotation of crops, consisting of turnips, barley, beans, and oats, shows that while the three great constituents of a manure—nitrogen, phosphoric acid, and potash—are all required in order to raise full crops and to maintain the fertility of the soil, the predominance which should be given to one or other of these constituents varies with the crop. The predominant constituent is—for

Turnips—Phosphoric acid.
Barley and oats—Nitrogen.
Beans—Potash.

Relative Importance of the Constituents.—The relative importance of the three constituents for these three classes of crops must be arranged in the following manner:—

Turnips.	Cereals.	Beans.
1. Phosphoric acid,	Nitrogen,	Potash.
2. Nitrogen,	Phosphoric acid,	Phosphoric acid.
3. (Potash),	Potash,	(Nitrogen).

The constituents enclosed in brackets should not be applied to the crops to which they refer unless it has been learned by experiment or observation that the land is deficient in them, and that the crops are benefited by them, for it may happen that they have an injurious instead of a beneficial effect.

Regarding the forms in which the three constituents should be applied, reference must be made to the information given under each heading in the previous pages. But it may be shortly noted that—

Forms of Manures for Turnips.—For turnips the phosphates should be applied either in a soluble form or in a state of very fine division—in the case of ground phosphates, they should be at least so finely ground as to pass through a sieve of 120 wires to the linear inch,—or they should be of a kind that rapidly rot in the soil (such as bone-meal), and at the same time so finely ground as to permit of their being rotted in great measure during the period of the crop's growth. The nitrogenous manure should be partly of a quick-acting and partly of a slow-acting kind, so as to be of service to the crop during the whole period of its growth.

Forms of Manure for Cereals.—For cereals the nitrogenous manure should be very rapid in its action, so as not to retard the ripening of the crop. If applied as a top-dressing, it should consist of nitrate. The phosphate cannot be too rapid, and on that account superphosphate is to be preferred to any other form of phosphate.

The importance of potash in a cereal manure will depend on whether grass and clover seeds are sown with the crop. If that is the case, potash salts take the second place, as the presence of potash in the manure is of importance for the nourishment of clover.

Forms of Manure for Beans.—For the bean crop, the form of potash salt that is most suitable is the muriate of potash. Superphosphate is preferable to other forms of phosphate, probably on account of the large amount of sulphate of lime contained in that manure; but if sulphate of lime is applied to the crop, any other good phosphatic manure may form part of the mixture. The only kind of nitrogenous manure that is to be recommended for this crop is a soluble one, and that in small quantity, applied with the seed.

Dung for Turnips, Cereals, and Beans.—When farmyard manure is used for the turnip crop, potash salts should not be applied to it, and any nitrogenous manure added should be soluble.

The need which cereal crops have of nitrogen points strongly to the conclusion that a part of the dung should be withheld from the root crop and applied to the white crop; and this is all the more to be recommended, as it is evident that a considerable loss of the nitrogen of the dung is inevitable when a heavy dunging is applied to the fallow break.

If dung is to be used for beans, it should be applied to the stubble, rather than put in with the seed.

Organic Matter.

While it has been stated that on ordinary soils the three constituents—phosphoric acid, nitrogen, and potash—are sufficient to form what is known as a complete manure, and that a manure containing two of these substances, or, it may happen, only one of them, is a sufficient manure to apply to certain crops in certain circumstances, it is of the utmost importance here to observe that, nevertheless, it must not be supposed that, in the manipulation of these three constituents, in reference to the crops they are producing, lies the whole question of manuring.

Consider Soil as well as Manure and Crop.—The rapidity with which light manures act upon the crops to which they are applied has tended to restrict our view too much to the two factors—manure and crop—and has caused us to think less of the *soil* than our forefathers did.

Before the days of light manures—a time comparatively recent—when the wants of a crop for phosphates, nitrates, and potash were unknown, farmers fixed their attention upon the soil, and used every means to raise its general fertility —to put it into what is called high "condition"—and this they did by the use of heavy manures containing a large amount of organic matter.

Function of Organic Matter.—It has since been discovered that plants can grow to perfection without organic matter, but the circumstances in which that is possible for crops are not those which prevail in ordinary farming and in this climate.

It is to the organic matter in the soil that are due many of the changes going on there that are beneficial to the roots of plants. The warmth and moisture of the soil are increased by the organic matter in it, and the acids formed by its decay have an important part to play in dissolving the mineral matter, which forms the food of plants. It is indeed the key to the treasures of the soil. But in the ordinary operations of agriculture —in the constant disturbing and working of the ground—organic matter is rapidly destroyed, so that if farmyard manure and organic composts or other substances rich in organic matter are not put into land under cultivation, or fed on it, it soon becomes unduly deprived of organic matter. And the soil is thus deteriorated as a medium for the growth of roots and for the retention of moisture, and as a store of fertility gradually becoming available for the nourishment of crops.

During very dry or cold seasons, and even during very wet ones, the want of organic matter in the soil is a source of danger to the crop. The fate of many plots at the stations during the recent drought showed how intimately the fertility of the land, and the health and safety of the crop, are concerned in the accumulation of organic matter in the soil.

Quick-acting Manures and Organic Matter.—However much, therefore, we may commend the application of quick-acting light manures—phosphates, nitrates, and potash salts—for the assistance of crops, it is quite evident that their proper position on most kinds of land is subordinate to that of the heavier manures and to the slowly acting manures rich in organic matter, which perform the important work of building up the fabric of the soil, and accumulating therein a reserve of fertility which is commonly known under the name of "condition," and which is also called "backbone" by those who are able to appreciate its importance.

Numerous other experiments of importance have been conducted throughout the country, both by societies and individuals, all of which have contributed to the fund of knowledge relating to the great subject of manuring. The Royal Agricultural Society of England, and the Bath and West of England, have been, and still are, specially prominent in this good work. In different sections of *The Book of the Farm*, notably in those relating to foods, and to the feeding of stock, reference has been made to the Woburn feeding experiments of the former society; and the manuring experiments there, although not as yet so conclusive as could be desired upon the main points under special investigation, are likewise interesting and important.

SEED-TIME.

The "seed-time" is a season of continual stir and bustle on the farm. The prognostics and variations of the weather are watched with the keenest interest and anxiety, for not only the progress of the spring work, but also the returns of the harvest are greatly influenced by the character of the weather during the seed-time.

Seasonable Working of Land.—Field-work will now be pushed on with all possible speed. Yet there are more points to be considered than the mere progress of the work. In particular, care must be exercised as to the condition in which the different kinds of soils are tilled and prepared for the crops. To stir stiff clay when it is soaked with wet would be ruinous. Better delay a little than commit the seed to a cold, unkindly, ill-prepared seed-bed. Better let the men and horses stand idle for a few days than run the risk of destroying the year's produce by working the land in an unseasonable condition. On the other hand, when the weather is favourable, and the land in good condition for tillage operations, let all hands do their very best, so that full advantage may be taken of every favourable spell of weather.

Selecting Seeds.

Farmers cannot be too careful in the selection of seeds. It matters not what the crop may be, the best possible seed should be secured. To ensure thoroughly reliable seeds of a high character, an extra outlay of a few shillings per acre may be entailed, but then these *few shillings* may add pounds to the value of the crop.

Improvement in Seeds.—In this matter of seeds, the farmers of the present day are well situated compared with their brethren in former times. The development of the Seed industry is indeed one of the most notable—one of the most beneficial—features in the progress of modern agriculture. The improvement of the animals of the farm has been accomplished on the farms by the stock-owners themselves. Equally important and equally great in its way has been the improvement of the plants of the farm. And this latter work has been carried out in the most thorough and energetic manner by a number of extensive and influential seed firms, who have for many years devoted great attention not only to the improvement of the old varieties of the farm crops, but also to the propagation and development of new varieties of increased producing power. There are many eminent firms who have in this way rendered good services to the country. Amongst the names most prominently associated with this great work of plant improvement are those of Sutton, Carter, Webb, Drummond, and Dickson; but there are several other firms which have also been active in similar well-doing.

The part which these enterprising firms, who give us the improved, selected, and tested seeds, have played in the progress of modern agriculture, has been greater by far than is generally recognised. It has, of course, been a matter of business, not of philanthropy with them; all the same, it is right to acknowledge the great power which the development of the seed trade has exercised in the advancement of agriculture.

An Extensive Seed Firm.—The fact that the work which the leading "specialist" seedsmen have been engaged in is of advantage to the farmer, is indicated by the vast proportions which the business of a few of these firms has attained. The business premises occupied by Messrs Sutton & Sons, Reading, cover no less than six acres of ground. This firm, established in 1806, is now the largest of its kind in the world. At its experimental grounds at Reading thousands of trials with farm and garden seeds are made every year, and anything of special promise is chosen for stock, and is in due time, when by further culture the "type" becomes sufficiently fixed, propagated extensively for sale. In this way, by this and other firms, many valuable varieties of grain, roots, vegetables, and other plants have been placed in the hands of the farmer. During the busy seed season, from January 1 till end of April, the number of letters reaching Messrs Sutton & Sons' establishment average from 1200 to 1600 per day; while the letters despatched range from 1800 to 2000 daily. From 700 to 800 seed orders have to be executed every day in the height of the season. The accounts opened to customers approach 70,000 in number, and it is curious to note that amongst these are no fewer than 800 with the name of Smith!

With the excellent facilities that are thus provided by the leading seed firms for procuring high-class seeds of proved purity and germination, farmers now run little risk of loss by weak or impure seed. They should in all cases see that they obtain seeds which have been tested for their vitality, and which are well cleaned and true to their kind. These remarks apply equally to all kinds of seeds; and once again we would remind the farmer that a few shillings for first-class seed may add pounds to the value of the produce.

Sowing is sometimes delayed by dilatoriness on the part of the farmer in providing the necessary supplies of seeds. Have these on the farm *before* they are required, so that they may be at hand when a suitable time arrives for sowing.

Change of Seed.—It is well known amongst practical farmers that great advantage may be derived by judicious change of seed. As a rule with roots, fresh seed is introduced every year, for it is only in exceptional cases where the farmer grows his own turnip-seed. With grain, however, the rule is reversed. The home-grown seed is used for the most part; but it has been clearly shown that by an occasional change from one climate, one soil, and one system of farming to another, the vitality and producing power of a particular kind or "stock" of grain are substantially increased. When one considers the artificial influences by which our improved varieties of grain have been brought to their highly developed condition, one cannot be in the least surprised that such changes of scene and surroundings should often exercise a beneficial effect upon the crop.

But all changes are not successful. Neither are the conditions essential to success very fully known. In almost every change of seed, as in every change of a sire, there is something of the nature of an experiment. As a rule, a change of seed from an early to a late district is followed by a marked benefit, notably in the earlier ripening of the crop, but also to some extent in the quantity and quality of the produce. The influence on the date of the harvest is most marked. For instance, by the habitual introduction of seed-oats from the south of Scotland every second or third year, the ripening of the crop on certain farms in the later districts of the north-east has been hastened by from six to ten days; and practical farmers acquainted with a late climate know that acceleration to that extent in harvest is a very important advantage — perhaps all the difference between a crop secured and a crop partially lost. The weight of the grain will also most likely be increased 2, 3, or more pounds per bushel. Then in taking seed from a late to an early district there may sometimes be an advantage—notably an increase in the bulk of the produce.

A good plan in changing seed is to try the change on a small scale in the first year, and if the results are satisfactory, use the variety more extensively in subsequent years. Farmers should be experimenting in this way very frequently, for by introducing fresh varieties well suited to their land, the produce of their crops may be substantially increased. A change of seed from a clayey to a light loamy or sandy soil is generally beneficial.

New Varieties of Farm Plants.—Farmers also derive much benefit by taking advantage of the many new and improved varieties of grain and roots which are brought out by experimenting seedsmen. Our leading seedsmen are continually engaged in propagating fresh and improved varieties of farm crops, more particularly of grain, mangels, swedes, turnips, and potatoes, and by availing themselves of these new and vigorous sorts of proved excellence, farmers may to a marked extent enhance their produce.

At the same time, it is well to say that caution should be exercised in introducing new varieties. Let them be tried on a small scale at the outset, and adopted extensively only after their suitability and high qualities have been unmistakably established.

Testing Seed.—Farmers should carefully avoid using *weak* or *unreliable* seed. Seeds of all kinds may now be procured pure, and of certain germination. This should always be insisted upon, and farmers should themselves test the seeds when they take them home. Even home-grown seed, however well it may look, should never be sown without having been first carefully tested. This may be done very easily with grain or grass seeds, by placing say a hundred seeds between two folds of damp blotting-paper laid on a meat or soup plate, with another similar plate placed face downwards over that plate. No artificial heat need be used, and the plates may sit on an open shelf in the farmer's parlour. The blotting-paper should be damped every day by sprinkling a little water on it by the hand. The object of having the two plates placed face to face is to cause a current of air to pass over the seeds. In this way cereal seeds will germinate in about a week, and grass-seeds in about three weeks. An efficient testing apparatus may be purchased at a moderate cost.

Grain-seeds are often tested under a very thin damp turf in a well-exposed spot in the farmer's garden. We have also seen it done on damp turfs, placed on the rafters over the heads of cattle, where, of course, the temperature is considerably higher than outside early in spring, when testing is usually carried out.

Clover, *turnip*, or any other leguminous seeds may be tested in a more simple and expeditious manner. Count out say 100 seeds, roll them into a piece of flannel, and dip into boiling water for four or five minutes, and on opening the piece of flannel all the reliable seeds will be found much swollen, and actually germinated, with the elementary root shooting out. The seeds which do not present this swollen appearance cannot safely be reckoned upon, and the quantity of seed to be given per acre should be regulated by the percentage of the reliable germinating seeds.

SOWING SPRING WHEAT.

A large extent of wheat is sown in spring after a crop of roots of one kind or another.

Good Land for Wheat.—To ensure a good crop of spring wheat, the land should be for some time in good heart, otherwise the attempt will inevitably end in disappointment. Wheat cannot be sown in spring in every weather and upon every soil. Unless the soil has a certain degree of firmness from clay, it is not well adapted for the growth of wheat —it is more profitable to sow barley upon it; and unless the weather is dry, to allow strong soil to be ploughed in early spring, it is also more profitable to defer wheat, and sow barley in the proper season. The climate of a place affects the sowing of wheat in spring; and it seems a curious problem in climate why wheat sown in autumn should ripen satisfactorily at a place where spring wheat will not. Experience makes the northern farmers chary of sowing wheat in spring, unless the soil is in excellent condition, and the weather very favourable for the purpose.

Date of Sowing.—In former times, even under the most favourable circumstances, wheat was seldom sown after the first week of March, but later varieties have been introduced which may be sown as late as April.

On farms possessing the advantages of favourable soil and climate, and on which it is customary to sow spring wheat every year, the root-land is usually ploughed with that view up to the beginning of March; and even where spring wheat is sown only when a favourable field comes in the course of rotation, or the weather proves tempting, the land should still be so ploughed that advantage may be taken to sow wheat. Should the weather take an unfavourable turn after the ploughing, the soil can afterwards be easily worked for barley.

Tillage for Wheat.—The land should receive only one furrow—the seed-furrow —for spring wheat, because if ploughed oftener, it would be deprived of that firmness so essential to the growth of wheat. The mode of ploughing this seed-furrow depends upon circumstances. If the land has a visible form of ridge, and easily becomes wet, it should be gathered up (fig. 34, p. 110, vol. i), and then it will have the appearance of being twice gathered up, as in fig. 40, p. 115, vol. i. If the land is flat, and the subsoil somewhat moist, gathering up from the flat will answer best, as in fig. 34. If the soil has a dry subsoil, though of itself a pretty strong clay, it may be cast with gore-furrows (figs. 36 and 37). And should the land be fine loam, resting on an open bottom, the ridges may be cast together without gore-furrows, as in fig. 36.

It is probable that a whole field may not be obtained at once to be ploughed, and this often happens for spring wheat; but when it is determined to sow wheat, a few ridges should be ploughed as convenience offers, and then a number of acres may be sown at one time. In this way a large field may be sown by degrees, whereas to wait till a whole field can be sown at once, may prevent the sowing of spring wheat that season. Bad weather may set in, prevent sowing, and consolidate the land too much after it had been ploughed; still a favourable week may come, and, even at the latter end of the season, the consolidated land can be ribbed with the small plough, which will move as much of the soil sufficiently as to bury the seed.

Double-furrow Plough.—To expedite the ploughing of the seed-furrow at a favourable moment, the double-furrow plough is used by some, though not so largely now as a few years ago. One form is represented in fig. 255 (made by Fowler & Co. on Pirie's Patent), and another in fig. 256, made by J. Cooke & Sons, Lincoln.

Advantages of the Double-furrow Plough.—The double-furrow plough is usually worked with 3 horses, and as to the question whether it effects a saving of draught as compared with two single furrow-ploughs, there has been much discussion. Experiments with the dynamometer have shown that there is little saving in this respect, and that the 3 horses have to exert about as much force as 4 horses, with 2 common ploughs doing the same amount of work, with a slight difference in favour of the double-furrow plough. In a trial with the double-furrow plough and others in 1870, the common plough, with a furrow of from 6½ to 7½ inches deep, gave a draught from 4 to 5 cwt.; while 9 double-furrow ploughs, with an average depth of furrow of 5½ inches, gave an average draught of 7 cwt.

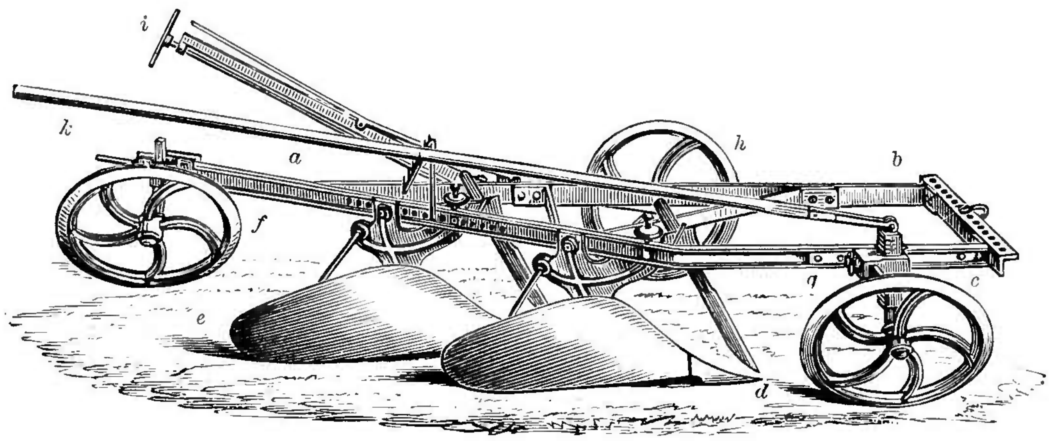


Fig. 255.—*Fowler's double-furrow plough with single lever.*

a to *b* Frame of wrought-iron flat bar.
a to *c* Frame of angle iron.
d Front plough fixed, with mould-board, coulter, and share.
e Hind plough, movable, with like mounting.
f g Inclined wheels with angular rims.
h Vertical wheel with angular rim.
i Handle and screw-rod.
k Lever for adjusting wheel *g*.
b c Cross or front bar acting as the bridle.

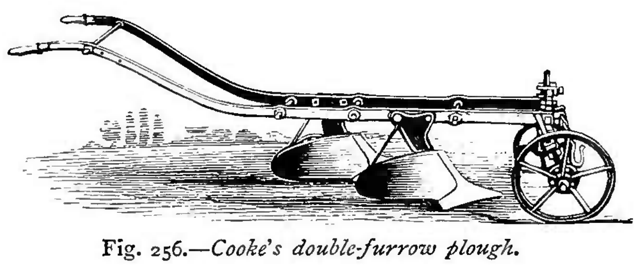


Fig. 256.—*Cooke's double-furrow plough.*

In regard to saving either men or horses in employing the double-furrow plough, a writer says: "It is a mistake to suppose, as many do, that the double-furrow plough saves 1 man and 1 horse. Turning over 2 furrows, and presuming the plough to be drawn by 3 horses (it is too fatiguing for 2 horses), it undoubtedly saves 1 horse and its keep, but it does *not* save a man. Two double ploughs might, indeed, be managed by 6 horses and 2 men, and thus a saving be effected of 1 man and 2 horses—that is, if farmers can get ploughmen to undertake the grooming of 3 horses. Most of them think they have enough to do with 2 horses, and it can hardly be expected that they will add a third to their labours without something like a corresponding addition to their wages. At the best, therefore, it will be seen that the new ploughs can save only 1 man out of 3, and of horses 2 out of 8, in turning over 4 furrows. But men at certain seasons of the year are needed on the farm for other work than ploughing, and it is perhaps doubtful whether the double ploughs will effect more than the saving of horses. This alone is a great matter." [1]

[1] *The Farmer*, January 26, 1870.

In recent years double-furrow ploughs have been losing favour in many parts of the country where they obtained a footing. The modern Anglo-American plough is now preferred by many for speedy ploughing. Still, in some circumstances, the double-furrow plough may be employed with advantage.

Several improvements have lately been effected in the double-furrow ploughs, and now they are, as a rule, lighter in draught, and more easily manipulated than in former times.

Sowing.—The land, having been ploughed, should be sown at once. To economise time, the seed-wheat should have been measured up in the sacks, or ready to be measured up in the corn-barn or granary, and, if pickling is to be done, the means of doing it provided.

Quantity of Seed.—Wheat should be sown thick in spring, as there is no time for the plant to *stool* or *tiller*—that is, to throw up a number of young shoots from one root, as is the case with autumnal-sown wheat. About 3 bushels per imperial acre will suffice of seed for spring wheat, but many farmers sow a little more. There is always a controversy about thick and thin sowing. Since spring wheat does not tiller, it stands to reason that it should be sown thick and buried regularly under the surface, which is most efficiently done by a drill-machine.

Pickling Wheat.—There is much to be said in favour of the *pickling* of seed-*wheat*—that is, subjecting it to a preparation in a certain kind of liquor—before it is sown, in order to ensure it against the attack of a fungoid disease in the ensuing summer, called *smut*, which renders the grain comparatively worthless. Some farmers affect to despise this precaution, as originating in an unfounded reliance on an imaginary specific. But the existence of smut, and its baneful effect upon the wheat crop, are no imaginary evils; and when experience has proved, in numberless instances, that steeped seed protects the crop from this serious disease, the small trouble and expense which pickling imposes may surely be incurred, even although it should fail to secure the crop. *How* pickling the seed prevents the smut in the crop, is a question more easily asked than answered; and it is, perhaps, from the want of a satisfactory answer that pickling is disregarded by incredulous farmers. Objection against the practice is as difficult to be stated as any reason for it, but the palpable fact stands uncontradicted, that one field sown with pickled wheat, and otherwise managed in the usual way, will most likely escape the smut; while the adjoining field, managed in exactly the same way, but sown with wheat without pickle, will most likely be affected more or less with the disease.

Various methods and materials for pickling are employed. A solution of blue vitriol is now most generally used, and the process, as described in former editions of this work, is seen in fig. 257.

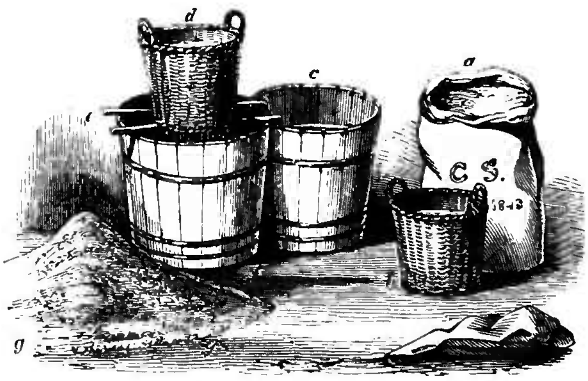


Fig. 257.—*Apparatus for pickling wheat.*

a Sackful of wheat.
b Basket to receive the wheat from the sack.
c Tub of pickle.
d Basket of pickled wheat.
e Drainer for basket.
f Tub to receive draining of pickle from the basket.
g Heap of pickled wheat.
h Sacks for the pickled wheat.

The pickling may be done on a part of the corn-barn floor. Two upright baskets are provided, each capable of holding easily about half a bushel of wheat, having upright handles above the rims. Pour the wheat into one basket from the sack, and dip the basketful of wheat into the tub of vitriol completely to cover the wheat, the upright handles protecting the hands from the vitriol. After it remains in the liquid for a few seconds, lift up the basket, so as to let the surplus liquid run from it into the tub again, and then place the basket upon the drainer on the empty tub, to drip still more liquid, until the other basket is filled with wheat and dipped in the vitriol tub. Then empty the dripped basket of its wheat on the floor, and as every basketful is emptied, let a person spread, by riddling it through a wheat-riddle, a little slaked caustic lime upon the wet wheat to dry it. Thus all the wheat wanted at the time is pickled and emptied on the floor in a heap.

Turning Pickled Wheat.—The pickled and limed heap of wheat is turned over and mixed in this way: Let two men be each provided with a square-mouthed shovel (fig. 114, p. 234, vol. i.), one on each side of the heap, one having the helve of his shovel in his right hand, and the other in his left; and let both make their shovels meet upon the floor, under one end of the heap of wheat, turning each shovelful from the heap behind them, till the other end of the heap is reached. Let them return in a similar manner in the opposite direction, and continue, until the wheat is thoroughly mixed and dried with the lime. The pickled wheat is then sacked up, and carried to the field in carts.

Seed-dressing to Ward off Birds.—A Surrey farmer says: "We are much troubled with crows and other birds eating the seed of wheat and other grain, but wheat more especially. The crows do most damage just when the plant begins to come through the soil. I have tried various dressings for the seed, but found the following by far the most effectual in warding off the crows: For one quarter of wheat take a two-gallon pail, into which put quarter full of fresh lime, mixing and stirring with hot water, just enough water to get it into a thick paste; then put in one pint of tar; stir all up together, and fill up the pail with water, and keep stirring. Pour this over the heap of seed, and keep stirring till all the seed is equally stained with the mixture. This is also effectual for barley, but no use for oats, as the birds can pick out the kernel." [1]

There are several most useful preparations for pickling wheat, not only for preventing smut, but also for preventing insects and crows and other birds from eating the seed. Chief among these special preparations are Down's "Farmers' Friend" and Clarke's and King's specifics.

Placing Sacks in the Field.—There is some art in setting down sacks of seed-corn on the field. The plan of placing the sacks of course depends on whether the seed is to be sown by the hand or by a machine. The sacks are set down across the field from the side at which the sowing commences. One row of sacks is sufficient, when the ridges are just long enough for the sower to carry as much seed as will bring him back again to the sack, and the sacks are then set in the centre of the ridge. When the ridges are short, the sacks are set upon a head-ridge; and when of such length as the sower cannot return to the sack by a considerable distance, two rows of sacks are set, dividing the length of the ridges equally between them, setting the two sacks on the same ridge. The sacks are placed upon the furrow-brow of the ridge, that the hollow of the open furrow may give advantage to the carrier of the seed to take it out easily as the sack becomes empty. In thus setting down the sacks of seed, it is intended to give the supply of seed more easily to the man who sows the seed by hand.

When a machine is employed to sow the seed, the sacks are set upon one of the head-ridges connected with the gate of the field, unless the field is so long that a row of sacks must be placed in the middle.

Where to begin Sowing.—If the surface is level, it matters not which side of the field is chosen for commencing the sowing; but if inclined, the side which lies to the left on looking down the incline should be the starting point. The reason for this preference is, that the first stroke of the harrows along the ridge is most difficult for the horses to draw; and it is easiest for them to give the first stroke *downhill*. This first action of the harrows is called *breaking-in* the land. It is the same to the sower at which side he commences the sowing, but ease of work for the horses ought to be studied.

Seed Carrier.—In Scotland the carrier of the seed is usually a woman, and the instant the first sack of seed is set down, she unties and rolls down its mouth, and fills the *rusky*, basket, pail,

[1] *Farming World*, p. 471. 1887.

or whatever she uses in conveying the seed, and carries it to the sower, who awaits her on the head-ridge from which he makes his start. Her endeavour should be to supply him with such a quantity of seed at a time as will bring him in a line with the sack where he gets a fresh supply; and as the sacks are placed half-way down the ridges when only one row is set down, this is easily managed; but with two rows of sacks, she must go from row to row and supply the sower, it being her special duty to attend to his wants, and not to consider her own convenience. Nothing can be more annoying to a sower than to have his sheet or sowing-basket served too full at one time, and too stinted at another; as also to lose time in waiting the arrival of the seed-carrier, whereas she should be awaiting his arrival. When two rows are at a considerable distance, on long ridges, two carriers are required to serve one sower. Better that the carriers have less to do than that the sower lose time and delay the harrows, which will likely occur when the carriers are overtaxed.

Seed-basket.—The basket or vessel in which the carrier conveys the seed is of various patterns—a deep or shallow basket, or ordinary pail, sometimes carried on the head, and in other cases in the hand or on the arm and haunches. The seed is most easily poured into the sowing-basket from the seed-basket on the head. It should be filled each time with just the quantity of seed the sower requires at a time.

The Seed-sacks.—The mouth of the sack should be kept rolled down, that the seed may be quickly taken out, for little time is usually at the disposal of the carrier. The carrier should be very careful not to spill any seed upon the ground on taking it out of the sack, otherwise a thick tuft of corn will unprofitably grow upon the spot. As one sack becomes empty, the carrier should take it to the nearest sack; and as the sacks accumulate, they should be put into one, and carried forward out of the way of the harrows. It is a careless habit which permits the sacks to lie upon the ground where they are emptied, to be flung aside as the harrows come to them.

One-hand Sowing.—In former times the sower by hand in Scotland was habited in a peculiar manner. He sowed by one hand only, and had a sowing-sheet wound round him, as shown in fig. 258. The most convenient sheet is of linen. It is made to have an opening large enough to admit the head and right arm of the sower through it, and a portion of

Fig. 258.—*Sowing-sheet and hand-sowing corn.*

the sheet to rest upon his left shoulder. On distending the mouth of the doubled part with both hands, and receiving the seed into it, the loose part of the sheet is wound tight over the left hand, by which it is firmly held, while the load of corn is supported by the part of the sheet which crosses the breast and passes under the right arm behind the back to the left shoulder. A *basket* of wicker-work, such as fig. 259, was very common in England for sowing with one hand. It was suspended by a girth fastened to two loops on the rim of the basket, and passing round the back of the neck; the left hand holding the basket steady by the wooden stud on the other side of the rim.

Two-hand Sowing.—But the system

of sowing with both hands is now more general than one-hand sowing. It should indeed be the universal method wherever hand-sowing is pursued. It is the most expeditious; and many people consider that the sowing can be done more evenly with two hands than with one.

For two-hand sowing a simple form of sowing-sheet is a linen semi-spheroidal

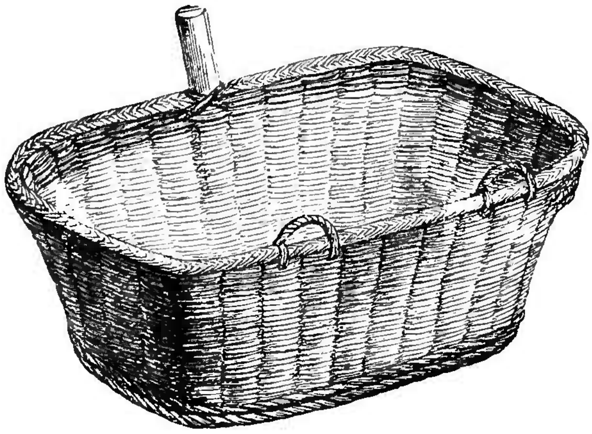


Fig. 259.—*English sowing-basket.*

bag, attached to a hoop of wood or of iron rod, formed to fit the sower's body, buckled round it, and suspended in front in the manner just described. Both hands are thus at liberty to cast the seed, one handful after the other.

Art of Sowing.—The following detailed description of the art of sowing by one hand is also so far applicable to sowing by both hands. Taking as much seed as he can grasp in his right hand, the sower stretches his arm out and a little back with the clenched fingers looking forward, and the left foot making an advance of a moderate step. When the arm has attained its most backward position, the seed is begun to be cast, with a quick and forcible thrust of the hand forward. At the first instant of the forward motion the fore-finger and thumb are a little relaxed, by which some of the seeds drop upon the furrow-brow and in the open furrow; and while still further relaxing the fingers gradually, the back of the hand is turned upwards until the arm becomes stretched before the sower, by which time the fingers are all thrown open, with the back of the spread hand uppermost. The motion of the arm being always in full swing, the grain, as it leaves the hand, receives such an impetus as to be projected forward in the form of a figure corresponding to the sweep made by the hand. The forward motion of the hand is accompanied by a corresponding forward advance of the right foot, which is planted on the ground the moment the hand casts forward the bulk of the seed.

The action is well represented in fig. 258, except that some would consider the sower should give his hand a higher sweep, especially on a calm day. The curve which the seed describes on falling upon the ground, is like the area of a portion of a very eccentric ellipse, one angle resting on the open furrow, and the other stretching 2 or 3 feet beyond the crown of the ridge, the broadest part of the area being on the left hand of the sower.

The moment the seed leaves it the hand is brought back to the sowing-sheet to be replenished, while the left foot is advanced and the right hand is stretched back for a fresh cast, and thrown forward again with the advance of the right foot.

The seed ought to be cast *equally over the ground.* If the hand and one foot alternately do not move simultaneously, the ground will not be equally covered, and a strip left between the casts. When the braird—that is, the young plants—comes up, these strips show themselves. This error is most apt to be committed by a sower with a stiff elbow, who casts the grain too high above the ground. The arm should be thrown well back and stretched out, though, in continuing the action, with the turning up the back of the hand, the inside of the elbow-joint becomes pained.

If the hand is opened too soon, too much of the seed falls upon the furrow-brow, and the crown receives less than its proportion. This fault young sowers are very apt to commit, from the apprehension that they may retain the seed too long in the hand. If the hand is brought too high in front, the seed is apt to be caught by the wind and carried in a different direction from that intended.

When the wind becomes strong, the sower is obliged to walk on the adjoining ridge to the windward to sow the one he wishes; and the sower should cast low in windy weather.

Some sowers take long steps, and make

long casts, causing some of the seed to reach across the ridge from furrow to furrow. Such a sower spills the seed behind the hand, and makes bad work in wind. The step should be short, the casts frequent, and the seed held firmly in the hand, then the whole work is under complete command. The sower should never bustle and try to hurry through his work; he should commence with such a steady pace as to maintain it during the day's work.

A sower with *both hands* makes the casts alternate, the hand and foot of the same side moving simultaneously with regularity and grace.

Sowing - machines. — Hand - sowing has been to a large extent superseded by sowing-machines. These do the work better than it can possibly be done by hand, and their use is therefore to be commended. Of seed-sowing machines there are many patterns, some dropping the seed in drills, others scattering it broadcast. A material difference exists between these two classes of machines. The broadcast machine deposits the seed upon the surface of the ground, and is in fact a direct substitute for hand-sowing; and as it deposits the seed very regularly, this machine is now extensively used.

The *drill-machine* deposits the seed at once at a specific depth under ground in rows, and at such distances between the rows, and with such thickness in the rows, as the will of the farmer may decide.

The seed being left by the broadcast machine on the ground like hand-sowing, is buried in the soil more or less deeply as the harrows may chance to take it; whereas the drill-machine deposits the seed in the soil at any depth the farmer chooses, and all the seed at the same depth, thereby giving him such a command over the position of the seed in the soil as no broadcast machine or hand-sowing can possibly do.

Broadcast Sowers. There are various forms of the *broadcast* sowing-machine. The one illustrated in figs. 260 and 261, made by Ben. Reid & Co., Aberdeen, exhibits the machine in the most perfect form, not only doing the work easily and well, but is so constructed that its long sowing-chest is divided into sections, the two end ones of which can be folded upon

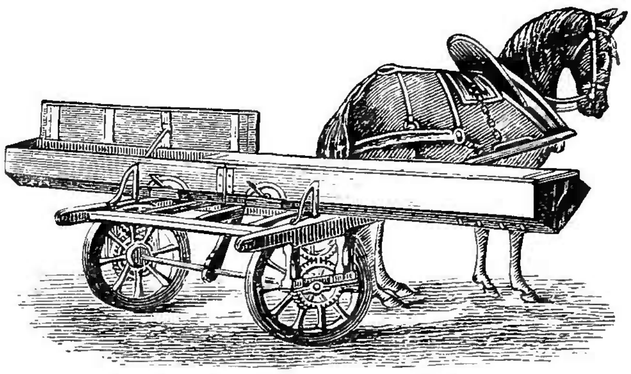


Fig. 260.—*Broadcast sower ready for work.*

the central division, whereby the machine may pass through any field-gate without having to remove the sowing-chest.

By the use of the drill-machine less

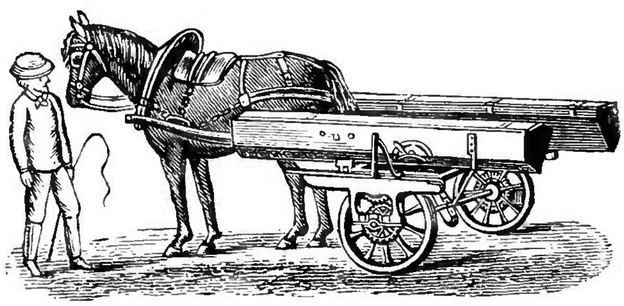


Fig. 261.—*Broadcast sower in transit*

seed will thus suffice, and another advantage is that the land between the rows may be hoed by the hand-hoe, or by a horse-hoe, such as in fig. 262 (Kells, Meats, & Co., Gloucester), thus tending to clean the land. Drilling is rightly enough in

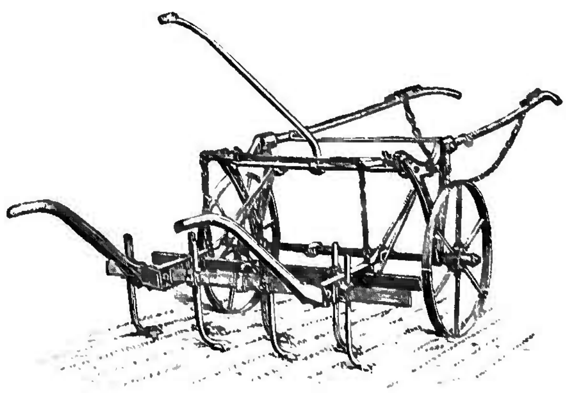


Fig. 262.—*Horse hoe.*

favour for good land in good heart, but on poor or medium land it does not give so much straw as broadcast sowing. The *sowing-gear* of the broadcast machine is connected with the main axle of the carriage, as shown in the figure. The arrangements for regulating the quantity of seed per acre are very simple and effective, and altogether the machine is very easily worked and controlled. About 18 feet is the usual width sown at once by the machine.

Hand Broadcast Sowers.—Fig. 263 represents a very ingenious and most useful hand broadcast sower, the "Little Wonder," of American invention, and brought to this country by Mr J. H. Newton, West Derby, Liverpoool. The illustration pretty well explains its appearance and action. A light box of thin wood is carried under the left arm with a strap over the shoulder. To the top part of this is attached a canvas receptacle for the seed, while on front

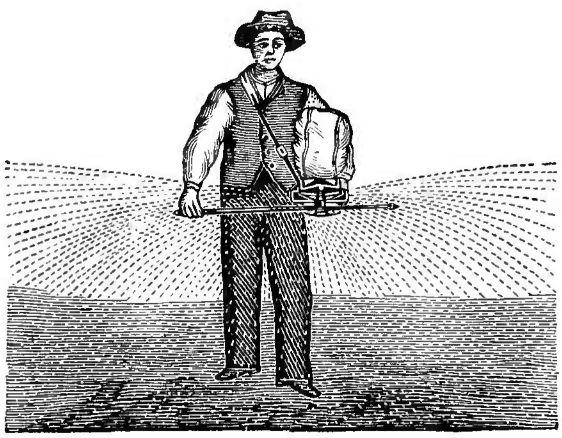


Fig. 263.—*Broadcast hand-sower*

and below is fixed a little tinned iron wheel, or rather four crossed pieces revolving on a spindle. Round this spindle is passed a thong which forms the string of a bow, and by "see-sawing" this bow the wheel revolves in alternate directions. An eccentric on the spindle moves a little hopper which keeps a regular stream of seed falling on to the revolving "wheel," and this in its turn sends the grain spinning out all round. It will cover a width of about 30 feet, but some have found it best in practice to go up the centre of one rig and down another, thus taking 14 or 16 feet at a time. It is thus possible, if kept supplied with seed, to do four acres per hour, while three is easy of attainment. To ensure an even braird, the machine should be carried in a level position. It sows all kinds of grain admirably, and is equally well adapted for sowing dry artificial manure.

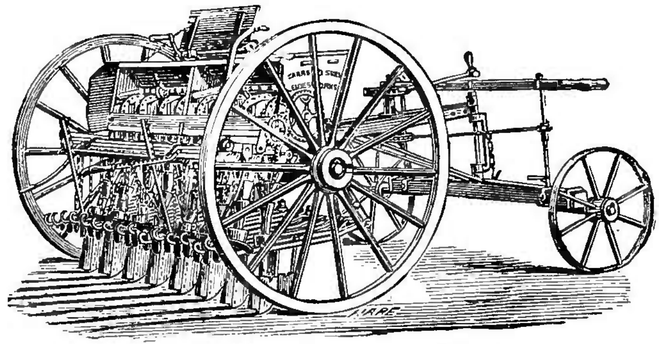


Fig. 264.—*Corn and seed drill.*

The quantity to be sown per acre is regulated by a little slide.

Strawson's ingenious air distributor may also be adapted for sowing grain broadcast.

Drill Sowers.—There are many patterns of these, and they are now very reliable in working. Ingenious and efficient devices are employed for regulating the quantity of seed per acre, the width of the drills, and the depth to which the seeds are deposited. Fig. 264 represents the improved Suffolk corn and seed drill made by R. Garrett & Sons, Suffolk.

The "Excelsior" drill-sowing machine (The Chadburn Manufacturing Company), represented in fig. 265, is a most ingenious American invention, designed to sow almost all kinds of farm seeds, as well as manure.

Width of Drill.—The width between the rows of wheat varies somewhat.

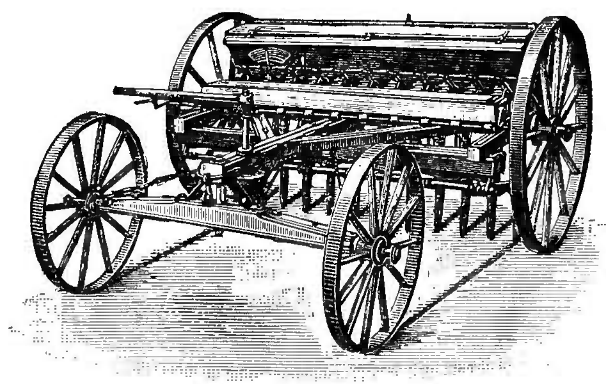


Fig. 265.—"*Excelsior*" *seed drill.*

On good land in high condition, 9 inches is a common width, but many consider that rather too great for ordinary land.

Hand Seed-drill.—There are small hand seed-drills both for grain and root crops. Fig. 266 represents R. Boby's very useful drill of this pattern.

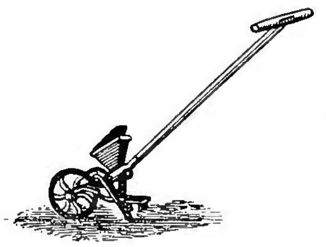


Fig. 266.—*Hand seed-drill.*

Harrowing.—The land, whether sown by hand or with any sort of machine, must be harrowed. The order in time of using the harrows differs with the sort of machine used for sowing the grain. When the grain is sown by hand or with the broadcast machine, the harrow is used chiefly after the grain has been sown, although many consider it desirable to "break in" the surface by a single or double turn of the harrows before sowing. But in sowing with drill-machines, the harrow is first used to put the land into the proper tilth for the machine.

Considering the operation the *harrow* has to perform in covering the seeds that have been cast upon the soil, and reducing the surface-soil to a fine tilth, it is an implement of no small importance; and yet its effects are apparently rude and uncertain, while its construction is of the simplest order. So simple indeed is this construction, that at a very remote period it appears to have taken that form which, in so far as the simple principles of its action are concerned, is almost incapable of further improvement.

Iron Harrows.—Fig. 267 represents Howard's set of iron harrows for a pair of horses. Sellar's harrows, suited for heavy land, are shown in fig. 268. Wooden harrows, once so common, are now out of date. Iron harrows are made of many patterns. Most of them are wonderfully durable, light in draught, and very effective in reducing the soil to a fine condition. They are made heavy or light, according to the work intended to be done. In some the teeth or tines are held in by screw and nut, and in others by being driven through holes of the required size.

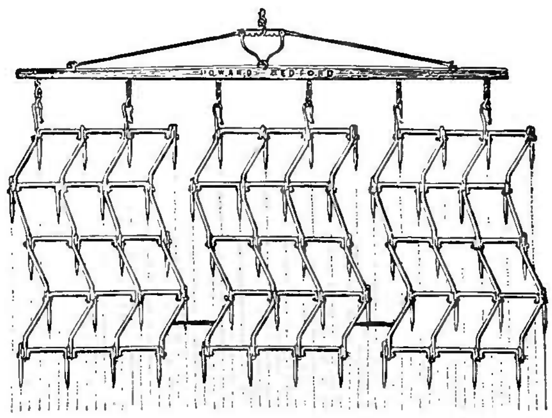


Fig. 267.—*English iron harrows.*

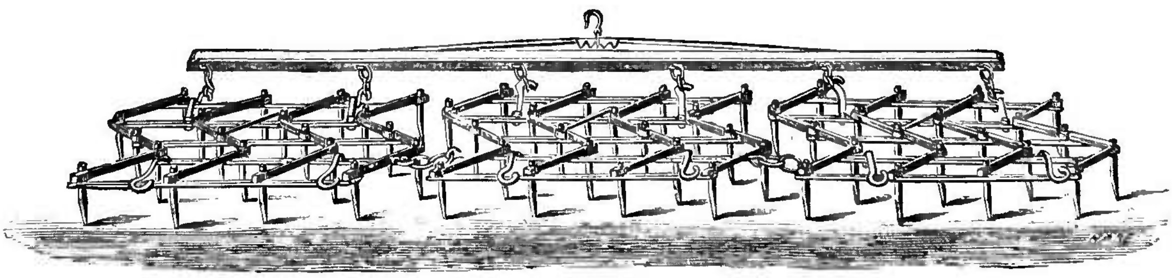


Fig. 268.—*Scotch iron harrows.*

Process of Harrowing.—Two pairs of harrows work best together, their united breadth covering the entire ridge, and lapping over the crown where the soil is thickest. One pair takes the lead, by going usually on the near side of the ridge, while the other pair follows on the off side, but the leader takes the side of the ridge whichever is nearest the open field. Each pair of harrows should be provided with double reins, one rein from each horse; and the ploughmen should be made to walk and drive their horses with the reins from behind the harrows. If a strict injunction is not laid upon them in this respect, the two men may be found walking together, the leading one behind the harrows, the other at the head of his horses. The latter is thus unable to know whether his harrows cover the ground which they ought to cover, and the two are more engrossed in talk than in the work in hand.

To draw harrows as they should be drawn, is really not so light work for horses as it seems to be. When the tines are newly sharpened and long, and take a deep hold of the ground, the labour is considerable. To harrow the ground well—that is, to stir the soil so as to allow the seed to descend into it, and bring to the surface and pulverise all the larger clods, as in the case of broadcast sowing—requires the horses to go at a smart pace; and for efficient working harrows should on all occasions be driven with a quick motion.

When the seed is sown by a drill-machine, it is deposited at a given depth; and in order that the harrows shall not disturb its position, the land is harrowed fine before the seed is sown, a single tine—that is, one turn of the harrows—along the drills covering the seed sufficiently.

Harrowing on Incline.—In harrowing after the broadcast seed, one must be guided by the circumstances of the case. If the harrowing commences at the foot of the incline, and with two pairs of horses, the following plan is adopted by some. The ridge next the fence should be ascended by the 2 pairs of harrows; and on gaining the top of the incline, the second ridge is descended, to break-in its seed; and *hieing*—that is, turning them round to the left—both the pairs of horses at the foot, the first ridge is again ascended, which finishes its double tine; and though both tines (or stripes or courses of the harrow) have been given on it in the same direction, the anomaly is submitted to in order to gain a favourable position for the horses to break-in the seed, which is from the top of an incline where there is an incline. *Hieing* the horses again on the upper head-ridge, the third ridge is broke-in down-hill; and *hieing* again on the lower head-ridge, the second ridge is ascended, and is thus finished in its double tine—given in opposite directions.

Thus by *hieing* both pairs of harrows at both ends, one ridge is broke-in on going down, and another receives the double tine on coming up the incline, which affords an easy mode of working the horses.

Suppose the harrowing had begun at the top of the declivity, the breaking-in commences at once on going down-hill; and to preserve the propriety of giving the double tines in opposite directions, the harrows come up the same ridge and finish it, the double tine up-hill being easy because of the ground having been passed over by the harrowing down-hill; and so on with every succeeding ridge.

As there is little room for two pair of harrows to turn at the end of one and the same ridge, the leading harrows are driven forward upon the head-ridge, and the horses are *hied* so as to move round upon the far side of the head-ridge, and still *hied* round, they take up their place on the same side of the ridge they had come down; while the hind harrows are *hupped* so far on the head-ridge as to turn on its far side, and then *hieing*, take up their position on the same side of the ridge they had come down, in rear of the leading harrows.

But where four pairs of horses are at work—and four pairs are required to cover in and finish as fast as the broadcast sower deposits the seed—this plan would be apt to lead to confusion. If the field ascends from the gate, each pair of harrows may go up a separate open furrow, as these require more harrowing than the other portions; and when the top of the field is reached, all the pairs go down the side of the field where the sower has commenced. At the bottom, the first pair of harrows pass along the head-ridge to the left in front of the second pair, which pass to the right, the one pair going up the land upon which the other came down. The third and fourth pairs do likewise, and in this way confusion in turning is avoided.

The entire movements are easily and quickly managed with double reins; but with a single rein, even with the voice, this mode of turning at the end of a ridge is apt to create confusion.

If the incline is begun to be sown at the opposite side of the field, the same arrangements as have just been described for easy breaking-in of the seed for the horses, whether from foot or top of the incline, should be followed; but in following them here the horses should be *hupped* —turned to the right—instead of *hied*, because the open side of the field is on a different hand.

When the field is *level*, it matters not from which side the breaking-in commences.

Cross harrowing.—After the appointed piece of ground, whether a whole field or part, has been sown and broken-in, the land is *cross-harrowed* a double tine—that is, at right angles to the former harrowing, and to the ridges. But as, for this operation, the ground is not confined within the breadth of ridges, the harrows cover the ground with their whole breadth, and get over the work in less time than in breaking-in.

Cross-harrowing is not easy for the horses, inasmuch as the stripes left in the ground by the breaking-in have to be cut through, and the irregular motion of the harrows, in jerking across the open furrows of the ridges, has a fatiguing effect upon the horses.

To finish the harrowing, another double tine along the ridges, as in the case of the breaking-in, may be necessary. This turn is easily and quickly performed, the soil having been so often moved; and should it seem uniform in texture, a single tine will suffice for a good finishing.

Efficient Harrowing.—To judge of the harrowing of land, the sense of feeling is required as well as that of sight. When well done, the soil seems uniformly smooth, and the small clods lie loosely upon the surface; the ground feeling uniformly consistent under the tread of the foot. When not sufficiently harrowed, the surface appears rough, the clods are half hid in the soil, and the ground feels unequal under the foot—in some parts resisting its pressure, in others giving way to it too easily.

The old saying that "good harrowing is half farming" has more wisdom in it than at first sight appears. The *efficient harrowing* of land is of more importance than seems generally to be imagined. Its object is not merely to cover the seeds, but to pulverise the ground, and render it of a uniform texture. Uniformity of texture maintains in the soil a more equable temperature, not absorbing rain so fast, or admitting drought too easily, as is the case when the soil is rough and kept open by clods.

Whenever the texture becomes sufficiently fine and uniform, the harrowing should cease, although the appointed number of double or single tines have not been given; for it is a fact, especially in light, soft soils, that over-harrowing brings part of the seed up again to the surface.

Water-furrows.—When the spring wheat was sown early in the season, in January or near the end of February, it was usually considered necessary in former times that the ridges should be *water-furrowed*, so that, in case of much rain falling, or snow melting, it may run off the surface of the ground by the water-furrows. Whatever of the spring wheat is sown late in the spring, in the last of February and beginning of March, the water-furrowing is not executed until after the sowing of the grass-seeds, if any are to be sown with the wheat crop.

Water-furrowing is making a slight plough-furrow in every open furrow, as a channel for rain-water to flow off the land. It may be executed lightly with a common plough and one horse, but better with a double mould-board plough and one horse; and as the single horse walks in the open furrow, the plough following obliterates his footmarks.

The better water-furrowing by the double mould-board plough consists in the channel having equal sides; and the furrow-slice on each side being small, compared with the one furrow-slice of the common plough on one side, the water can run more freely into the furrow. The plough simply goes up one open furrow and down another until the field is finished, the horse being *hied* at the turns into the open furrow. Water-furrowing finishes the work of the field.

Under-drainage *v.* Water-furrows.—On average soils there will be no necessity for water-furrows if the land is thoroughly under-drained. The importance of this latter is now universally acknowledged, and great benefit has been derived by the large extent to which drainage has been executed throughout the country. When the soil is exceptionally adhesive, and water apt to lie in pools on its surface, it is very desirable that water-furrows should be provided to prevent this.

Wheat after Grass.—The foregoing relates mainly to the sowing of wheat after a root crop. But a large extent of spring wheat is also sown after grass, chiefly in England, and some of the earlier and drier districts of Scotland. The success of spring wheat after grass in England attests the superiority of the English climate, which is too dry, and too warm in the southern counties, for the perfect growth of oats. A great obstacle to sowing wheat in Scotland in spring is the action of two classes of soil on the growth of that plant. Clay soils are too inert in the average climate of Scotland to mature the growth of wheat in a few months; and the light soils, though more favourable to quick vegetation, want stamina to support the wheat plant, and are, besides, too easily affected by drought in early spring—it being no uncommon occurrence in Scotland to experience a severe drought in March, and during the prevailing east wind.

Wheat cannot be safely sown in the autumn in Scotland after the end of October, which is the time for sowing after potatoes. Some sow it in November, to the risk of producing a thin crop. To plough up lea before October would be to sacrifice the aftermath. Many farmers do this without hesitation, rather than lose the advantage of sowing wheat in good time before the winter sets in. But with others the aftermath is of greater importance, and they accordingly defer the ploughing of the lea till winter, and the sowing of the wheat till spring. January is considered a good month for wheat-sowing, but it is only in exceptional seasons and in favoured districts that the weather permits of this. There is thus a considerable extent of spring wheat sown after grass.

Presser-roller.—This implement was called into use with the object of consolidating light soils, so as they might withstand the drought of spring and support the wheat plant until it attains maturity. The action of the presser-roller is to consolidate the soil in the lineal spaces in which the seeds of wheat are to have root; hence it is applicable only in drill culture on loose soil, whether after lea or on bare land.

The presser-roller is in perspective represented in fig. 269, and fig. 270 gives edge-view of the two pressing-wheels detached from the carriage, in which is the axle of the two pressing-wheels as they appear edgewise, their weight being about 2 cwt. each. The pressing-wheels

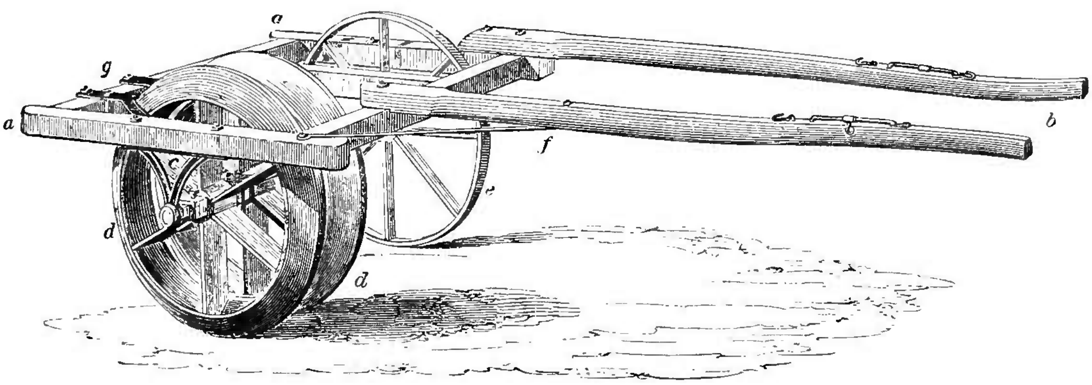


Fig. 269.—*Presser-roller.*

a a Rectangular frame.
b Pair of shafts.
c Cast-iron bracket.
d d Two pressing wheels.
e Light carriage-wheel.
f Iron stay-rod.
g Two iron scrapers.

are held at the required distance by square collars. A transverse section of the ground undergoing the pressing process is the shaded part of the section, exhibiting the state of a soft soil when pressed by the roller; and the dotted lines of the newly-ploughed furrow-slices of lea undergoing consolidation. With reference again to fig. 270, the pressing-wheels are to be understood as running always upon the last-turned-up furrows but one; while the light carriage-wheel runs always upon the solid land, where the horse also walks, the shafts being placed at that side.

But the presser is now being more advantageously used as to *time*, in the consolidation of soft soils, by being constructed with 4, 6, or more pressing-wheels; and in this form the carriage-wheel is not required. In using the pressure of this construction, the field must be ploughed for the seed-furrow, either entirely or in part, before the pressing is begun; and the field is regularly gone over by the presser, which, from its now increased weight, will require two horses. In this form, with 6 pressing-wheels and with 2 horses, the

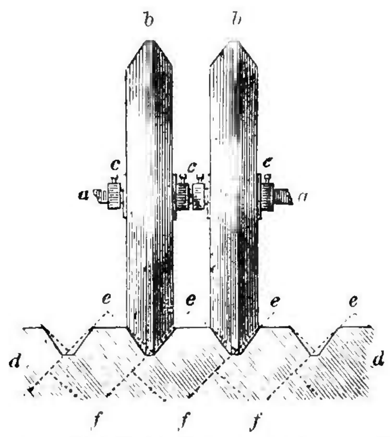


Fig. 270.—*Action of the edge of presser-wheels.*

a a Axle.
b b Two pressing-wheels.
c c c Square collars upon the axle.
d d Transverse section of ground being pressed.
e f Newly ploughed lea, furrow-slices in dotted lines.

machine will press-roll from 8 to 9 acres in a day. The entire weight of the 6-wheel rollers amounts to about 12 or 13 cwt. The work done by them is very efficient.

Use of the Land-presser.—The land-presser is not now used so extensively as it was formerly. This is to be regretted, for there can be no doubt of its beneficial influence upon light soils liable to suffer from drought in spring. The presser may also be beneficially employed in compressing light turnip-land when ploughing into ridges, to render it more fit for spring wheat; and in using it for this purpose it might be employed in the same manner as on lea. The late Hugh Watson Keillor, Forfarshire, stated that, having used the land-presser, he could "with confidence recommend it *on all light soils with every sort of corn crop.*"[1] The late Mr A. Bowie, Mains of Kelly, Forfarshire, remarked: "The presser is a most useful implement for easy dry soils. For saving seed and growing heavy crops it is a powerful auxiliary to the farmer of such soils; perhaps it is equal, if not superior, to the drill in these respects."

[1] *Jour. Agric.*, iv. 545.

Spring Varieties of Wheat.—As to the varieties of wheat which should be sown in spring in different localities, it would be imprudent to dogmatise. With the great attention now being given to the improvement of farm plants, and to the bringing out of new varieties and stocks of exceptional vigour and power of production, it is quite probable that the variety which is considered best to-day will be excelled in the near future. Farmers must therefore be constantly on the outlook for improved sorts, and be guided by the experience of the time as to which variety they should select.

It is this same consideration — the great ingenuity and enterprise employed in developing new sorts, and the rapidity with which one good sort is supplanted by a still better—which influenced us in deciding not to attempt in this work a detailed description of the different varieties or sorts of the respective farm crops now in use in this country.

For guidance as to the best varieties to use, no farmer need have any difficulty. By a careful study of the experience of other farmers, and due consideration of his own peculiar conditions as to soil and climate, he is not likely to be far wrong as to the selection of varieties.

Of course care must be taken not to sow a *distinctly winter* variety of wheat in spring. As to a winter wheat no mistake can be made, for however early may be the habit of the variety sown, the very circumstance of its being sown in autumn, when sufficient time is not given to the plant to reach maturity before winter, will convert it for that season into a winter variety. The wheat plant is a true annual, but when sown late, and the progress of its growth is retarded by a depression of temperature, it is converted for the time into a biennial. It is therefore highly probable that, as the nature of wheat is to bring its seed to maturity in the course of one season, any variety sown in time in spring would mature its seed in the course of the ensuing summer or autumn. This is believed to be a fact; nevertheless, circumstances may occur to modify the fact *in this climate.* Under the most favourable circumstances, the wheat plant requires a considerable time to mature its seed; and a variety that has long been cultivated in winter, on being sown in spring in the same latitude, will not mature its seed that season should the temperature fall much below the average, or should it be cultivated on very inferior soil to that to which it had been accustomed. In practice, therefore, it is not safe—at least in so precarious a climate as that of Scotland—to sow *every variety* of wheat in spring.

Spring Wheat-seed from Early Districts.—Wheat taken from a warm to a cold climate will prove earlier there than the native varieties, and, in so far, better suited for sowing in spring; and if the same variety is an early one in the warm latitude—bringing its seed to maturity in a short period, perhaps not exceeding 4 months—then it may safely be sown as a spring wheat, whether it be red or white, bearded or beardless.

The long experience of the late Mr Patrick Sheriff, East Lothian, led him to the conclusion that autumn wheats should not be sown in spring, as they will not produce a sufficient number of prolific ears.

Late Varieties of Wheat.—Special attention has been given in recent years to the bringing out of varieties of wheat suitable for sowing late in spring. Considerable success has been attained, and there are varieties now in use which in average years give fairly satisfactory results, although not sown till March or April.

Manuring Wheat.—In the description of the Rothamsted experiments in pages 135-169 of this volume, much useful and suggestive information as to the manuring of wheat will be found. Wheat is usually sown on land in good heart, for the most part after a potato or root crop, with which a heavy dressing of dung and artificial manure had been applied. In this case no special application of manure may be necessary for the wheat beyond perhaps a top-dressing with a little ammonia salts or nitrate of soda in spring. The sulphate of ammonia may be sown at the same time as the seed for the spring wheat, or early in spring for winter wheat, but nitrate of soda should not be sown until the plants are able to immediately assimilate the manure. From 1 to 2 cwt. per acre are common quantities of these fertilisers for top-dressing wheat.

When the land has not been liberally manured with the preceding crop, a heavier dressing, including phosphatic and potassic manures, must be given to the wheat crop; or it may be manured with dung. See chapter on "Manures and Manuring."

SOWING BEANS.

Beans take about 7 months to come to maturity, and should therefore be sown early—as early in spring as possible. They should be sown in February if the weather and the condition of the land permit; in no case later than March. A very favourable season may hasten the plant through its courses of vegetation in a shorter time; but a very unfavourable season will so retard it as almost to prevent the formation of the seed.

In Scotland the bean is not a reliable crop. It was never cultivated extensively there, and in recent years has lost ground slightly. Strong land is best suited for beans, and it still holds an important place on good carse farms. The land must be in good heart, and is generally well manured with dung in the previous autumn or winter. Beans are sown on the flat surface, or in rows from 15 to 20 inches apart, or in raised drills from 25 to 30 inches wide. The bean crop occupies varying positions in the rotation. It usually comes in between two cereal crops, between two crops of wheat, between oats and wheat, or between wheat and barley.

The bean crop is valuable both for its straw and grain. Though the crop fail in seed, it seldom fails to produce good fodder provided it can be well secured. A dry season stints the growth of the haulm, but produces beans of fine quality; and a wet season prevents the growth of the bean, but affords a bulky crop of fodder.

The *culture* for beans is not dependent so much on the soil as on the peculiar growth of the plant. Bearing fruit-pods on its stem near the ground as well as near the top, it should have both light and air; and its leaves being at the top, and its stem comparatively bare, weeds find room to grow. The plant should therefore be wide asunder in the row and between the rows, so that the crop may become luxuriant and the land cleaned.

Beans were long wont to be sown *broadcast*, and are so sown still in some cases. It is not a good plan, however, for it has a great tendency to leave the land full of weeds.

Varieties of Beans.—Several varieties are in cultivation. Those most largely sown are the common Scotch or horse bean, and the common tick-bean. The former is the best suited for northern districts, and under favourable circumstances grows to a height of 4 or 5 feet, weighing from 62 to 65 lb. per bushel. The seed is large, flat, of a dingy whitish colour, with a black eye, and irregularly wrinkled on the sides. The tick-bean, which is shorter in the straw, and generally more prolific, is the variety most largely cultivated in England. The seed is smaller, plumper, a pound or two heavier per bushel than the seed of the horse-bean. Amongst the other best-known varieties are the Russian or winter bean, the Mazagan, and the Heligoland bean.

Quantity of Seed.—From three to four bushels per acre are the most general quantities. In the north it is more frequently four than three, sometimes even five bushels. The seed is sown by machines of various patterns—sort of barrow-shaped appliances, worked by hand or horse power, and sowing usually one or three drills or rows at a time.

Manure for Beans.—Land intended for beans is usually well dunged in the autumn, or early in winter, with perhaps from 8 to 12 tons of farmyard dung, spread just before the land is ploughed. The dung will be all the better for this purpose if it is tolerably fresh, and it should be spread evenly on the land. In other cases, the dung is spread early in spring on the flat or in drills, as for turnips. When the dung is to be spread in drills, these are opened a little deeper than if the land were simply drilled to receive the seed.

Formerly it was thought that beans could not be grown satisfactorily without farmyard dung, but, as shown clearly by the Highland and Agricultural Society's experiments, that idea was not well founded. The artificial manures which gave the best results in these experiments are described by Dr Aitken on p. 182. Potash is the dominant ingredient. It is seen that, unaccompanied by potash, neither phosphates nor nitrate is of much use to the bean, whether applied separately or together; but the addition of potash to either or both, at once enormously increases the crop. The artificial manures were applied in March, three days before the seed was drilled in with the three-drill bean-barrow.

Beans and Nitrogenous Manure.—Seeing that a leguminous crop such as beans contains a great deal more nitrogen than cereal crops, it might be expected that nitrogenous manures would exercise a more beneficial effect upon beans than upon cereals. It has been found, however, that such is not the case. At Rothamsted extensive experiments have been carried out in the manuring of beans and other leguminous crops, but curiously enough the results have not been so clear or instructive as those obtained from the manuring experiments with most other crops. Sir J. B. Lawes says:—

"The general result of the experiments with beans has been, that mineral constituents used as manure (more particularly potash) increased the produce very much during the early years; and to a certain extent afterwards, whenever the season was favourable for the crop. Ammonia salts, on the other hand, produced very little effect; notwithstanding that a leguminous crop contains two, three, or more times as much nitrogen as a cereal one grown under similar conditions as to soil, &c. Nitrate of soda has, however, produced more marked effects. But when the same description of leguminous crop is grown too frequently on the same land it seems to be peculiarly subject to disease, which no conditions of manuring that we have hitherto tried seem to obviate.

"Experiments with peas were soon abandoned, owing to the difficulty of keeping the land free from weeds, and an alternation of beans and wheat was substituted; the beans being manured much as in the experiments with the same crop grown continuously.

"In alternating wheat with beans, the remarkable result was obtained, that nearly as much wheat, and nearly as much nitrogen, were yielded in eight crops of wheat in alternation with the highly nitrogenous beans, as in sixteen crops of wheat grown consecutively without manure in another field, and also nearly as much as were obtained in a third field in eight crops alternated with bare fallow."

Ploughing for Beans.—Strong land intended for beans is usually ploughed about the end of autumn or early in winter, so that it may have the benefit of the pulverising influences of winter. If the land is very heavy and liable to hold surface water, it will be useful to plough it in the direction of the greatest inclination or fall, so that there may be no cross-furrows to retain the water. But when the land can be ploughed across the inclination it will be well to do so, and then the drills, if the crop is to be grown in drills, will follow the inclination, thus crossing the autumn furrow.

Spring Tillage for Beans.—The amount and kind of tillage which bean land should receive in spring will depend upon the nature and condition of land, and the character of the season. If the

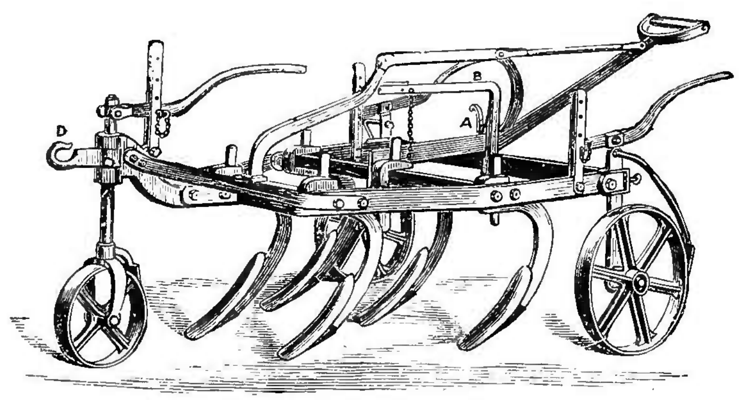


Fig. 271.—*Clay's cultivator.*

land lying in the winter furrow is tolerably friable, harrowing may be sufficient. As a rule, however, a turn of the grubber or cultivator will be found beneficial. The improved grubbers or cultivators are excellent implements for pulverising surface soil. They do their work well, and are very speedy—a consideration of special importance at this time of the year.

Fig. 271 represents Clay's well-known

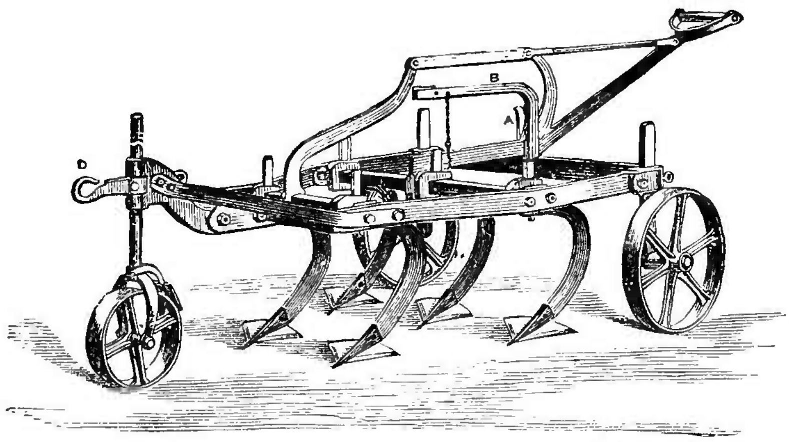


Fig. 272.—*Broadshare cultivator.*

cultivator, while in fig. 272 the same implement is fitted as a broadshare cultivator. Other forms of grubbers will be referred to in dealing with tillage for root crops.

The action of the grubber or cultivator in the soil is to stir it effectually as deep as the tines descend, and at the same time retain the surface-soil in its existing position. This advantage is especially appreciated in early spring, when it is precarious to turn over the soil with the plough, lest by a fresh fall of rain it should become wetter and worse to work than if it had not been ploughed at all. If the land be raw and not very clean, and the weather precarious, the grubber will prepare the soil for harrowing, of which it should receive one double tine along the ridges, the grubbing having been given across them. Should this not be sufficient to reduce the clod, another double tine should be given across the ridges, when the land will be ready for sowing.

If the weather in spring is favourable, and the beans are to be sown broadcast or in rows on the flat, ploughing across the winter furrow is by many considered desirable. The modern grubbers or cultivators, however, do their work so well that the necessity for the plough in spring is much lessened.

In preparing land in spring for beans, care should be taken not to grub or harrow more in one day than can be drilled up or sown on the same or the following. A fall of rain on this prepared ground before it is drilled for the seed would be detrimental to the crop.

Sowing Autumn-manured Beans.—The process of sowing beans upon land which had been purposely dunged and ploughed in autumn or early winter, is thus described by Mr F. Muirhead:—

"We will suppose the time has arrived for sowing the seed. The young farmer should previously have had his bean-sowing machine examined, repaired if necessary, and well oiled. He should also have provided the requisite quantity of seed—say 4 bushels of common Scotch beans for every imperial acre, and he had better have an extra bag of beans for every twenty he intends to sow, in case he may need a little more to finish the field than he anticipated,

"He should visit the field a day beforehand, and ascertain the length of the proposed drills, and how many make an imperial acre; and the following table may assist him:—

Inches wide. Drills.	Yards long. Imperial acre.
26	6701
27	6453
28	6222

"The open furrows should be filled in with two or three bouts of a two-horse plough, and the ends or headlands marked off, say, to hold eight drills, which should be ample room to admit of horses and ploughs turning quickly without treading on the newly formed drills. If the land requires a double stroke of heavy harrows before being drilled, as much should be harrowed the afternoon previous to sowing (provided weather is somewhat settled) as to allow the ploughs to get to work *readily* the following morning, or the foreman had better be sent half a day beforehand to do this, and to open, say, ten or twelve drills; and care should be taken, if the field has much inclination from top to bottom, to begin at that side of it which will, in covering up the sown seeds, give the horses the heavy furrow *down* hill. The following morning fully as much seed is taken out to the field as will likely be needed during the forenoon, and the bags should be placed along the top headland, if drills are not too long to admit of the three-drill horse sowing-machine sowing a 'bout' or six drills before it needed to be refilled, care being taken that the seed always covered the pinions for forcing out the beans.

"In placing the bags with the seed, suppose that it takes thirty drills to be an acre imperial, and we wish to sow 18 stones per acre, it will be more convenient to have the beans weighed up to that weight in each bag, and place the bags along the headland, one bag at the last drill of each acre; and in beginning to sow, it will be found of advantage to take out as much extra seed in a bag as cover the pinions of the sowing-machine, so that when the *first* bag is all sown, the person in charge knows at once whether the machine is sowing too quickly or too thinly. Perhaps if the first bag were accurately divided into two, and set down separately, at half an acre for each, the setting of the machine would be the sooner tested. The sowing-machine will now begin and sow the three outside drills, and the ploughs will commence and cover up the seed as they go *down hill*, and open fresh drills at the required width as they return. One sowing-machine will easily keep four or five pairs of horses at work." [1]

Sowing Spring-manured Beans.—When the dung has to be applied to the *drills* in spring, it is carted to the field, and thrown in graipfuls as the horse moves along the drills, just as in the dunging of roots or potatoes. The graipfuls are then spread evenly along the bottom of the drills, which, having received the seed, are thereupon closed.

If the dung has to be applied in spring, and it is intended to sow the beans *broadcast* or *in rows* on the flat, then the land receives a single or double turn of the harrow, the dung is spread evenly on the surface, and the land ploughed, the seed, perhaps, being dropped by the single bean-barrow into every third drill. And as the furrows are about 9 inches in

[1] *Farming World Almanac*, 1888.

breadth, the three furrows will place the rows of beans at 27 inches apart. This ploughing finishes the operation.

When the land is manured in the spring, and the seed sown broadcast, the dung in the same state is spread broadcast upon the surface. The further part of the operation depends on the state of the weather. Should it promise well until the bean-sowing is finished, the dung may be ploughed in, the seed sown broadcast upon the ploughed surface, harrowed in with a double tine, and the ridges water-furrowed. Should the weather seem doubtful, a safer plan is to sow the seed broadcast upon the spread dung, and plough in both seed and dung together, and the surface will be secured from danger. In this case the plants will come up in rows of the breadth of the furrow—9 inches apart.

Harrowing Drills.—If it is considered desirable to harrow the drills, this may be done about a fortnight after the sowing, if the surface is at all dry. If the land is wet, the harrowing should be delayed, and the first dry state of the surface taken advantage of. The common harrow is sometimes used to harrow down drills; but a better implement is the *saddle drill-harrow*, such as represented in fig. 273, made by C. Clay & Co., Wakefield. This harrow is worked in pairs; and, to render it applicable to its purpose, it is made of an arch form, partially embracing the curvature of the drill, and on this account is best fabricated of iron. The pair of harrows are drawn by one horse, walking between the drills.

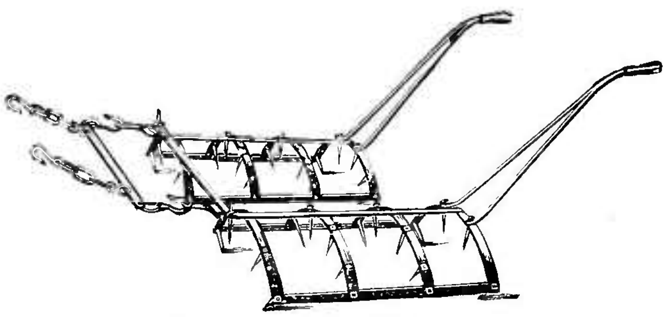


Fig. 273.—*Saddle drill-harrow.*

Beans and Peas Mixed.—Beans and peas are often grown together, the seed being sown broadcast. The most general proportion is about one-third of peas to two-thirds of beans.

Botanical Character of Beans.—It was an observation of De Candolle, that "it is remarkable that the botanical character of the *Leguminosæ* should so strictly agree with the properties of their seed. The latter may be divided into two sections—namely, the first, *Sarcolobæ*, or those of which the cotyledons are thick, and filled with fecula, and destitute of cortical pores, and which, moreover, in germination do not undergo any change, but nourish the young plant by means of that supply of food which they already contain; second, the *Phyllolobæ*, or those of which the cotyledons are thin, with very little fecula, and furnished with cortical pores, which change at once into leaves at the time of germination, for the purpose of elaborating food for the young plant. All the seeds of the *sarcolobæ* are used as food in different countries, and none of those of *phyllolobæ* are ever so employed."

Ancient Notions regarding Beans.—The ancient Greeks had some strange notions regarding the bean. Thus Didymus the Alexandrian says: "Do not plant beans near the roots of a tree, lest the tree be dried. That they may boil well, sprinkle water with nitre over them. Physicians, indeed, say that beans make the persons that eat them heavy; they also think that they prevent night dreams, for they are flatulent. They likewise say that domestic fowls that always eat them become barren. Pythagoras also says that you must not eat beans, because there are found in the flour of the plant inauspicious letters. They also say that a bean that has been eroded becomes whole again at the increase of the moon: that it will by no means be boiled in salt water, nor, consequently, in sea-water," &c.[1]

SOWING PEAS.

Peas are sown to a smaller extent than they were at one time in this country. They seldom take a prominent place as an ordinary rotation crop, but are largely

[1] Owen's *Geoponika*, i. 82.

grown near populous towns for sale in the green pod.

Peas give the best results on light and friable loamy soils of a calcareous character, or which had been recently dressed with lime or chalk. It is a general observation, that annual weeds are encouraged in growth amongst peas; and the pea being a precarious crop, yielding a small return of grain, except in fine warm seasons, a mere good crop of straw is insufficient remuneration for a scanty crop of grain, accompanied with a foul state of land. Hence in many cases turnips have been substituted for peas.

Peas, for a long period, were invariably sown broadcast; but seeing their tendency to protect weeds, and that drill-culture rendered the land clean, the conclusion was obvious that peas sown in drills would admit of the land being cleansed. It was found that the straw by its rapid growth creeping along the ground soon prevents the use of the weeding instruments. To counteract this tendency, the practice was introduced of sowing peas and beans together, and while their seasons of growth coincide, the stems of the bean serve as stakes to support the bines of the pea. The proportion of pea to bean when mixed usually is as 1 to 3.

Tillage for Peas.—It is somehow considered of little moment how the land shall be ploughed, when the pea is to be sown by itself. Sometimes only one furrow after the stubble is given; and when the land is tender and pretty clean, a sufficient tilth may be raised in this manner to cover the seed, which requires neither a deep soil for its roots (which are fibrous and spreading near the surface), nor a deep covering of earth above them, 2 inches sufficing for the purpose. But a single furrow does not do justice to the land, whatever it may do for the crop. The land should be double drilled or grubbed after the spring ploughing.

Since the pea can be cultivated along with the bean, it will grow on good strong soils; and its spreading roots enable it to grow on thin clays, where the bean does not thrive. But as corn, the pea, as has been indicated, thrives best on light soils. In clay, it produces a large bulk of straw, and the grain depends on the season being dry and warm; and as this is not the usual character of our climate, the yield is but indifferent.

Dung is seldom given to the pea when sown by itself, having the effect of forcing much straw with little grain.

When peas and beans are reaped together, they are separated when thrashed simply by riddling, the peas passing through the meshes of the riddle, while the beans are left upon the riddle.

Sowing Peas. — Peas are sown by hand when cultivated broadcast, and with the barrow when in rows, in every third, or in every furrow. With beans, they are sown by a barrow; on drilled land, broadcast by the hand: the seed falling to the bottom of the drills is covered by the harrows passing across the drills. Like beans, peas are sown on ploughed lea in some parts of England. On lea, the pea is dibbled in the harrowed surface, the holes being placed about 9 inches asunder. When varieties of the white garden-pea are cultivated in the field, as in the southern counties of England, these various modes of sowing them deserve attention; as also in the neighbourhood of large towns, where the garden-pea is cultivated and sent in a green state to the vegetable market.

The quantity of seed per acre varies, in drilling, from 2½ to 3 bushels per acre in the south, and sometimes as much as 4 in the north. The rows are usually from 12 to 15 inches apart. A little more seed is used in sowing broadcast.

The *varieties* of peas are very numerous. Of the varieties of the field-pea, the partridge grey pea in fig. 231, p. 497, vol. i., is suited to light soils and late situations, and is considered of excellent quality, and prolific when the crop is full.

TRANSPLANTING TURNIP BULBS FOR SEED.

When a farmer gets possession of a first-class variety of turnip, which he finds well suited to his land, he should grow from it every year at least as much seed as will supply his own wants—perhaps even a quantity for sale. The seed should be grown from well-formed bulbs, transplanted, perhaps early in March, just before spring growth begins to show itself. With intelligent care, and good varieties of roots, the seed may be grown successfully.

The extent of ground required is not great. Reckoning the crop of seed at 30 bushels per acre, weighing 50 lb. per bushel, and allowing 3 lb. per acre of seed for the turnip crop, 10 square yards of ground will supply the seed for every acre of turnips grown on the farm. It is necessary to have the plants of different sorts of turnips at a considerable distance from each other; because, if near, one variety will be impregnated by another, by bees and other insects carrying the pollen of one flower to another.

Let a piece of ground be selected for each variety of seed to be raised. Spare spaces in the corners of fields may be converted into nurseries for the purpose. Let the ground receive a little dung; and the easiest mode of making friable mould at once upon such places is trenching with the spade, and removing stones and weeds. Then select the best-formed bulbs of the different kinds from the fields as they are growing; take them up carefully, preserving the roots and fibres entire, and cutting off the shaws nearly close to the bulb.

A line of trench is made in the ground, deep enough to contain easily the bulbs and roots, which are inserted at 12 inches apart, and leaving the tops only above the ground, when the earth is returned into the trench. The rows of transplanted bulbs should be 3 feet asunder, to allow air to the plants, and afford room for a person to pass between them to watch the seed, when it is near ripe, from the depredation of small birds. In rows wide apart the plants become stronger and more prolific.

The best time of transplanting turnips is about the beginning of March, before any symptoms of spring growth appear. In a large piece of ground the plough can form the trenches, and harrows reduce the ground into mould.

The ground occupied for raising turnip-seed should be protected by a fence of hurdles against stock, otherwise the crop may suffer.

Birds often play havoc with turnip-seed as it approaches maturity. Unless some means are employed to scare off the birds, they may indeed destroy almost the entire crop. Boys are often told off to this duty, others throw old fisher nets over the seed, and this latter is the most effective method of prevention.

SOWING BARLEY.

It may be laid down as an axiom that the seed-bed upon which barley is to be sown should be fine, moderately deep, and clean, with an abundant supply of all the ingredients necessary for the growth of the plant present in a soluble or readily available form. Land after turnips is the place in the rotation which is generally set aside for the growth of barley.

Tillage for Barley.—If the land is not of the heavy order of soils, all that is necessary is the ordinary ploughing, especially if it can be accomplished by the second week of February. The action of the weather and frost will break down and mellow the soil, rendering it friable, so that a double tine of the harrows before putting in the seed is all that is needed to obtain a seed-bed in good tilth. On the heavier class of soils, and where ploughing cannot be done until later, more especially where the turnip crop has been eaten off by sheep, two ploughings may be necessary as well as harrowing before seeding.

But the simplest and easiest mode of procedure is to plough the land with one of the new Anglo-American ploughs, which will break down the furrow, leave the land level, and in excellent tilth. By this plan the old method of cross-ploughing, scarifying, grubbing, ribbing, &c., may be obviated.

It is probable that some of the turnip-land which may have been ploughed for spring wheat may have to be sown with barley, on account of inclement weather preventing the sowing of wheat in seasonable time. In that case, whether the land had been gathered up from the flat, or cast together, it should be seed-furrowed in the same form for the barley, to retain the uniform ridging of the field; for the ploughing for spring wheat being the seed-furrow, and the ridges made permanent, it would be impossible to reverse the ploughing with one furrow, without leaving one ridge on each side of the field half the width of the rest.

The ridges would have to be ploughed *twice* to bring them back to their proper form, but for which there could not be time, so they must be stirred with the grubber, or ribbed with the small plough.

Another method which is being adopted by farmers is to plough the land after turnips, in breaks of six ridges, gathering four and splitting two. This has become advisable nowadays, owing to the advent of the reaper, for which the old open furrows were very unhandy, while the crop was uneven, as the growth on the crown of the ridge was heavier than that in the furrow which divided the ridges.

If the ridges have consolidated on being long ploughed, the grubber will make a suitable bed for the barley seed, and keep the dry surface uppermost. If the soil is dry and loose on the surface, and tilly below, it will be best preserved by ribbing with the small plough.

A capital implement for preparing a fine seed-bed is the "Acme harrow," illustrated in fig. 274, an ingenious

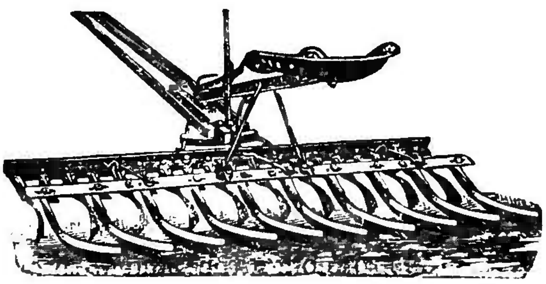


Fig. 274.—*Acme harrow.*

American invention, and brought to this country by Lankester & Co., London. It breaks up and pulverises the surface soil most thoroughly.

By putting such ridges thus into the best state for barley, there will be no difficulty in ploughing the rest of the land. The first furrow upon the trampled soil should be the *cross*-furrow.

Although the field may not be cleared of turnips to allow cross-ploughing from side to side, any portion should be ploughed, and, after harrowing the cross-ploughed land a double tine along, it should be gathered up from the flat, or yoked together; and both the cross and ridging-up furrows should be *deep*. The cross-ploughing should be turned over with a broad furrow-slice, but the ridging-up should be done with a deep narrow furrow-slice, to subdivide and pulverise the soil.

Sowing.—Sowing barley upon a fine evenly pulverised surface requires strict attention, inasmuch as on whatever spot every seed falls, there it lies, the soft earth having no elasticity to make the seed rebound and settle on another spot. Hence, of all sorts of corn, barley is the most likely to be striped in sowing by hand, so every handful must be cast with great force. Walking on soft ground in sowing barley is attended with considerable fatigue. Short steps are best suited for walking upon soft ground, and small handfuls are best for grasping plump slippery barley.

The broadcast machine sows barley as well as oats on the ploughed surface, and so do the corn-drills across the ridges after the surface has been harrowed. The grubbed surface is best sown by a drill-machine, affording the seed a firm hold of the ground, while the surface ribbed with the small plough is best sown by hand, or with the broadcast machine, the seeds falling into the ribs, from which the young plants rise in rows, the ground being harrowed only a double tine along the ribs. Barley may be sown any time fit for spring wheat, and as late as the month of May. But the earlier crop will be of better quality and more uniform, though the straw may be shorter.

Quantity of Seed.—The quantity of seed sown broadcast is from 2½ to 4 bushels to the acre. When sown early, less suffices; when late, more is required, because less time is given to tiller and cover the ground. Sown with the drill, 2 bushels suffice.

Brown makes some sensible remarks on this subject. "Amongst the farmers," he says, "it seems a disputed point, whether the practice of giving so small a quantity of seed (3 bushels per acre) to the best lands is advantageous. That there is a saving of grain, there can be no doubt; and that the bulk may be as great as if more seed had been sown, there can be as little question. Little argument, however, is necessary to prove that thin sowing of barley must be attended with considerable disadvantage; for if the early part of the season be dry, the plants will not only be stinted in their growth, but will not send out offsets; and if rain afterwards falls—an occurrence that must take place some time during the summer, often at a late period of it—the plants *then begin to stool*, and send out a number of young shoots. These young shoots, unless under very favourable circumstances, cannot be expected to arrive at maturity; or if their ripening is waited for, there will be great risk of losing the early part of the crop—a circumstance that frequently happens. In almost every instance an unequal sample is produced, and the grain is for the most part of inferior quality. By good judges it is thought preferable to sow a quantity of seed sufficient to ensure a full crop without depending on its sending out offsets. Indeed, when that is done, few offsets are produced—the crop grows and ripens equally, and the grain is uniformly good." [1]

Germination of Barley and the Weather.—No grain is so much affected by weather at seed-time as barley. A dash of rain on strong land is liable to cause the crop to be thin, many of the seeds not germinating, whilst others burst. In moist, warm weather, the germination is certain and very rapid; and it has been observed, that unless barley germinate quickly, the crop will be thin. We have seen the germ of barley pierce the ground only 36 hours after it had been sown, when the ground was smoking by evaporation of moisture, caused by a hot sun in a close atmosphere. We have also traced the germ of barley to its root to the depth of 9 inches below the surface; and this shows that land should be ploughed to a moderate depth for barley.

Harrowing for Barley.—The harrowing required for barley land sown broadcast is generally less than for oat land, a double tine being given in breaking-in the seed, and a double tine across immediately after. When sown with the drill-machine, the harrowing is perhaps a double tine along, and double tine across the ridges, before the seed is sown. When sown on ribbed land, the only harrowing may be a double tine along the ribs, just to cover the seed, as the ribs afford it a sufficient hold of the ground. Care, however, should be taken in all cases to ensure a fine even seed-bed for barley. The condition of the land will be the best guide as to the amount of harrowing required in individual cases.

The head-ridges are ploughed and sown by themselves.

Finishing.—The grass seeds are then sown with the grass-seed sowing-machine; the land harrowed a single tine with the light grass-seed harrows, and thereupon finished by immediate rolling. On strong land, apt to be incrusted on the surface by drought after rain, rolling may *precede the sowing of grass seeds*, and the work is finished with the grass-seed harrows, and perhaps another turn of the roller. On all kindly soils, rolling last is best for keeping out drought, and giving a smooth surface for harvest-work.

Soil for Barley.—Medium and light loams of a calcareous and friable nature—such as are generally known as good turnip lands—are best adapted to barley.

Barley is grown most largely after turnips, and is especially suited for following where a portion of the roots has been consumed on the land by sheep. In some cases it is sown after potatoes or beans, especially if the land and the season are unfavourable for wheat. When intended for barley, the potato or bean land is gathered up for the winter, water-furrowed, and gaw-cut; and in spring it may be grubbed or cross-ploughed and ridged up for the seed-furrow.

Barley is sown also after wheat, and the sample is always fine-coloured. Barley is never sown in Scotland after lea, but might be if the land were partially fallowed in spring. Barley does not stand the winter in Scotland as it does in the warm calcareous soils of the south of England. Winter barley is early ripe, and prolific; but if the weather causes it to tiller in spring, it produces an unequal sample, containing a large proportion of light grain.

Varieties of Barley.—The varieties of barley are numerous. They are generally distinguished by the number of rows of grain which grow upon the ear. The kind which is cultivated in this country to the greatest extent is two-rowed or long-eared, from which many improved varieties have sprung, notably the "Chevalier," "Annat," "Dunlop," &c.

The *Chevalier* variety was propagated by a Mr Chevalier, who, when examin-

[1] Brown's *Rur. Aff.*, ii. 45.

ing one of his fields, noticed an ear of better quality, being larger, with better filled grain, than the others around. This ear he selected and propagated in his garden.

The *Annat* barley originated from the produce of three ears selected by Mr Gorrie, Annat Gardens, hence its name.

The *four-rowed* or *common* barley is best known under the name of bere or bigg, and is confined chiefly to Northern Europe, and in this country to the north of Scotland, or to poor upland soils. There is also a *six-rowed* variety, but it is not extensively grown.

Uses of Barley.—The great bulk of the better samples of barley is used for distillery purposes, a small proportion being employed for the manufacture of pot barley or barley-meal, chiefly confined for use in Scotland. The inferior or damaged barley is used as food for animals.

Manuring Barley.—When it follows a well-manured root crop, as it generally does, barley seldom requires or receives any further manuring. Barley is a suitable crop for land on which a portion of the root crop has been consumed by sheep, and in this case the soil is usually in good heart, especially if the sheep have been allowed extra food, such as cake or grain along with the roots. The custom is to plough this land with a light or moderate furrow, and thus give the barley an abundance of readily available plant-food within the reach of its shallow roots.

But when the land has not, by previous treatment, become sufficiently stored with fertility for barley, this crop will, as a rule, respond satisfactorily to direct dressings of suitable manure. Being a rapid-growing shallow-rooted plant, barley should have plenty of readily available food within easy reach of the surface. Quickly acting artificial manures are thus specially suited for barley. Superphosphate and nitrate of soda, or sulphate of ammonia, in different quantities and proportions, according to the character and condition of the land, are extensively and advantageously used as top-dressing for barley. The first and last should be applied at seed-time; nitrate of soda, which acts more rapidly than sulphate of ammonia, may be applied in moist weather a few weeks later. Common quantities, per acre, are 2 to 3 cwt. superphosphate, and ½ to 1 cwt. of the nitrogenous manure. In many cases a light dressing of sulphate of ammonia or nitrate of soda is found to be very effective alone. In other cases a combined dressing of phosphatic, nitrogenous, and potassic manures gives the best results.

Rothamsted Barley Experiments.

The experiments on the manuring of barley at Rothamsted are full of interest to farmers. They have gone on continuously since 1852, and are capable of teaching some important lessons. Briefly summarised, the results are as follows:—

No Manure.—The plot which has had no manure of any kind since the beginning of the experiments gave an average of 17⅞ bushels for the thirty-two years up to 1883—4½ bushels less than the average of the first ten years.

Farmyard Dung.—Applied at the rate of 14 tons every year for thirty-two years, this gave for that period an average of 49½ bushels, or about 31½ over the unmanured plot.

Mineral Manures.—Mineral manures alone—that is, superphosphate of lime, and sulphates of potash, soda, and magnesia—gave very poor crops, both of grain and straw. Superphosphate alone, on an average of the thirty-two years, gave only about 5 bushels more than the plot with no manure; the increase from potash, soda, and magnesia over no manure was barely 2 bushels per acre, and from all these mineral manures combined scarcely 6 bushels.

Nitrogenous Manures.—These supplied in sulphate of ammonia or nitrate of soda gave more than double the increase produced by the mineral manures. Ammonia salts, 200 lb. per acre (containing 43 lb. nitrogen), gave an average of 30¾ bushels for the thirty-two years—nearly 13 bushels over the unmanured plot. Nitrate of soda, 275 lb. per acre (containing 43 lb. nitrogen), gave nearly 4 bushels more per acre. *Rape-cake*, 1000 lb. per acre, calculated to yield 49 lb. of nitrogen, raised the produce to 43¼ bushels.

Nitrogenous and Mineral Manures combined.—These in combination produced excellent crops, more than the average of the country, continuously for thirty-two years. This result is very interesting, showing that barley responds admirably to the influence of readily acting artificial manures. Equal quantities of nitrogenous and mineral manures applied in the autumn to wheat, and in spring to barley, gave considerably more produce from the latter crop than the former.

Practical Conclusions.—From the results of the experiments with various manures for barley, it is inferred that in corn-growing the soil is most rapidly exhausted of its nitrogen, next of phosphates, and most slowly of potash. Nitrogenous manures are thus the first and cheapest essential, but, especially for barley, phosphatic manures are also required, and give a good return. To most soils of a clayey tendency, dressings of potash will be unnecessary for cereals; but where it is deficient, a small allowance may be expected to exercise a wonderful influence on the crop. Here, as in general farm practice, it was found that superphosphate is more effective with the spring-sown than with the autumn-sown cereals.

Barley after Corn.—In reference to the practice of growing barley after a crop of wheat, Dr Fream says:[1] "It may be laid down as a general rule, applicable to the country at large, that, on the heavier soils, full crops of barley of good quality may be grown with great certainty after a preceding corn crop, under the following conditions: The land should be got into good tilth. It should be ploughed up when dry, as soon as practicable after the removal of the preceding crop. In the spring it should be prepared for sowing by ploughing or scuffling, as early in March as possible, if sufficiently dry. The artificial manure employed should contain nitrogen, as ammonia or nitrate (or organic matter), and phosphates. From 40 lb. to 50 lb. of ammonia (or its equivalent of nitrogen as nitrate) should be applied per acre. These quantities would be supplied in 1½ cwt. to 2 cwt. of sulphate of ammonia, or 1¾ cwt. to 2¼ cwt. of nitrate of soda. With either of these there should be employed 2 cwt. to 3 cwt. mineral superphosphate of lime. Rape-cake is also a good manure for barley; from 6 cwt. to 8 cwt. would supply about as much nitrogen as would be equal to from 40 lb. to 50 lb. of ammonia. With this manure, as with guano, the addition of superphosphate is unnecessary. Whatever manure be used, it should be broken up, finely sifted, sown broadcast, and harrowed in with the seed."

[1] *Rothamsted Experiments*, 120.

SOWING OATS.

In Scotland and Ireland by far the greater portion of the ploughed lea is sown with oats—a small extent being sown in some parts with spring wheat or vetches, &c. In England oats are grown extensively after turnips or mangels, which have been carted off the land. And in all northern and high-lying districts unfavourable for the ripening of wheat or barley, oats are the prevailing crop after turnips.

Oats are sown on all sorts of farms, from the strongest clay to the lightest sand, and from the highest point to which arable culture has reached on moorland soil to the bottom of the lowest valley on the richest deposit. The extensive breadth of its culture does not imply that the oat is naturally suited to all soils and situations, for its fibrous and spreading roots indicate a predilection for friable soils; but its use as food among the agricultural population generally, and its suitability to support the strength of horses, have induced its extensive cultivation.

Varieties of Oats.—The oat plant thrives best in a cold climate, and is grown in the chief countries lying in the temperate zone. It comes to its greatest perfection in Scotland. This is to a certain extent due to the climate, but the care which the Scotch farmer expends upon his oat crop also contributes to this result. The varieties which occupy the greatest breadth are the Common Improved or White oats, and to a lesser extent Black or Tartarian. Common oat is the name by which farmers designate the variety which is commonly grown in the respective districts in which they farm. For instance, in the northern counties, Sandy oats are regarded as the Common oat; in Perthshire and western counties, late Angus;

in Roxburgh and Berwickshire, Blainslie, &c.

The following are the chief varieties: The Potato, Poland, Angus, Blainslie, Hopetoun, Sandy, Tartarian, Tam Finlay, Red and Dun oats, Canadian oats, Swiss oat, &c.

Sowing.—The sowing of the oat seed is begun with the common varieties of oats about the beginning of March. It is the custom in some parts to sow the improved varieties a fortnight after the common. The ploughed lea ground should be dry on the surface before it is sown, as otherwise it will not harrow kindly; but the colour of dryness should be distinguished from that arising from dry hard frost, a state improper to be sown upon. Every spot of the field need not be alike dry — even thorough draining will not ensure that, though spots of wet indicate where dampness in the subsoil exists.

Harrowing before Sowing.—Should the lea have been ploughed some time and from young grass, the furrow-slices will lie close together at seed-time; but when recently ploughed, or from old lea, or on clay land in a rather wet state, the furrow-slices may be as far asunder as to allow a good deal of the seed to drop down between them, and thus be lost, as oats will not vegetate beyond 6 or 7 inches deep in the soil. In such states the ground should receive a double tine or strip of the harrow before being sown. This should be done in every case unless the furrows are small and packed quite closely.

When oats are sown by hand upon dry lea ground, the grains rebound from the ground and dance about before depositing themselves in the hollows, in rows, accommodating themselves between the crests of the furrow-slices, and do not so readily show bad sowing as upon a smooth surface. Were the ground harrowed along the ridges, so as not to disturb the seed in the furrow-slices, the crop would come up as if sown by drill; but as the land is cross-harrowed, the braird comes up broadcast.

Quantity of Seed.—The quantity of common oats usually sown is from 4 to 5 bushels to the acre. In deep friable land in good heart, and in early districts, from 3 to 4 bushels of improved varieties is considered sufficient seed.

A man does a good day's work if he sows broadcast by one hand 16 imperial acres of ground in ten hours. Some men can sow 20 acres; and double-handed sowers will do even more than 20 acres.

Harrowing after Sowing. — The tines of the harrows should be particularly sharp when covering in seed upon lea. After the land is broken in with a double tine, it is harrowed across with a double tine, which cuts across the furrow-crests, and then along another double tine, and this quantity commonly suffices. At the last harrowing the tines should be kept clean from grassy tufts, and no stones should be allowed to be dragged along by the tines, to the injurious rubbing of the surface. On old lea, or hard land, another single tine across or angle-ways may be required to render the surface fine; and, on the other hand, on light soil a single tine along after the double one across may suffice. In short, the harrowing should be continued until the ground seems uniformly smooth and feels firm under the foot. The head-ridges are harrowed by themselves at the last.

Water-furrows.—If the land is liable to suffer from surface-water, *water-furrows* may be formed in the open furrow, after sowing. But since underground drainage has become so general and thorough, this practice has become almost a thing of the past.

Machine-sowing. — Almost every farm with two or more pairs of horses, and even smaller holdings, has its broadcast or drill sowing-machine. Hand-sowing is thus being replaced by the machine. The practice in sowing oats with machines, whether broadcast or drill, is similar to that in sowing wheat and barley. To enable the drill to make good work in sowing on ploughed lea, the surface must be well broken up with the harrow. Where the surface is rough, and the furrows tough, the broadcast machine would be preferable.

Improvements in Oat-culture.—Until a comparatively recent period the cultivation of oats was much neglected. The prevailing idea amongst farmers seemed to be that any kind of culture, no matter how slovenly, was good enough for this crop. Even yet, amongst the less advanced districts, no great improvement has been effected in this respect. It remained for the enlightened Scotch farmer to lead the way towards placing the cultivation of this crop in its proper position, as being one of the most important operations of the farm.

One old writer informs us that "of all the plants commonly cultivated in the field, oats seem to have the greatest power of drawing nourishment from the soil, and hence, are justly considered as greatly exhausting the land;" and, by way of proof, he tells us that "oats are generally the last crop which would return any increase of the seed."

The principal reason is, we suspect, that oats are a deep-rooted plant, and can search for food over a greater area than the other corn crops.

Ploughing for Oats.—Difference of opinion exists as to the depth to which lea ground should be ploughed for oats. One opinion is that a depth of 4 inches is sufficient, with the furrow-slices laid down close; others contend that the land should be ploughed 9 inches in depth, and not laid over close. To determine which opinion is the more correct, it should be taken into account that the roots of oats are fibrous, and permeate through the soil to a greater depth than the roots of barley. This being their character, a good depth of furrow will be best for oats. Much of course will depend upon the depth and the character of the soil and of the subsoil; but as a rule, it is considered undesirable to plough lea shallower than 7 inches, to afford a considerable amount of pabulum to the roots of the plants.

Thick and Thin Sowing.—An uncertainty still exists in the minds of farmers whether thick or thin, drill or broadcast, sowing of oats is the better mode. Experiments have been made on both these points. Mr A. Bowie, Mains of Kelly, Forfarshire, sowed, in 1856, oats at 5 bushels and 2½ bushels the Scotch acre, on two farms, and the results were as follows:—

At West Scryne Farm.

		£	s.	d.
Increase of corn after 2½ bushels per acre over 5 bushels	=6 bushels at 25s. per quarter,	£0	18	9
straw „	=95 stones imperial at 3½d.,	1	7	8
Saving of seed	=2½ bushels at 25s. per quarter,	0	7	9
	Total saving,	£2	14	2

At Mains of Kelly Farm.

		£	s.	d.
Increase of corn after 2½ bushels per acre over 5 bushels	=6¾ bushels at 28s. per quarter,	£1	3	7
straw „	=30 stones imperial at 4d. per st.	0	10	0
Saving of seed	=2½ bushels at 28s. per quarter,	0	8	9
	Total saving,	£2	2	4

	quarters	bushels
Gross produce at Scryne after 2½ bushels per acre seed	= 11	2½
Kelly „	= 10	0
Total,	21	2½
Gross produce at Scryne after 5 bushels per acre seed	= 10	4½
Kelly „	= 9	1¼
Total,	19	5¾

The land in both cases was pressed with the presser-roller. Experiments in drill-sowing with oats in Nairnshire gave these results:—

After 6 bushels per Scotch acre, 5 qrs. 24 lb.
„ weight of grain 40½ lb. per bushel.

After 4½ bushels per acre, 6 qrs.
weight of grain 39½ lb. per bushel.

In another experiment, where 4½ bushels of oats per Scotch acre were sown with the drill, and 6¼ bushels with the broadcast machine, the broadcast looked best throughout the season, but the drill produced 1 qr. 15/7 bushel per acre more. The experimenters recommend from 3½ to 4 bushels of oats, and 3 bushels of barley, of seed per acre.

Sowing Mixed Varieties.—Experiments have shown that a mixture of varieties of oats sown together may produce a heavier crop than when sown singly. For example: J. Finnie of Swanston obtained, when sown singly, from potato oats 74 bushels, Hopetoun 65, early Angus 63, sandy 56 to 61; whereas, when mixed, these results were obtained: Hopetoun 5 parts, and Kildrummie 1 part, produced 85 bushels; Hopetoun and sandy, 80; Hopetoun and early Angus, 76; potato and early Angus, 66; and potato and sandy, 66 bushels. It thus appears that potato oats alone produced 8 bushels more than when sown with either early Angus or sandy oats; that Hopetoun, with Kildrummie, produced 20 bushels more than when alone, with sandy 15 more, and with early Angus 11 more.

Thus an average of 13 bushels more per acre was obtained by mixing seeds of oats of different varieties than when sown singly, and that from a space of ground which took 6 bushels of seed.

It must be borne in mind that, in mixing varieties of oats, the varieties to be mixed should come to maturity at the same time. It would be interesting to hear this physiological difference between potato and Hopetoun oats explained—the potato yielding the larger produce by itself, while the Hopetoun required other varieties to stimulate it to a larger production.

Oats and Barley Mixed.—Another practice prevalent in the north of Scotland is to sow a mixture of barley and oats in the proportion of 4 bushels of oats to 1 bushel of barley. Good results ensue, especially on land where oats, after brairding, become thin or die out. The gross produce is greatly increased, and an excellent food for horses and cattle is obtained.

It is more than probable that the greater produce which is thus obtained from a mixture of oats and barley than from either alone, is that oats and barley search for their food in different layers of the soil—oats penetrating to a considerable depth, whilst barley confines its search mainly to the upper portion of the soil.

Manuring for Oats.—In its manurial requirements oats are not much different from barley. They abstract a little more nitrogen and potash, and about the same quantity of phosphoric acid. Oats require more moisture than either wheat or barley, and delight in soils enriched by decayed vegetable matter. Thus oats give large yields on land newly reclaimed, or on land which has been for a considerable time under grass.

Superphosphate of lime and nitrate of soda applied as a top-dressing give good results when the land requires manuring. The nitrate is specially useful when a bulky crop of straw is desired. Common dressings consist of from ½ to 1 cwt. of nitrate of soda, and from 1 to 2 cwt. of superphosphate. On light land a little potash is sometimes applied with advantage. Guano is also a capital dressing for oats.

But the practice of top-dressing oats is not general. The oat crop, indeed, receives less manure in direct applications than any of the other ordinary farm crops — that is, when the oats follow either grass or roots. Of course when the oats follow another corn crop some dressing is considered necessary.

ROLLING LAND.

The common land-roller is an implement of simple construction, the acting part of it being a cylinder of wood, of stone, or of metal. Simple, however, as this implement appears, there is hardly an article of the farm in which the farmer is more liable to fall into error in its selection.

From the nature of its action, and its intended effects on the soil, there are two elements that should be particularly kept in view—*weight* and *diameter* of the cylinder. By the weight alone can the desired effects be produced in the highest degree, but these will be always modified by the diameter. Thus, a cylinder of any given weight will produce a greater pulverising effect if its diameter is 1 foot, than the same weight would produce if the diameter were 2 feet; but then the one of lesser diameter will be much heavier to draw; hence it becomes necessary to choose a mean of those opposing principles. In doing this, the material of the cylinder comes to be considered.

Wood, which is frequently employed for the making of land-rollers, may be considered as least adapted of all materials for the purpose. Its deficiency of weight and liability to decay render it objectionable. *Stone*, though not deficient in weight, possesses the one marked disadvantage of liability to fracture. This of itself is sufficient to place stone rollers in a doubtful position as to fitness. *Iron and steel* are undoubtedly the most appropriate of all materials for this purpose.

Diameter and Weight of Rollers.—There has been much discussion from time to time as to the most advantageous diameter for a land-roller. The preponderance of practical evidence is to the effect that a diameter of 2 to 2½ feet is, under every circumstance, the one that will produce the best effects with a minimum of labour from the animals of draught. In many cases, however, rollers of less as well as of greater diameter are in use. The weight is, of course, proportioned to the force usually applied, generally 1 but often 2 horses. The weight of roller, including the frame corresponding to this, is from 10 to 15 cwt. But some think it better that the roller itself should be rather under these weights, and that the carriage be fitted up with a box, in which a loading of stones can be stowed, to bring the machine up to any desired weight. Such a box is, besides, useful in affording the means of carrying off from the surface of the ground any large stones that may have been brought to the surface by the previous operations.

Divided Roller.—In a large and heavy roller, in one entire cylinder, the inconvenience of turning at the headlands is very considerable, and has given rise to the improvement of having the cylinder in two lengths. This, with a properly constructed carriage, produces a very convenient form of land-roller. Fig. 275 is a perspective of the land-roller constructed on the foregoing principles, with the carriage-frame crossed by the horse-shafts. The cylinder is in 2 lengths of 3 feet to 3 feet 3 inches each, and 2 feet in diameter; the thickness of the metal is according to the weight required. The axle, in consequence of the cylinder being in two lengths, requires to be of considerable strength, and of malleable iron; upon this the two sections of the cylinder revolve freely, and the extremities of the axle are supported in bushes in the semicircular end-frames. Two iron stay-rods pass from the end-frames to the shafts as an additional support to the shafts.

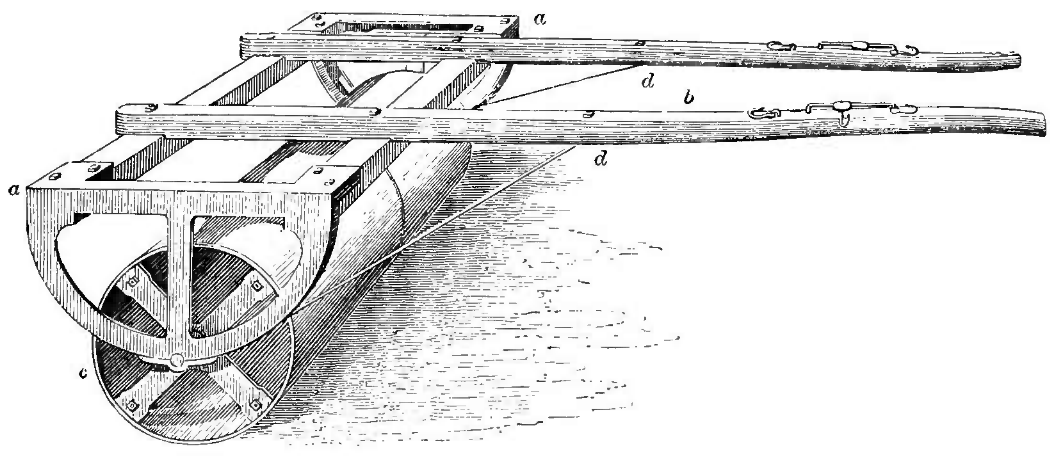


Fig. 275.—*Cast-iron land-roller.*

a a Carriage-frame. *b* Horse-shafts. *c* Cylinder. *d d* Iron stays.

Excellent rollers are now made of steel sheets fixed on wrought or cast-iron ends.

Water-ballast Roller.—A very convenient form of roller, made by Barford & Perkins, Peterborough, is represented in fig. 276. It is made in two enclosed cylinders of wrought iron, formed so that by filling or partially filling the cylinders with water, the weight of the roller may be varied as desired. These water-ballast rollers are made of many sizes for field and garden work, and are exceedingly convenient to work and move about. A water-ballast roller, 2 feet in diameter, weighs about 11 cwt. when empty, and 22 cwt. when quite full of water.

Process of Rolling.—The rolling is always effected across the line of ridges. Otherwise the open furrows would not receive any benefit from it. Although the dividing of the cylinder into two parts facilitates the turning of the implement, it is not advisable to attempt to turn the roller sharply round, as part of the ground turned upon may be rubbed hard by the cylinders, with the result that young plants may be injured or killed.

The rolling is sometimes executed in feers of 30 yards in width, *hieing* the horses one-half of the feering, and *hupping* them in the other half. This, however, is unnecessary with care at the turning. When the ploughman becomes fatigued with walking, it may be allowable for him to sit on the front of the framing, where a space is either boarded or wrought with hard-twined straw-rope, as a seat from whence to drive the horses with double reins and whip. With this indulgence, an old ploughman, employed only in ploughing, could take the rolling when urgent work was employing the stronger horses in the cart.

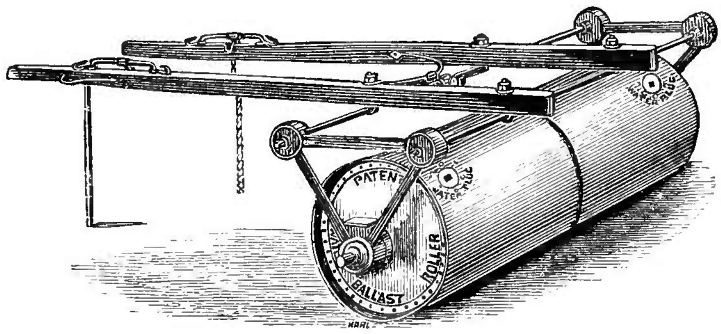


Fig. 276.—*Water-ballast roller.*

Speed in Rolling.—Were a 6-feet roller to proceed uninterruptedly for ten hours, at the rate of 2½ miles per hour, it would roll about 18 acres; but what with the time spent in the turnings and the markings-off of feerings, 10 to 12 acres a-day may be considered a good day's work. When the weather is favourable, and a large extent of ground has to be rolled, it is a good plan to work the roller from dawn to nightfall, each horse or pair, as the case may be, working 4 hours at a time. In this way, 16 hours' constant rolling, from 4 in the morning till 8 at night, may be obtained in the course of 24 hours, and from 25 to 30 acres rolled with one roller.

Time for Rolling.—The usual time for rolling is immediately after the seed has been sown. But the condition of the land as to moisture must be considered. The young braird on strong land is much retarded when the earth becomes encrusted by rain after rolling, so that such land in wet districts is in rainy seasons not rolled until the end of spring, when the plant has made some progress, and the weather continues dry. Light friable dry land should be rolled immediately after the seed is sown and harrowed, if there is time to do it. But the rolling of one field should not be allowed to cause delay in the sowing of others in dry weather. There will be plenty of time to roll the ground after the oat seed and other urgent operations at this season are finished.

On the other hand, the rolling is most effective in securing smoothness in the surface immediately after harrowing has been completed. And for the sake of the reaping-machine a smooth surface is of much importance.

In preparing land for grass and clover seeds the roller is not, as a rule, used so much as it should be. An even firm seed-bed is of the utmost importance for these tiny seeds.

GENERAL PRINCIPLES OF CORN CULTURE.

The sowing of the chief cereal crops has thus been dealt with very briefly. Much more might have been said on the subject, but there seems to be little necessity for describing at great length operations which are so simple as the cultivation of corn. Of all important work upon the farm this is, perhaps, the most simple and the most uniform in the methods of procedure.

The simplicity and the universality of the general principles of *corn cultivation* are well shown by Professor Wrightson in the following admirable epitome:—

"No business pursuit is easier than corn cultivation, and this is why we have such millions of bushels of corn thrown in upon us. It is a cheap cultivation. All we have to do is to plough the land, throw on the seed, and scratch it in. Of course we must do this at the right time of the year, and in the proper manner. When we take wheat or barley, or oats [to be sown in the autumn or winter], after a root cropped on the land, a very general method of cultivation is as follows: We first plough about 4 inches deep, then broadcast the seed upon the newly turned up fallow, and put the harrows on and give it a really good harrowing, so as to break the compact furrow and cover the seed thoroughly—that is all. Protect it from the ravages of the birds, and in the spring of the year roll and harrow it, and that is pretty much the cultivation of corn after roots. A great deal of corn is taken after grass and clover crops; and the cultivation of either oats or wheat, or barley after lea, is much the same thing. We plough and press, and often sow the seed upon the pressed furrow and harrow it in.

"Again, in other cases we plough, press, or heavily roll, harrow repeatedly, and drill. That again is the whole of the cultivation. Corn crops sometimes follow peas or beans, in which case the plan would be to dung the surface, and then proceed as before, ploughing in the dung, and either broadcasting or else producing a proper seed-bed with the use of the harrow, and drilling in the corn." [1]

Insect attacks upon corn and other crops are dealt with in a special chapter.

CROSS-PLOUGHING LAND.

The first preparation for barley seed after turnips is ploughing the land across at right angles to the existing ridges. The surface of the ground where sheep consume turnips is left in a smooth state, trampled firm by the sheep, presenting no clods of earth but perhaps numbers of small round stones, which should be removed with carts before the cross-ploughing is begun. The small stones are useful for drains, or to repair farm roads, and the large stones for dykes.

A plough then feers the ground for cross-ploughing. The reason that land is cross-ploughed for barley, and not for spring wheat, after turnips eaten off by sheep, is, that wheat thrives best when the soil is firm and not too much pulverised —whereas the land cannot be in too fine a condition for barley. Moreover, if the turnip-land were not cross-ploughed after the sheep left it, their manure would not be sufficiently intermixed with the soil, and in consequence the barley would grow irregularly in small rows, corresponding to the drills that had been manured for the turnip crop.

Preparing Turnip-land.— During the time the land is gradually being prepared for barley seed, as the sheep clear the ground of turnips, the stubble-land, which had been ploughed in autumn and in winter, and is to bear green crops in the ensuing season, should be cross-ploughed, and cultivated, as opportunity offers—that is, if the sowing of the oat seed is also finished.

Harrowing before Cross-ploughing.—The portion of the stubble-land first to be cross-ploughed is for beans. Every winter-ploughed field for cross-ploughing in spring is freed from large clods by *harrowing*. The winter's frost may have reduced the clods of the most obdurate clay soil, and the mould-board of the plough may thus be able to pulverise them fine enough, while the lighter soils may have no clods upon them. In this case it would seem loss of time to harrow the ground before cross-ploughing, and some farmers do not then use the harrow; yet, in the majority of cases, the harrowing will be found beneficial. One cannot be sure that, in the strongest soil, all the clods have been reduced to the heart by frost; and should any be buried by the cross-furrow while still hard, they will not afterwards be so easily pulverised amongst the soft soil as when exposed upon the harder surface of the winter-furrow. Then in the lightest soils, the harrows not only make a smoother surface, but intermix the surface dry frost-pulverised soil with the moister and firmer soil below, as far as the tines of the harrows can reach.

There is not much time lost in harrowing before cross-ploughing; and although it should require a double tine to pulverise the clods, or equalise the texture of the ground, it should be *across* instead of along the ridges, to fill up the open furrows with soil, whether the land had been previously ploughed with gore-furrows or not.

If time presses, the feerings for cross-ploughing may be commenced by one plough almost immediately after the har-

[1] *Prin. of Ag. Practice*, 136.

rows have started; and if the harrows cannot get away before the plough, the plough can take a bout or two round the first feering till the harrows have reached the second feering; or, still better, the harrows can go along each feering, preparing the ground for the plough, and then return and finish the harrowing between the feerings.

Thus, in fig. 277, after the first feering *e f* across the ridges has been ploughed, the plough can either take a bout or two round *e f*, till the harrows have passed the next feering *g h*, or the harrows can

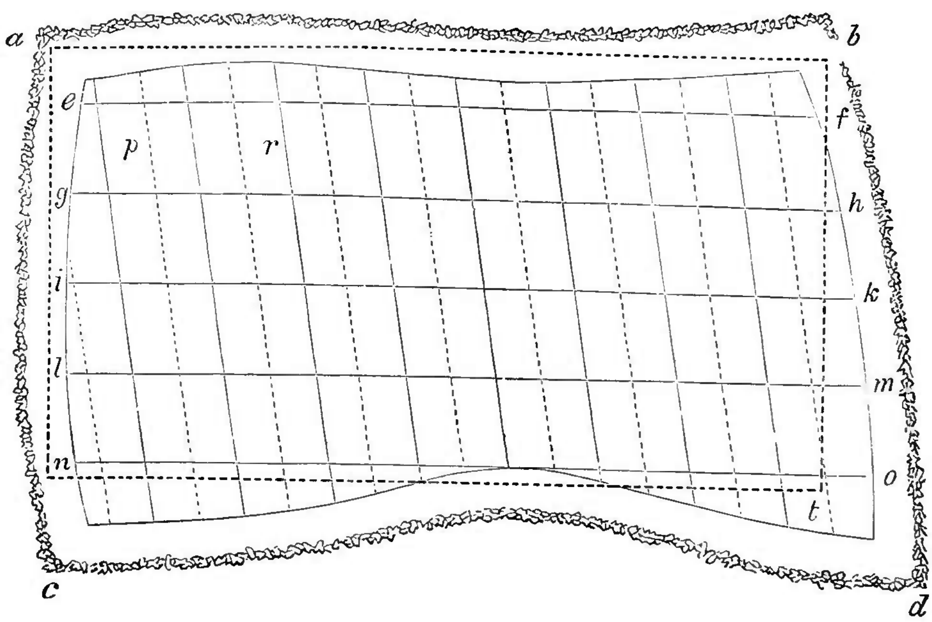


Fig. 277.—*Field feered for cross-ploughing.*

go along the line of each feering, at 30 yards' distance, first *e f*, then *g h*, then *i k*, and so along *l m* and *n o* in succession, and prepare the ground for feering, and then return and harrow out the ground between *e* and *g*, *g* and *i*, *i* and *l*, and *l* and *n*. In this way the harrowing and feerings, and ploughing the feerings, may go on at the same time.

System of Cross-ploughing.—But if time is not urgent, the systematic way is to feer the field across, at 30 yards' distance, from *e* to *n*, across the whole field, and the ploughs take up the feerings in succession. To illustrate this more fully, suppose that all or as much of the field to be cross-ploughed has been harrowed as will give room to a single plough to make the feerings without interruption. In choosing the side of the field at which the feerings should commence, it is a good rule to begin at the side farthest from the gate and approach gradually towards it, because then the ends of the finished feerings will not be passed, and the trampling of the ploughed land be avoided. The convenience of this rule is felt not in cross-ploughing only, but in prosecuting every kind of field-work; for besides avoiding damage to finished work, it is gratifying to the mind that, as work proceeds, the approach is nearer home; while it conveys the idea of a well-laid plan to have the operations of a field commenced at the farthest end and finished at the gate, where all the implements meet, ready to be conveyed to another field. The gate is like home, and in most cases it is placed on the side or corner of a field nearest the steading.

Ploughing Irregular Fields.—Peculiar forms of fields involve considerations in field operations of more importance than mere convenience—as loss of time. It is always desirable to commence a feering at a *straight* side of a field, whence in striking off the feerings parallel spaces of ground are included. Where this precaution is neglected, much time is needlessly spent in ploughing a number of irregular pieces of ground. It is better to leave all irregularities of ploughing to the last; and as an irregularity must occur along the side of a crooked fence, it is a saving of time to throw the irregular ploughing to that side.

In applying this rule to fig. 277, it so happens that the straighter side of the field is nearest the gate *b*, and the crooked fence, *c* to *d*, farthest from it. The feering, therefore, should begin along the side of the straightest fence *a b*, and terminate in an irregular space along the crooked fence *c d*. A straight feering could, no doubt, be made at first near *c d*, leaving irregularities between it and the fence; but the setting off that feering *exactly parallel* with the straighter fence *a b*, to avoid making another irregularity at *a b*, would impose considerable trouble, and take up more time than the advantage would compensate for avoiding passing the ends of the ploughed ground along the side-ridge, *d* to *b*, or of working from the gate *b* instead of to it. Let the first feering, then, be made about 7 or 8 yards from the fence *a b*, or from the ditch-lip of the fence where there is a ditch.

Ploughing Ridges and Feerings.—Some farmers neglect the head-ridge in the cross-ploughing, and measure the feering from the open furrow which divides the head-ridge and the ends of the ridges. The head-ridges ought to be ploughed at this time along with the rest of the field, for, if neglected now, the busy seasons of spring and early summer will draw away attention from them, till, what with trampling in working the green crop and the drought of the weather, they will become too hard to plough, and will lose the ameliorating effects of sun and air in the best part of the year.

In cross-ploughing the ridges of the field, the head-ridges must be ploughed in length, for they can never be *cross*-ploughed. But if it be desired to plough the head-ridges with the side-ridges, which form the head-ridges in cross-ploughing, and the side-ridges must be ploughed before the crop can be sown upon them, the first feering should be struck at 7 or 8 yards down the ridges from the side of the head-ridge, in the line of *f e*; and *feering* is executed by throwing the furrow-slices right and left along the same furrow, as already described in feering ridges in fig. 33, p. 108, vol. i. The next feering is *h g*, at 30 yards' distance from *f e*, and so on, feering at every 30 yards' distance, to the last feering *o n*. As each feering is made, the ploughmen take it up in succession; and should the feerings have been finished before the ploughs entered the field, the ploughs all commence at once.

Ploughing the feerings is plain work; but a hindrance occurs at the last and irregular feering at *o n*—not that any intricacy is involved in ploughing irregular pieces of ground, but the loss of time is considerable. This feering is ploughed like the rest, till the open furrow of the head-ridge is reached; and if the head-ridges are included in the feerings, the ploughing goes on till the ditch-lip or fence is reached; but if the head-ridge is to be ploughed with the side-ridges, the last feering should be made at the open furrow of the head-ridge at *o n*, and the bent head-ridge will be ploughed with the side-ridges and upper head-ridge round the field without leaving any unploughed space at *s*. Had the field been a true rectangle, like the space included within the dotted lines *a n t b*, the feering might have been struck from either fence, and there would have been no loss of time in ploughing alternate long and short furrows.

Depth of Cross-furrow.—The depth of the cross-furrow varies with the character of the soil. It is often, in good soil, deeper than the winter-furrow. The deepness is easily effected by the plough passing under the winter-furrow and raising a portion of the fresh soil below it. If the under soil is suitable, the 2 inches of fresh subsoil mix well with the thicker winter-furrow.

Cross-ploughing the first furrow in spring is unsteady work for the ploughmen, the open furrows presenting little resistance to the plough compared with the crown of the ridge.

The depth of the cross-furrow may vary from 8 to 12 inches, 10 inches being quite common. Sometimes 3 horses are yoked in the plough, as in fig. 26, p. 97, vol. i., for cross-ploughing.

Grubbers or cultivators are now extensively employed in spring tillage. To these operations fuller reference will be found in the chapter dealing with sowing turnips.

SOWING GRASS SEEDS.

Any time after the middle of February until the middle of May, when the weather is dry, grass seeds may be sown. They are generally sown in company with another crop; and the crops they accompany are cereals.

VARIETIES OF GRASSES.

The grasses all belong to the natural order *Gramineæ*. The following varieties are those principally used in agriculture, and for the descriptions of these we are indebted to Mr Martin H. Sutton, the author of 'Permanent Pastures,' as revised and greatly enlarged by his son, Mr Martin J. Sutton :—

Agrostis alba—*var.* stolonifera.

(Fiorin, or Creeping Bent Grass.)

Fr. *Agrostide blanche stolonifere.* Ger. *Fioringras.*

Roots creeping, rootstock perennial and stoloniferous. Stems 6 inches to 3 feet. Leaves numerous, narrow, flat, short, and usually scabrid; sheath smooth; ligule long and acute. Panicle spreading, with whorled branches. Spikelets small, one-flowered. Empty glumes larger than flowering glumes, unequal, smooth, and awnless. Flowering glumes slightly hairy at the base, with occasionally a minute awn. Palea minute and cloven at the point. Flowers from July to September. Grows in pastures and damp places throughout Europe, Siberia, North Africa, and North America (fig. 278).

Although none of the creeping bent grasses are considered particularly nu-

Fig. 278.—Fiorin, or creeping bent grass (*Agrostis alba*, var. *stolonifera*).

tritious for cattle, yet this variety is sometimes desirable in permanent mixtures, in consequence of its value in affording herbage early in spring and late in autumn, before and after other grasses have commenced or left off growing. Its long fibrous roots and creeping habit are naturally adapted for moist situations.

Alopecurus pratensis.

(Meadow Foxtail.)

Fr. *Vulpin de prés.* Ger. *Wiesen Fuchsschwanz.*

Roots fibrous, rootstock perennial. Stems 1 to 3 feet, erect and smooth. Leaves flat and scabrid; sheath smooth and longer than its leaf; ligule large and truncate. Panicle spike-like, cylindrical, and obtuse. Spike-

Fig. 279.—Meadow foxtail (*Alopecurus pratensis*).

lets one-flowered, and laterally compressed. Empty glumes larger than flowering glumes, awnless, but hairy on the keel. Flowering glumes with straight awn inserted at the middle of the back. Palea none. Flowers from the middle of April to June. Grows in meadows and pastures throughout Europe, North Africa, Siberia, and North-western India (fig. 279).

Meadow foxtail is one of the earliest and best grasses for permanent meadows and pastures, and may also with advantage be included in mixtures for 3 or 4 years' lea. It furnishes a large quantity of nutritive herbage, produces an abundant aftermath, and is eagerly eaten by all kinds of stock. The leaves are broad and of dark-green colour. The habit is somewhat coarse, hence it is unfit for lawns or bowling-greens, but its very early growth recommends it as eminently suitable for ornamental park purposes. It succeeds best on well-drained, rich, loamy, and clay soils, makes excellent hay, and should be included in a larger or smaller proportion in most mixtures for permanent pasture. Meadow foxtail is admirably adapted for irrigation. It also flourishes under trees, and should be sown plentifully in orchards and shaded pastures.

Anthoxanthum odoratum.

(Sweet-scented Vernal.)

Fr. *Flouve odorante.* Ger. *Gemeines Ruchgras.*

Roots fibrous, rootstock perennial. Stems tufted, erect, 1 to 2 feet, glabrous, and with few joints. Leaves hairy, flat, and pointed; sheath ribbed and slightly hairy; ligule hairy. Panicle spike-like, pointed at summit, uneven below. Spikelets lanceolate,

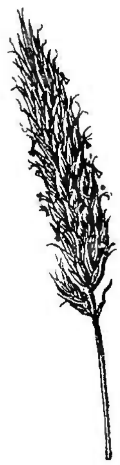


Fig. 280.—Sweet-scented vernal (*Anthoxanthum odoratum*).

one-flowered. Empty glumes in two pairs; outer two much larger than the flowering glumes, unequal, hairy at the keels and pointed at the ends, but awnless; second pair shorter and narrower than first pair, equal; also hairy and both awned, one with short straight awn inserted at the back near the summit, the other with long bent awn inserted at the centre of the back. Palea adherent to the seed. Flowering glumes small, glabrous, and awnless. Stamens two. Anthers large. Flowers April and May. Grows in fields, woods, and on banks throughout Europe, Siberia, and North Africa (fig. 280).

To the presence of this grass our summer hay-fields owe so much of their fragrance that it should be included in all mixtures for permanent meadow or hay. The scent is less distinguishable in a fresh than in a dried state, but its very pleasant taste, somewhat resembling highly flavoured tea, is discernible at all stages of its growth. In point of productiveness, this grass is inferior to foxtail, cocksfoot, and other strong-growing varieties; but the quality is excellent, the growth very early, and the plant continues to throw up flowering stalks till quite late in the autumn. On account of the broad foliage, this grass is ill adapted for grounds where short grass is indispensable; but for parks and pleasure-grounds it is especially suitable, on account of its bright green colour. Pastures in which this grass abounds naturally (such, for instance, as the extensive sheep-grazing districts in Kent), produce the finest mutton; and, both in a young state and when mixed with other varieties, it is much relished by cattle and horses. It is valuable in hay, as its flavour enhances the price, and it also yields a good quantity of feed after the hay crop is cut. It constitutes a part of the herbage on almost every kind of soil, particularly on such as are deep and moist.

Avena flavescens.

(Yellow Oat-grass.)

Fr. *Avoine jaune.* Ger. *Goldhafer.*

Rootstock perennial, creeping, and somewhat stoloniferous. Stems 1 to 2 feet, erect,

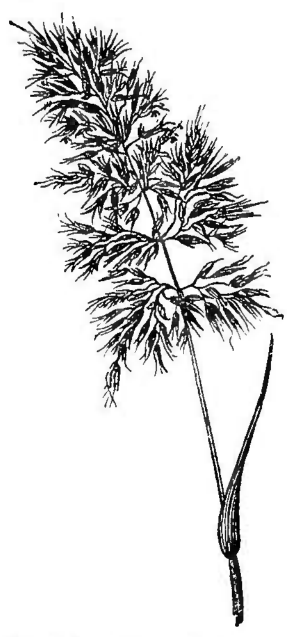


Fig. 281.—Yellow oat-grass (*Avena flavescens*).

glabrous, and striated. Leaves flat, sheath slightly hairy; ligule truncate and ciliated.

Panicle spreading, with many branches, broad at the base and pointed at the summit. Spikelets small, three- or four-flowered, shining, and of a bright yellow colour. Empty glumes unequal, keeled, and rough. Flowering glumes hairy at the base and toothed at summit, with slender twisted awn springing from below the middle of the back. Palea narrow, short, and blunt. Flowers June, July, and August. Grows in dry pastures throughout Europe, North Africa, and Asia (fig. 281).

This grass may easily be discerned in July by its bright golden cluster of flowers, and is among the latest varieties in coming to maturity. The leaves are of a pale-green colour, hairy, and although they are not produced in great abundance, are much relished by cattle. It affords sweet hay, and yields a considerable bulk of fine herbage. After the crop is cut for hay, a large aftermath is produced. This grass thrives on calcareous land, but is useless in moist low-lying pastures.

Avena elatior.

(Holcus avenaceus, Arrhenatherum avenaceum.)

(Tall Oat-grass.)

Fr. *Arrhénathère élevée.* Ger. *Hoher Wiesenhafer.*

Rootstock perennial, widely creeping. Stems 2 to 4 feet, erect and smooth; leaves scabrid and flat; sheath smooth; ligule short and truncate. Panicle erect and sometimes slightly nodding at the apex, widely spreading during flowering, closed before and after. Spikelets two-flowered. Empty glumes unequal and pointed. Flowering glumes two, the lower with long twisted awn, the upper with short straight awn. Flowers June and July. Grows in meadows and pastures throughout Europe, Africa, Asia, and America.

A strong-growing and rather coarse grass of good feeding quality. The flavour is slightly bitter, and on this account cattle do not at first manifest a liking for it, but when mingled with other grasses the objectionable characteristic is imperceptible. Although this plant is classed among perennials, it cannot be relied on as strictly permanent, and therefore we do not advise its employment for a longer period than three or four years. For alternate husbandry, however, it may be freely sown among other grasses, and its presence will augment the weight of the crop. On poor thin land tall oat-grass is useless, but on drained clays and rich soils generally it grows luxuriantly. The plant is a gross feeder, and must be liberally treated to bring it to perfection. The seed needs to be buried more deeply than is safe with other grasses.

Cynosurus cristatus.

(Crested Dogstail.)

Fr. *Cynosure cretelle.* Ger. *Kammgras.*

Rootstock perennial, stoloniferous. Stems tufted, height 1 to 2 feet, erect, smooth, and wiry. Leaves very narrow, ribbed, slightly hairy; sheath smooth; ligule short and bifid. Panicle spike-like, secund. Spikelets many-flowered, ovate, flat, with a barren spikelet consisting of empty glumes arranged in a pectinate manner at the base. Empty glumes sharply pointed, shorter than flowering glumes, unequal, with prominent rough keels. Palea very thin, slightly ciliated. Flowering glumes lanceolate, with short awn at summit. Flowers July and August. Grows in dry hilly pastures throughout Europe, Western Asia, and North Africa (fig. 282).

Crested dogstail is a fine short grass, and constitutes a considerable portion of the herbage of sheep-walks and deer-parks. It is found in most meadows,

Fig. 282.—Crested dogstail (*Cynosurus cristatus*).

whether used for hay or grazing. Sinclair describes it as forming "a close dense turf of grateful nutritive herbage, and is little affected by extremes of weather." From our own experience and observation, we can fully indorse the opinion of this eminent authority, and recommend its being included in all best permanent mixtures. We have especially noticed the beneficial results obtained by its use with other grasses in sheep-pastures; and it is generally believed that sheep fed on pastures containing dogstail are less liable to foot-rot than when fed on pastures composed of the more soft-leaved varieties. On account of its close-growing habit and evergreen foliage, it is particularly valuable for lawns, pleasure-grounds, and other places kept under by the scythe.

Dactylis glomerata.

(Rough Cocksfoot).

Fr. *Dactyle gloméré.* Ger. *Gemeines Knaulgras.*

Roots fibrous, rootstock perennial. Stems 2 to 3 feet, erect, stout, and smooth. Leaves glaucous, broad, flat, keeled, and rough; sheath scabrid; ligule long. Panicle secund, spreading below, close and pointed above. Spikelets three- to five-flowered, laterally compressed, and closely clustered at the end

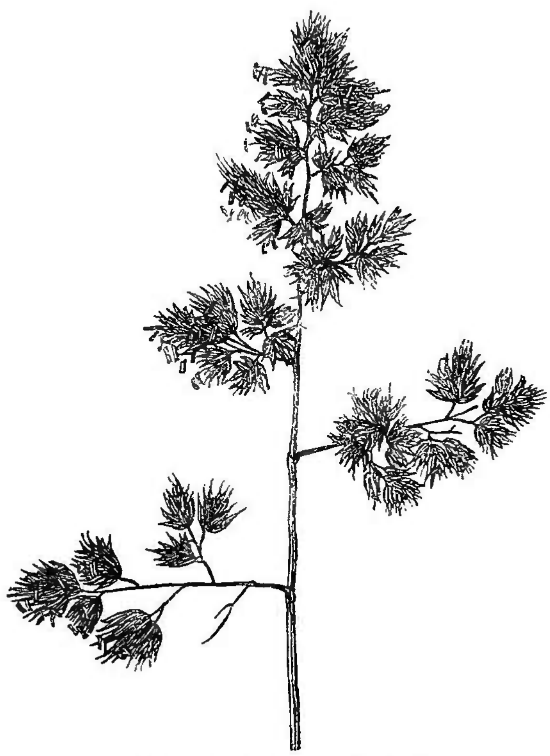


Fig. 283.—Rough cocksfoot (*Dactylis glomerata*).

of the branches. Empty glumes smaller than flowering glumes, unequal, keeled, and hairy on upper part of the keel, pointed at the summit. Flowering glumes with hairy keel, pointed and ending in a short awn. Palea bifid at summit, and fringed at base. Flowers May to August. Grows in pastures, woods, orchards, and waste places throughout Europe, North Africa, North India, and Siberia (fig. 283).

This well-known grass grows luxuriantly in deep rich soils and low-lying meadows. For the enormous quantity of produce it yields, the rapidity with which it shoots forth again after having been eaten or cut, and also for the important fact of its being so much relished by horses and cattle, it is eminently suitable for sowing with other quick-growing grasses for alternate husbandry. It should be included in permanent mixtures for tenacious soils and damp situations; but in parks and ornamental grounds its tufty habit of growth renders it inadmissible. It withstands drought well, makes excellent hay, and succeeds under trees, &c. It is very useful for sowing in covers, if allowed to grow without checking.

Festuca pratensis.

(Meadow Fescue.)

Fr. *Fétuque de prés.* Ger. *Wiesen Schwingel.*

Rootstock perennial, creeping. Stems tufted, 18 inches to 3 feet high, erect and smooth. Leaves flat and smooth; sheath smooth;

Fig. 284.—Meadow fescue (*Festuca pratensis*).

ligule short. Panicle spreading, but closer and narrower than in *F. elatior*, with fewer branches. Spikelets many-flowered, lanceolate. Empty glumes, shorter than flowering glumes, unequal and acute. Flowering glumes rough, and slightly awned. Palea acute and ribbed, with hairy nerves. Flowers June and July. Grows on good pastures throughout Europe and Northern Asia (fig. 284).

One of the earliest, most nutritious, and productive of our natural grasses. Both in its green and dried state it is eagerly eaten by all kinds of stock. It is useful for 3 or 4 years' leas, but is especially suitable for permanent pasture purposes. It is more adapted for moist than dry soils; still it constitutes a considerable portion of the herbage of all high-class pastures. Meadow fescue is thus referred to by Commander Mayne, in his 'Four Years in British Columbia and Vancouver's Island': "Cattle and horses are very fond of *F. pratensis*, or sweet grass, and it has a wonderful effect in fattening them. I have seen horses on Vancouver's Island, where the same grass grows, which had been turned out in the autumn, brought in in April in splendid condition, and as fresh as if they had been most carefully treated all the time." Although particularly robust in habit, it never grows in large tufts, as is the case with some coarse-growing grasses. The hay from it is plentiful, and of excellent quality.

Festuca elatior.

(Tall Fescue.)

Fr. *Fétuque élevée.* Ger. *Hoher Schwingel.*

Rootstock perennial, stoloniferous or tufted. Stems 3 to 6 feet, erect and smooth. Leaves broad, flat, and smooth; sheath smooth; ligule short. Panicle diffuse and nodding. Spikelets half an inch long or more, many-flowered, lanceolate. Empty glumes shorter than flowering glumes, acute and unequal. Flowering glumes broad, rough, and toothed at the apex. Palea acute and ribbed, with hairy nerves. Flowers June and July. Grows in damp pastures and wet places throughout Europe, North Africa, and North America (fig. 285).

Some botanists consider the *F. elatior* and the *F. pratensis* to be identical, and these grasses are consequently to be found in many botanical works bracketed together as synonymous. There is, however, a decided difference, which is clearly manifest not only in the seed, but in the growth of the two varieties. The seed of the true *F. elatior* is broader and longer than that of *F. pratensis.* The growth, too, is more robust, of much greater size in every respect, and it will consequently produce a heavier bulk of hay or feed. The panicles also of the *F. elatior* are quite distinct from those of the

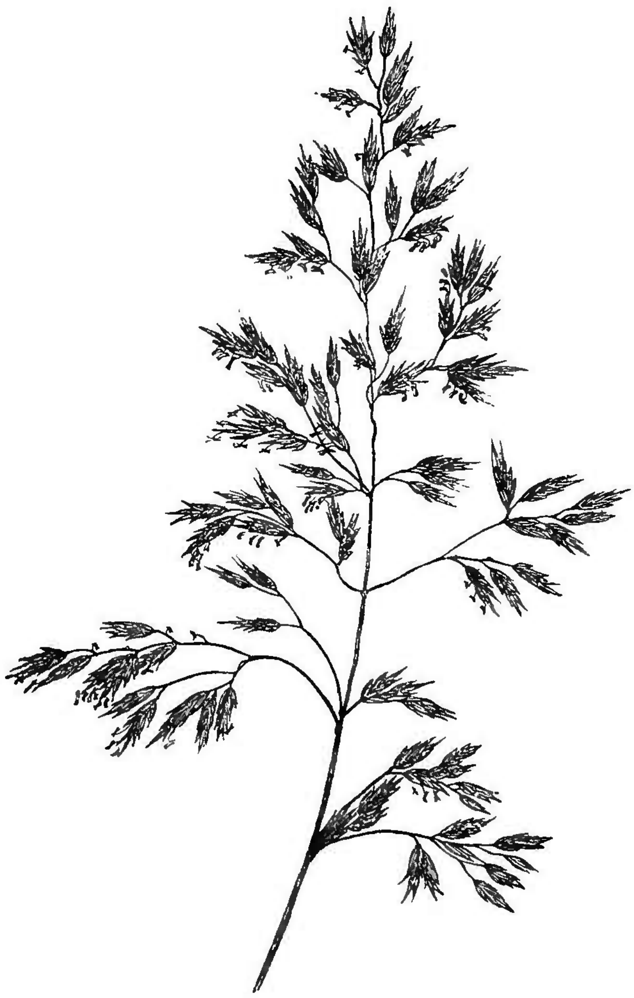


Fig. 285.—Tall fescue (*Festuca elatior*, var. *fertilis*).

F. pratensis, being branched, bent, and drooping, and composed of large clusters. Those of the *F. pratensis*, on the contrary, are decidedly upright in their early stages of growth, becoming slightly bent as the flower approaches maturity. On account of its luxuriant habit, we do not recommend the use of *F. elatior* where a fine turf is required; yet as a productive grass, and one which is greedily eaten by stock, it may form a part of permanent mixtures for moist and strong soils where the crop is intended for grazing, and also for irrigation purposes. It is admirably adapted for covers, in which its large seeds are useful as food.

Festuca heterophylla.

(Various-leaved Fescue.)

Fr. *Fétuque feuilles variées.* Ger. *Wechselblätteriger Schwingel.*

Roots fibrous, rootstock perennial, tufted. Stems numerous, erect, and smooth. Leaves various, dark green, lower ones folded, upper ones flat. Panicle diffuse. Spikelets many-flowered. Empty glumes unequal, shorter than flowering glumes, with prominent mid-rib and long awn. Flowers June and July. Grows in meadows and pastures throughout Central Europe; introduced into Great Britain for cultivation in permanent pastures.

This species is a native of France, where it is extensively grown, and was introduced to England in 1814. It is well adapted to our climate, and is valuable for parks and ornamental grounds, for its beautiful dark-green foliage. It is also particularly suited to pastures, on account of its large bulk of herbage; but it produces little feed the same season after mowing.

Festuca ovina.

(Sheep's Fescue.)

Fr. *Fétuque des brebis.* Ger. *Schaf Schwingel.*

Rootstock perennial, creeping or tufted. Stems 6 to 12 inches, erect, and densely tufted, rough at the upper part and smooth below.

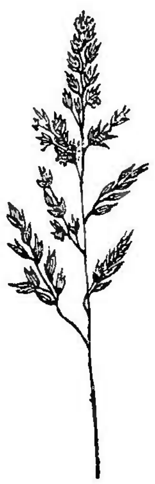


Fig 286.—Sheep's fescue (*Festuca ovina*).

Leaves very slender, chiefly radical, upper ones rolled; sheath smooth; ligule long and bilobed. Panicle small, erect, contracted, and subsecund. Spikelets small, upright, and many-flowered. Empty glumes shorter than flowering glumes, unequal, and acute. Flowering glumes small, with minute awn. Palea toothed, with hairy nerves. Flowers June and July. Grows in dry, hilly pastures throughout Europe, Siberia, North Africa, North America, and Australia (fig. 286).

This grass is supposed to have received its specific name from Linnæus, on account of its being so much relished by sheep; and Gmelin, the eminent Russian botanist, says that the Tartars generally pitch their tents during the summer months in close proximity to it, on account of its value to their herds. There is no question but that on good upland pastures, especially if used for sheep grazing, this grass should form a large proportion of the herbage. In produce it is inferior to some others, but deficiency in quantity is more than counterbalanced by its excellent nutritive qualities. From its remarkably fine foliage it is particularly suited for lawns and pleasure-grounds, which are constantly mown.

Festuca duriuscula.

(Hard Fescue.)

Fr. *Fétuque durette.* Ger. *Harter Schwingel.*

Rootstock perennial, creeping. Stems 1 to 2 feet, erect, and tufted, but less so than in *F. ovina*. Stem-leaves flat, lanceolate, and striated; sheath downy; ligule long. Panicle erect and spreading. Spikelets many-flowered, and larger than in *F. ovina*. Outer glumes lanceolate and unequal. Flowering glumes narrow, with a short awn. Palea

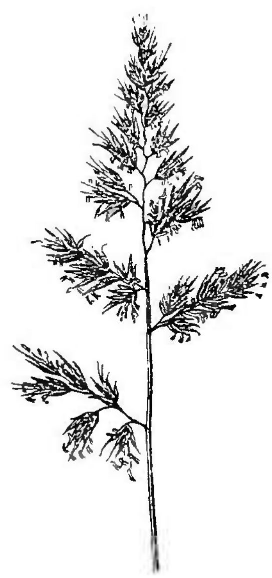


Fig. 287.—Hard fescue (*Festuca duriuscula*).

toothed, with hairy nerves. Flowers June and July. Grows in damp, hilly places throughout Europe, North Africa, Siberia, North America, and Australia (fig. 287).

This is one of the most valuable and important of the smaller fescues, and its presence in hay is generally indicative of superior quality. It comes very early, retains its verdure during long-continued drought in a remarkable manner, and is one of the best of pasture grasses. All kinds of stock eat it with avidity, but especially sheep, which always thrive well on the succulent herbage it produces. From the fineness of its foliage, and the fact of its resisting the drought of summer and cold in winter, it is eminently adapted for sowing in parks and ornamental grounds. A large quantity of food is produced after the grass is cut for hay.

Festuca rubra.

(Red Fescue.)

Fr. *Fétuque rouge.* Ger. *Rother Schwingel.*

Rootstock perennial, with long creeping stolons. Stems erect, 2 to 3 feet. Leaves flat and rolled ; sheath hairy ; ligule long. Panicle spreading, and slightly drooping at apex. Spikelets many-flowered, of a reddish colour. Empty glumes unequal. Flowering glumes lanceolate, with a short awn. Flowers June and July. Grows in dry low-lying places near the sea, throughout Europe, North Africa, Siberia, and North America.

Although this grass is considered by some to be merely a variety of *F. duriuscula*, altered in habit by frequent cultivation on dry soil, yet to the careful observer there will appear an appreciable difference between the two varieties. The leaves are broader, of darker colour than the *F. duriuscula*, while the growth is not so strong. The principal difference, however, is in the creeping habit of *F. rubra*, which enables it to live on loose, light, dry soils, where most other grasses fail. Its creeping roots penetrate so deeply into the soil, as to enable the plant to maintain a fresh and green appearance when other varieties are burnt up. It is particularly adapted for pastures by the seaside. The nutritive value of this grass when just in flower is much greater than at an earlier period.

Glyceria fluitans.

(Floating Sweet Grass.)

Syns.—POA FLUITANS and FESTUCA FLUITANS.

Fr. *Glycérie flottante.* Ger. *Schwimmgras.*

Rootstock perennial, stoloniferous. Stems branched, floating or creeping, stout and smooth. Leaves short, flat, and broad ; ligule long, broad and pointed at apex. Panicle erect and branching. Spikelets oblong and many-flowered. Empty glumes unequal, flowering glumes scabrid, and blunt at apex. Palea with ciliated nerves. Flowers July and August. Grows in damp places throughout Europe, Siberia, North Africa, and North America.

This grass is found growing naturally by the sides of ditches, pools, lakes, and rivers, and is perhaps the only water-grass which is eaten with avidity by both sheep and cattle. The leaves are narrow, of a pale green colour, and succulent. It is valuable for moist situations, and thrives especially in the Fen districts.

Lolium perenne.

(Perennial Rye-grass.)

Fr. *Ivraie vivace.* Ger. *Englisches Raygras.*

Roots fibrous, rootstock perennial, sometimes stoloniferous. Stems 1 to 2 feet, bent at the base, ascending, smooth, and slightly compressed. Leaves flat, narrow, and pointed ; edges and upper surface scabrid ; sheath smooth and compressed ; ligule short and blunt. Panicle spiked. Spikelets sessile, distichous, and many-flowered. Empty glumes, only an outer one to each spikelet, except in the case of the upper spikelet, which has two, lanceolate, smooth, distinctly ribbed, and shorter than flowering glumes. Flowering glumes obtuse, ribbed, and with sometimes a minute awn. Flowers May and June (fig. 288).

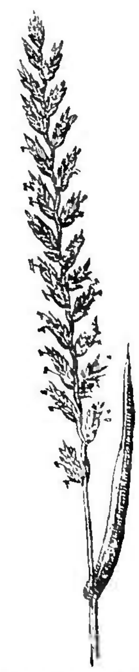


Fig. 288 —Perennial rye-grass (*Lolium perenne*).

There has since 1882 been much discussion as to the character and value of rye-grass, and the part which it should play in the formation of permanent and temporary pastures, the former in particular. In that year Mr C. D. L. Faunce de Laune of Sharsted Court, Sittingbourne, contributed a paper to the *Journal of the Royal Agricultural Society of England* (vol. xviii., sec. ser., part 1) "On Laying Down Land to Permanent Grass," and there he condemned rye-grass, and urged "the necessity of eliminating" it from all mixtures of seeds to be sown in the formation of permanent pastures. In the same publication and through other channels he continued his denunciation of rye-grass, stating that—"My observations lead me to believe that rye-grass is detrimental to the formation of 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 fail to live unless highly manured by accident or on purpose."[1]

Mr de Laune has certainly formed excellent permanent pastures without the assistance of rye-grass, and it cannot be denied that much good has resulted, and more good will still result, from the discussion which he has aroused; for it is well known that farmers did not, as a rule, give sufficient attention to the selection of seeds for pastures, and it is also more than probable that rye-grasses sometimes bulked more largely in seed-mixtures than was desirable.

Mr W. Carruthers, consulting botanist to the Royal Agricultural Society, joined with Mr de Laune in the controversy, in so far as to contend that rye-grass is no more perennial than the wheat plant; that it would die out in two years unless kept free from seeding; and that it should therefore be excluded from permanent pastures. But he has recommended rye-grass for temporary pastures, and admits that if it were eaten close down and not allowed to seed, "they might keep it alive as long as they like."

But the attack upon this particular plant, which has occupied such a prominent place in British pastures, has not prevailed. It has, indeed, been successfully repelled by Dr Fream, Sir John B. Lawes, and others, who have demonstrated the important and significant fact that rye-grass with white clover form the dominant constituents of many of the finest old pastures in the country, including the celebrated feeding pastures of Leicestershire. The results of Dr Fream's investigations are recorded in the *Journal of the Royal Agricultural Society*, vol. xlviii., sec. ser., part 2.

Although we have deemed it necessary to give this bird's-eye view of the "Battle of Rye-grass," as the discussion has been aptly termed, we cannot remove rye-grass from its wonted place in grass-seed mixtures, whether for permanent or temporary pastures. As to the relative quantity of rye-grass and other grasses, hard-and-fast rules should not be insisted upon. The quantities we have stated will not suit equally well in all circumstances; and while some may think it well to use still larger quantities of rye-grass, others may perhaps find smaller give better results.

An article on perennial rye-grass in *The Field*, on November 20, 1886, contains the following information:—

"The modern evidence in favour of perennial rye-grass, proving it to be a true perennial, exists in the report, prepared for Sir John Lawes by Mr Willis, on the flora of a pasture in Leicestershire, near Market Harborough. I am able to give the following details:—

"After fencing off a portion of the pasture to exclude the cattle, the grass in the enclosure was allowed to grow for the purpose of being botanically examined, when it was found that 75 or 80 per cent of the whole herbage was composed of two species only—Lolium perenne (common rye-grass) and Trifolium repens (white Dutch clover).

"The meadow in question was selected as the best 'old pasture' of the district. Its soil was a 'maiden' yellow loam 3 feet deep, resting on gravel, which secured natural drainage. It had not been cut for hay within memory, and was depastured every year by the following extraordinary head of stock: Two sheep per acre throughout the winter, receiving

[1] *Jour. Royal Agric. Soc. Eng.*, xviii., sec. ser., part 2.

½ lb. cotton and linseed cake each daily for four months, and a little hay during latter part of winter when the grass is most scanty, and sixteen oxen, or one per acre and two over, entered early in April, and remaining till October or November, when they were fit for the butcher. The oxen received no extraneous food, except 6 lb. each daily of the same mixture of cake during the last month.

"It is a general remark that the pastures are good in proportion to the production of rye-grass and Dutch clover."

Lolium italicum.

(Improved Italian Rye-grass.)

Fr. *Ivraie d'Italie.* Ger. *Italienisches Raygras.*

Roots fibrous, annual. Stems 4 to 6 feet, erect, stout, and somewhat rough. Leaves broad and succulent. Panicle spiked, erect, and distichous. Spikelets many-flowered. Flowering glumes with long awns. Flowers June and July (fig. 289).

The Italian rye-grass was introduced into this country in 1831 by the late Charles Lawson. It is very distinct in its character and seed from ordinary rye-grass, and as it is not perennial, it is only suitable for alternate husbandry, and producing early feed in the spring for sheep and cattle; but in permanent pastures it is to be avoided entirely. For sewage cultivation it stands in the first rank of all forage plants.

It has produced extraordinary crops at various sewage farms. On account of its rapid growth, and for its succulent herbage, it is invaluable for early sheep feed. It may be sown with safety any time between the months of February and October. If alone, 3 bushels per acre is the quantity required; but if sown on a corn crop with clovers, a much smaller quantity will suffice. In the latter case, it should not be sown until the corn is up. The mode of cultivation is exceedingly simple—harrowing the ground before and after sowing, and rolling subsequently, being all that is required. If the land is in good condition, three or four heavy cuttings per annum may be obtained, even without liquid manure; but undoubtedly, the more manure applied, especially in liquid form, the more abundant the crop; and it is important that the liquid should be applied immediately after cutting.

It is a common notion that wheat will not answer after Italian rye-grass. The following opinion of the late Mr William Dickinson on this point is worth consideration: "Thirty sheep may be kept upon Italian rye-grass, fed through hurdles, upon as little land as ten can be kept upon the common system upon common

Fig. 289 —Italian rye grass (*Lolium italicum*)

grass; and the finest crops of wheat, barley, oats, and beans may be grown after the Italian rye-grass has been fed off the two years of its existence. *Wheat invariably follows the Italian—splendid crops are grown where wheat had not been grown before.*"

Phleum pratense.

(Timothy, or Meadow Catstail.)

Fr. *Fléol des prés.* Ger. *Timothygras.*

Rootstock perennial, somewhat creeping. Stems 1 to 3 feet, erect and smooth. Leaves short, flat, and soft; sheath smooth; ligule oblong. Panicle spike-like, cylindrical, elongate, and compact. Spikelets one-flowered, laterally compressed. Empty glumes larger than flowering glumes, equal, each with stiff hairs on the keel and a short scabrid terminal awn.

Palea minute and pointed. Flowering glumes awnless, toothed, and much smaller than empty glumes. Flowers end of June to August. Grows in meadows and pastures throughout Europe, North Africa, Siberia, and Western Asia (fig. 290).

One of the most common of our meadow plants. In some parts of America it attains a great height, and forms the bulk of the grass hay of that country. In England it is largely cultivated in

Fig. 290.—Timothy (*Phleum pratense*).

conjunction with other strong-growing grasses. For early feeding timothy is superior to cocksfoot. It may be pastured for some time through the spring without damage to the hay crop. It succeeds well on soils of a moist and retentive nature, and is keenly relished by all kinds of stock, whether in a green state or made into hay. In addition to its usefulness for permanent pasture, it possesses a high value for alternate husbandry.

Poa pratensis.

(Smooth-stalked Meadow-grass.)

Fr. *Paturin des prés.* Ger. *Wiesen Rispengras.*

Rootstock perennial, creeping and stoloniferous. Stems 1 to 2 feet, erect, smooth, and rather stout. Leaves flat, rather broad and slightly concave at the tip; sheath smooth and longer than its leaf; ligule short and blunt. Panicle loose, spreading and pyramidal in shape. Spikelets compressed, four-flowered. Empty glumes much webbed, lanceolate, almost equal. Flowering glumes larger, webbed, keeled, and acute. Palea short. Flowers June and early in July. Grows in meadows and pastures throughout Europe, Siberia, North Africa, and North America (fig. 291).

This variety in early spring presents a beautiful green appearance, and is easily distinguished from *Poa trivialis* by its smooth culms and leaves. Being of a more creeping habit than other Poas, it is sometimes condemned as exhausting the soil. On account of its unusual earliness and great productiveness at a period of the season when other grasses are comparatively dormant, it should be

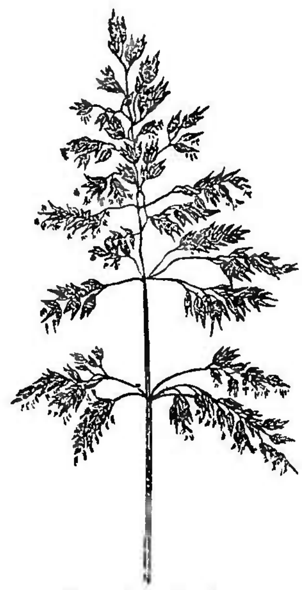


Fig. 291.—Smooth-stalked meadow-grass (*Poa pratensis*).

included in permanent pasture mixtures where early feed is of importance. *Poa pratensis* flourishes in dry soil, makes excellent hay and aftermath, and is valuable for garden lawns and ornamental grounds.

Poa trivialis.

(Rough-stalked Meadow-grass.)

Fr. *Paturin commun.* Ger. *Gemeines Rispengras.*

Rootstock perennial, somewhat creeping, but not stoloniferous. Stems 1 to 2 feet, rough and slender, erect. Leaves flat, narrow, acute, and rough; sheath rough and equal to its leaf; ligule long and pointed. Panicle loose, spreading and pyramidal in shape. Spikelets two- or three-flowered, and compressed. Empty glumes webbed, lanceolate, and nearly equal. Flowering glumes keeled and acute. Palea short and slightly fringed. Flowers June to end of July. Grows in meadows and pastures throughout Europe, Siberia, North Africa, and North America (fig. 292).

This grass is somewhat similar in appearance to *P. pratensis*, but the two varieties differ materially in habit and general properties. It will be seen, on referring to the illustrations, that the flower-stems of the *P. trivialis* are slightly drooping in habit, while those of the *P pratensis* are more erect; that the ligule (or small tongue) of the leaf in the former is pointed, while in the latter it is blunt. *P trivialis* is adapted for good deep rich moist loams, stiff heavy clays, and irrigated meadows. It is unsuited for dry upland pastures, and if sown in such positions will soon disappear. Opinions differ as to the merits of this grass, some botanists declaring it to be only a second-rate variety. Our own experiments quite confirm Sinclair, who thus refers to it: "The superior produce of this Poa over many other species of grass, its highly nutritive properties, the season at which it arrives at perfection, and the marked partiality which horses, oxen, and sheep have for it, are merits which distinguish it as one of the most valuable of those grasses which affect rich soil and sheltered situations."

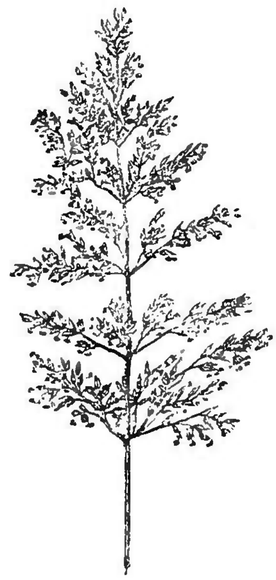


Fig. 292.—Rough-stalked meadow-grass (*Poa trivialis*).

Poa nemoralis sempervirens.

(Hudson's Bay, or Evergreen Meadow-grass.)

Fr. *Paturin des Bois a feuilles persistantes.*
Ger. *Wintergrünes Hain Rispengras.*

Rootstock perennial, slightly creeping, but not stoloniferous. Stems 1 to 3 feet, erect, and smooth. Leaves narrow, pointed, rough on the surface and outer edges; sheath smooth; ligule none or very minute. Panicle diffuse, slender, and nodding; spikelets lanceolate, compressed. Empty glumes acute, nearly equal, sometimes slightly webbed. Flowering glumes rather large, lanceolate, with three hairy ribs. Palea with nerves slightly fringed. Flowers June and July. Grows in woods and shady places throughout Europe, Northern Asia, and North America (fig. 293).

The great recommendations of this grass are its perpetual greenness, and dwarf, close-growing habit. These qualities, as well as its reproductiveness, render it one of the very best varieties for lawns or pleasure-grounds, and the fact that it thrives under the shade of trees considerably enhances its value. It yields a good bulk of herbage, endures drought, and starts growth early in spring.

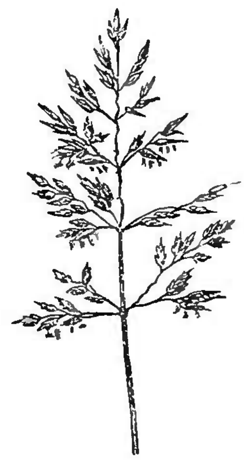


Fig. 293.—Evergreen meadow-grass (*Poa nemoralis sempervirens*).

Poa aquatica.

(Water Meadow-grass.)

Fr. *Paturin aquatique.* Ger. *Wasser Rispengras.*

Rootstock perennial, creeping and stoloniferous. Stems erect, smooth, and very stout. Leaves broad, rough, and with prominent ribs; ligule short and truncate; sheath smooth. Panicle spreading, with many branches. Spikelets many-flowered, oblong and compressed. Empty glumes unequal and short. Flowering glumes short, broad, and with prominent nerves. Flowers July and August. Grows in wet places throughout Europe, Siberia, and North America.

Poa aquatica grows luxuriantly in the Fen counties, where it forms a rich pasturage in the summer, and constitutes the chief winter fodder. In districts which are wholly or partially flooded, it is entitled to increased attention. It may be cut three or four times a-year, and produces an immense quantity of herbage on soils which will not grow other grasses. The seed is generally scarce.

VARIETIES OF CLOVERS.

The clovers belong to the natural order *Leguminosæ*, genus *Trifolium*. The generic name is evidently derived from the triple leaves of the plants.

The following are the usually cultivated forms of *Trifolium* :—

Systematic Name.	Common Name.	Colour of Flower-head.
T. incarnatum	"Trifolium"	Crimson.
T. pratense .	Meadow clover	Red or purple.
T. hybridum	Alsike	Pink and white.
T. repens	Dutch clover	White.
T. minus	Suckling clover .	Yellow.

Importance of the Clovers.—This tribe includes, therefore, the most valuable herbage plants adapted to European agriculture—the white and red clovers. Notwithstanding what has been said of the superiority of *lucerne*, and of the excellence of *sainfoin* in forage and hay, the red clover for mowing, and the white for pasturage, excel, and probably ever will, all other plants.

Soils and Climate for Clovers.—The *soil* best adapted for red clover, *Trifolium pratense*, is deep sandy loam, which is favourable to its roots; but it will grow in any soil, provided it be dry. Marl, lime, or chalk promotes its growth. The *climate* most congenial to it is neither hot, dry, nor cold. Clover produces most seed in a dry soil and warm temperature; but as the production of seed is only in some situations an object of the farmer's attention, a season rather moist, provided it be warm, affords the most bulky crop of herbage.

Clover Seed.—Red-clover seed is imported into Britain from America, Germany, Holland, France, and even Italy, where it is raised as an article of commerce. What has been obtained from the last two countries has been found often too tender to stand an English winter. In Switzerland, clover seed is prepared for sowing by steeping in water or oil, and mixing it with powdered gypsum, as a preventive to the attacks of insects.

Perennial Red Clover.—The perennial red variety — *Trifolium pratense perenne*, or cow-grass — bears a great resemblance to the biennial in its general habits and appearance, and is thus accurately described in 'Permanent and Temporary Pastures,' Sutton, 2d edition, pp. 68, 69.

"*Trifolium pratense perenne* differs from broad clover in having a somewhat taller, smoother, and, except in its very young state, a less hairy stem, and a stronger, less fibrous, and more penetrating root. It carries its flowers some way above the foliage, surpasses broad clover in succulence and weight of crop, and stands frosts much better.

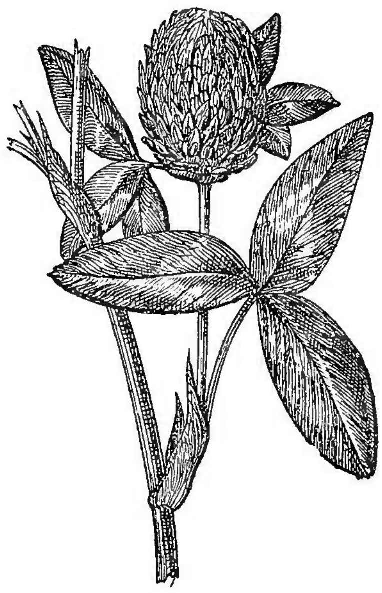


Fig. 294.—Perennial red clover (*Trifolium pratense perenne*).

"The root of perennial red clover reaches down into the subsoil, enabling it to obtain moisture and nourishment in the hottest weather, when red clover gives up from drought. This penetrating habit also affords a means of sustenance to the plant on land which is too poor to grow broad clover, and makes it desirable to increase the proportion of this seed for pastures on thin uplands.

"Perennial red clover has two characteristics which greatly augment its value: it does not begin to flower until at least ten days later than broad clover, and its more robust and solid stems remain succulent and eatable by stock long after broad clover has become pithy and withered. Perennial red clover fills up the gap between the first and second cuttings of broad clover, coming into use at a time when there is no other available green food for the horses of the farm, but it rarely gives a second crop of any consequence.

"Cow-grass produces comparatively little seed from its single crop; whereas red clover yields a good crop of seed from the second cutting, after the first has been taken as fodder. For these reasons, seed of the perennial variety is necessarily high in price."

Sinclair says, in his 'Hortus Graminens Woburnensis': "In the fertile grazing lands between Wainfleet and Skeg-

Fig. 295.—Red or broad clover (*Trifolium pratense*).

ness in Lincolnshire, this true perennial red clover (*Trifolium pratense perenne*) is abundant. . . Last summer, when examining the rich grazing lands in Lincolnshire, I found this plant to be more prevalent than any other species of clover. The natural appearance of this plant in these celebrated pastures is such as to recommend it strongly for cultivation. It being strictly perennial, and the root only slightly creeping, it may be used for the alternate husbandry, for which the *Trifolium medium* is inadmissible on account of its creeping roots, constituting what, in arable lands, is termed *twitch*. The nutritive powers of this species are superior to those of the *Trifolium medium*. . It thrives better when combined with other grasses than when cultivated by itself; but this, indeed, is also the case with all the valuable grasses. The slightly creeping root remains permanent in the experimental garden, while the roots of the common broad-leaved clover have almost disappeared in the third season from sowing. For permanent pasture, therefore, this variety (*Trifolium pratense perenne*) is the only proper one to cultivate."

Meadow Trefoil.—*Trifolium medium*—meadow trefoil—is often confounded with perennial red clover, otherwise so worthless a weed would never have been recommended as a valuable constituent for our permanent pastures on light soils, where it never fails, by its obtrusive character, to destroy the more valuable pasture-plants around it. Sinclair owns that "the *Trifolium medium* is inadmissible in alternate husbandry, on account

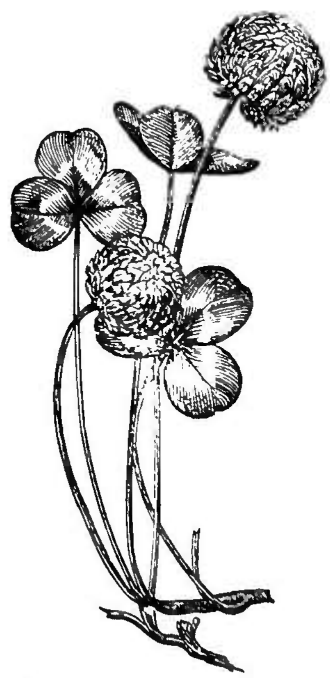


Fig. 296. Perennial white clover (*Trifolium repens perenne*).

of its creeping roots, constituting what, in arable lands, is termed *twitch;*" and the twitch is most abundant, and therefore most troublesome, in light soils, not only in arable fields, but in pasture, where it usurps the place of better plants.

Creeping Trefoil.—*Trifolium repens*—creeping trefoil, Dutch white, or sheep's clover — is indispensable for low-lying pastures, and is, indeed, better adapted to pastures than to meadows. Curtis affirms that a single seedling covered more than a square yard of ground in one summer.

White Clover.—White clover is sometimes called shamrock, but it is not the true Irish shamrock. In the eastern counties it is called white suckling, which fact causes it to be confounded with *Trifolium minus*—yellow suckling, which latter plant in Norfolk and Suffolk, singularly enough, is invariably called red suckling.

Alsike Clover.—*Trifolium hybridum*—hybrid trefoil, Alsike clover—is a species possessing the properties of the red and white clovers, and was considered by Linnæus a hybrid between them. It

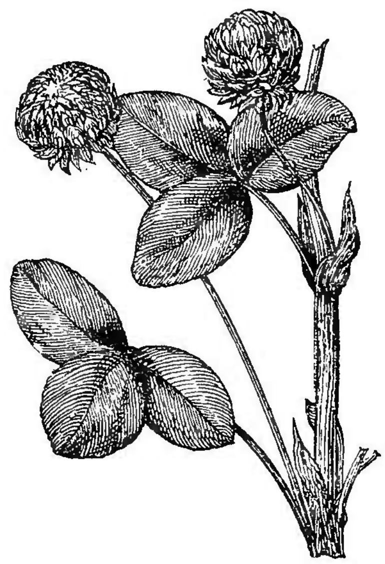


Fig. 297.—Alsike clover (*Trifolium hybridum*).

is a native of the south of Europe, but has been introduced into the agriculture of Germany and Sweden, where it is cultivated to considerable extent in the district of Alsike. Its average duration is three years, it resists cold well, it thrives in moist lands and under irrigation, but is susceptible to drought.

Trifolium incarnatum.—*Trifolium incarnatum*, a most beautiful dark crimson-flowered clover; makes good food for cattle, and grown with winter barley, or sown alone on wheat stubbles in August, it makes excellent fodder for sheep in the month of May. It is strictly an annual, and can never be sown without risk north of the Humber. There are now in cultivation four distinct varieties — *T. incarnatum*, *T. incarnatum tardum*, *T. incarnatum tardissimum Suttoni*, and *T. tardissimum album*.

By sowing all these varieties at the same time in the autumn, the period during which Trifolium can be fed or cut, the following summer will be extended to at least a month. Whereas, when the early Trifolium is sown alone, it has to be all consumed in about a week, to prevent its getting pithy and worthless.

Trifolium minus—yellow suckling—is often confounded with *Medicago lupulina*, yellow or hop trefoil. Suckling,

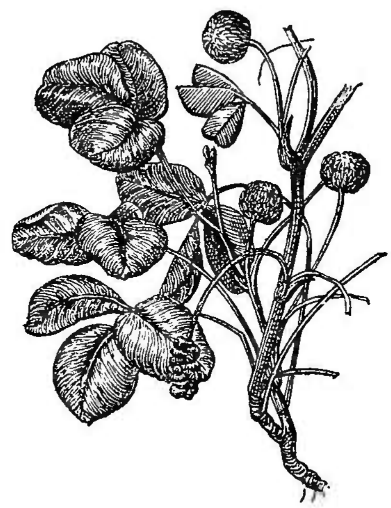


Fig. 298.—Common yellow clover or trefoil (*Medicago lupulina*).

however, is much harder, and more wiry in the stem, darker in the foliage, and has paler flowers than the *Medicago*. Although an annual or biennial, it is much more suited for permanent pastures than trefoil is, and is equally at home on dry soils and strong land.

Medicago lupulina.—Although not a *Trifolium*, no account of the agricultural clovers would be complete without reference to this plant, commonly known under the names of trefoil, black medic, or hop clover. This is the earliest of all the clovers to come to maturity in spring. On calcareous soils it is invaluable.

These are all the species of clover that seem to deserve special notice, out of 166 described by botanists.[1]

Impurities in Clover.—The most frequently occurring impurities in samples of clover seed are the seeds of dodder, plantain, sorrel, dock, cranesbill, wild carrot, self-heal, corn bluebottle, chickweed, chamomile, and scorpion grass.

Varieties of Grasses sown.—For one year's lea it has been usual for them to consist only of red clover, *Trifolium pratense;* white clover, *Trifolium repens;* rye-grass, *Lolium perenne;* Italian rye-grass, *Lolium Italicum;* and, on light soils, the yellow clover, *Medicago lupulina.* These, in common parlance, are called the *artificial grasses*, because they are sown every year like any other crop of the farm, and are of temporary existence.

But of late it has been found very desirable to include other strong growing perennial varieties, such as cocksfoot and Timothy, even where the mixture is to remain down but one season, and they are still more indispensable for 2, 3, 4, or 6 years' leas. The quantities sown vary but little over the country. The seeds are proportioned according as the grasses are to remain for one year or longer.

Seeds for Rotation Grasses.

Every county and district has peculiarities of climate and soil, which should be taken into consideration when deciding upon the exact varieties and proportions of the grasses and clovers sown. But the following mixtures will generally be found a useful standard to work by.

For *One Year's Lea.*—Where clovers are to be sown alone, 16 lb. should be sown per acre, in the following proportions:—

	lb.
Trefoil	5
White clover	1½
Alsike	2
Red clover	6½
Suckling	1

At a cost of about 12s. per acre.

Where rye-grass is the only grass used, 20 lb. in all should be sown, and the following will be found a desirable prescription:—

	lb.
Rye-grass .	8
Red clover	8
Trefoil	3
White clover	½
Suckling	½

Costing about 12s. 6d. per acre.

But a far better prescription (20 lb. in all), and one costing no more, is the following:—

	lb.
Cocksfoot .	½
Rye-grass .	4½
Italian rye-grass	3
White clover	1
Red clover	4½
Suckling	½
Alsike	1
Trefoil	4
Timothy	1

Two Years' Lea.—When a lea has to remain down for two seasons, a slightly heavier seeding is required, and 24 lb. in all should be sown. The following is an extremely useful prescription:—

	lb.
Cocksfoot .	2
Rye-grass .	6
Italian rye-grass	4
Timothy	3
Red clover	2½
Alsike	3
Trefoil	2½
Suckling	1

This will cost about 14s. 6d. per acre, but must not be depended upon for more than two years.

For 3 *or* 4 *Years' Lea* other valuable grasses, like foxtail, meadow fescue, and lucerne, may be included with advantage; 32 lb. should be sown per acre, made up as follows:—

	lb.
Foxtail	1
Cocksfoot .	2
Meadow fescue .	1
Rye-grass .	12
Italian rye-grass	4
Timothy	2½
White clover	2
Cow-grass	3
Alsike	1
Suckling	1
Lucerne	1½
Trefoil	1

Costing about 20s. per acre.

For 5, 6, *or* 7 *Years' Lea*, from 36 lb. to 40 lb. of seed should be sown per acre, and may consist of the following:—

[1] Don's *Gen. Sys. Garden. Bot.*, ii.—"Legumen."

	lb.
Perennial rye-grass	12
Italian rye-grass	8
Foxtail	1
Meadow fescue .	2
Hard fescue . .	3
Smooth-stalked meadow-grass	2
Cocksfoot .	2
Timothy	2
Cow-grass	1½
White clover	1½
Suckling	1
Lucerne	½
Trefoil	2½
Alsike	1

At a cost which need not exceed that of the foregoing mixture.

The process of sowing these temporary mixtures is so identical with that practised in the sowing of permanent grasses, that the whole subject may be treated under one head.

Grasses and Clovers for Permanent Pasture.

In Great Britain the laying down of land to permanent pasture steadily increased during the twelve years up till 1888, when the area under permanent grass amounted to considerably more than one-half of the cultivated land of the United Kingdom. With the decline in the price of wheat there is every reason to believe that the area of permanent pasture will continue to increase. Still, soil and climatic influences must determine in a great measure the extent of arable land that can with profit be converted into permanent pasture. Districts like the eastern and southern parts of England, being dry, are better adapted for corn than grass, and a glance at the returns for the various counties will show that the proportion of land under grass is smallest where the rainfall is lightest. In the western and northern districts, where the rainfall is heavy and strong lands abound, the summer is colder, and thus grass preponderates.

Permanent seeds like lea mixtures are generally sown in corn, and a wheat plant is perhaps best for this purpose, though oats and barley are much more commonly chosen.

Grasses for different Soils.—It is impossible to give exact advice as to the kinds and quantities of grasses and clovers required, in consequence of the extreme diversity of the soils of the country, but the following table will help greatly to determine which varieties are most suitable for any particular soil under consideration. An ample seeding per acre is 28 lb. of the larger grasses and 12 lb. of clovers, &c.; and nearly all prescriptions include the following varieties:—

Grasses.	Especially suitable for—
Agrostis stolonifera (fiorin) .	Heavy and alluvial soils.
Alopecurus pratensis (meadow foxtail)	Rich deep soils.
Anthoxanthum odoratum (sweet vernal)	Medium and light soils.
Avena elatior (tall oat-grass) .	All soils.
Avena flavescens (yellow oat-grass)	Dry and calcareous soils.
Cynosurus cristatus (crested dogstail)	Medium and light soils.
Dactylis glomerata (rough cocksfoot)	All soils.
Festuca duriuscula (hard fescue)	Medium, light, and thin soils.
Festuca elatior (tall fescue)	Deep heavy soils, and clays.
Festuca heterophylla (various-leaved fescue)	Rich deep soils.
Festuca ovina (sheep's fescue)	Calcareous and thin soils.
Festuca pratensis (meadow fescue)	Medium and heavy soils.
Lolium perenne (perennial rye-grass)	All soils.
Phleum pratense (timothy grass)	Deep heavy soils, clays, and alluvial.
Poa nemoralis (wood meadow-grass)	Rich medium soils.
Poa pratensis (smooth meadow-grass)	Light thin soils.
Poa trivialis (rough meadow-grass)	Rich, heavy, and alluvial soils.

Standard Seed Mixtures.—The following prescriptions may be considered very safe standards:—

Good Loamy Soil.

	lb.
Foxtail .	2½
Sweet vernal	½
Cocksfoot .	4
Meadow fescue	3½
Various-leaved fescue	1
Sheep's fescue	1½
Hard fescue	3
Red fescue	2
Perennial rye-grass	9
Smooth-stalked meadow-grass	½
Rough-stalked meadow-grass	1
Wood meadow-grass	½
Dogstail	½
Timothy	2½

Lucerne	1
White clover	2½
Cow-grass	2
Alsike	1½
Suckling	½
Yarrow	¼

Costing about 35s. per acre.

Gravelly Soil.

	lb.
Fiorin	½
Golden oat-grass	½
Sweet vernal	½
Cocksfoot	2
Meadow fescue	2
Various-leaved fescue	½
Sheep's fescue	1½
Red fescue	3
Hard fescue	3½
Perennial rye-grass	9
Smooth stalked meadow-grass	3½
Wood meadow-grass	1½
Dogstail	1½
Timothy	1
Lucerne	1
White clover	2
Cow-grass	2
Trefoil .	1
Suckling	3
Yarrow	¼
Lotus corniculatus	¼

Costing about 32s. per acre.

Clay Soil.

	lb.
Fiorin	2
Foxtail	4
Cocksfoot	4
Meadow fescue	3
Tall fescue	1
Various-leaved fescue	2
Hard fescue	1½
Perennial rye-grass	9
Rough-stalked meadow-grass	1½
Timothy	4
White clover	1
Cow-grass	2½
Alsike	3
Trefoil .	1½

Costing about 36s. per acre.

Peaty Soil.

	lb.
Foxtail	2
Agrostis	4
Cocksfoot	2½
Tall fescue	1
Meadow fescue	4½
Water meadow-grass	1
Smooth-stalked meadow-grass	2½
Rough-stalked meadow-grass	1½
Timothy	3½
Perennial rye-grass	9
Trefoil	3½
Alsike .	1½
White clover	1½
Cow-grass .	2

Costing about 34s. per acre.

Mr De Laune's Mixtures.

In the description of rye-grass reference will be found to the objections raised by Mr Faunce de Laune to the inclusion of rye-grass in seed mixtures for permanent pastures. Although, as indicated there, good reason has been shown why farmers should still put faith in rye-grass, it may nevertheless be of interest to produce here the particular mixtures of seeds recommended by Mr De Laune for the formation of permanent pastures on different soils. They are as follows: [1]—

	Good or Medium Soils. lb. per acre.	Wet Soils. lb. per acre.	Chalky Soil. lb. per acre.
Foxtail	10	4	...
Cocksfoot	7	10	14
Catstail	3	3	3
Meadow fescue	6	3	2
Tall fescue .	3	8	...
Crested dogstail	2	2	5
Rough meadow-grass	1½	2	...
Hard fescue .	1	1	4
Sheep's fescue	1	...	4
Fiorin	1½	2	...
Yarrow	1	1	2
Golden oat-grass	...	...	1
Perennial red clover	1	1	1
Cow-grass	1	1	...
Alsike	1	1	1
Dutch clover	1	1	1
Total lb.	41	40	38

As the germination of the seed and the equal distribution of the plant depend upon the accuracy of the process, the details of sowing should be carried out with due regard to the serious loss which failure certainly entails.

Time of Sowing.—The best time for sowing depends much upon the weather, and no hard-and-fast period can be named. April may be properly regarded as a safe and favourable month in which to sow; but if the seed-bed is ready, and the land in working order by the middle of March, there need be no scruple as to putting in the seed. Sowing before is better than immediately after a shower, even supposing the land can be worked soon after rainfall. The seeds sown before rain gradually absorb moisture from the soil and dew until wet weather

[1] *Jour. Royal Agric. Soc. Eng.*, xviii., sec. ser., part 1.

sets in, and then the plants spring up with great rapidity. To sow later than the middle of May is most hazardous.

Methods of Sowing.—Grass seeds are sown by hand and with machines. The hand-sowing is confined mainly to small farms, while on moderate and large farms the machine is almost universally used.

Hand - sowing.—Sowing grass seeds by hand is a simple process, although it requires dexterity to do it well.

Clover and rye-grass seeds are so different in form and weight, that they should never be sown at one cast. The sower has little control over the grass seed, the least breath of wind taking it wherever it may. His sole object is to cast the seeds equally over the surface, and, as they cannot be seen to alight on the ground, he must preserve the strictest regularity in his motions. Being small and heavy, the clovers, even in windy weather, may be cast with tolerable precision. It is pleasant work to sow grass seeds by the hand. The load is comparatively light, and the ground having been harrowed fine, and perhaps rolled smooth, the walking is easy.

Machine - sowing. — But now the grass-seed broadcast sowing-machine, fig. 260, has superseded the necessity of hand-sowing on most farms. This is a most perfect machine for sowing grass seeds, distributing them with the utmost precision, and to any amount, and so near the ground that the wind affects but little even the lightest grass seed. Its management is easy when the ground is ploughed in ordinary ridges. The horse starts from one head-ridge, and walks in the open furrow to the other, while the machine is sowing half the ridge on each side, the driver walking in the furrow behind the machine, using double reins. On reaching the other head-ridge, the gearing is put out of action till the horse, on being *hied*, enters the next open furrow from the head-ridge; and on the gearing being again put on, the half of a former ridge is sown, completing it with the half of a new one by the time the horse reaches the head-ridge he started from. Thus 2 half-ridges after 2 half-ridges are sown until the field is all covered.

The seed is supplied from the head-ridge, upon which the sacks containing it were set down when brought from the steading.

The head-ridges are sown by themselves. But the half of the ridge next the fence on each side of the field cannot be reached by the machine, and must be sown by hand.

When ridges are coupled together, the horse walks along the middle between the crown and open furrow, the furrow-brow being the guide for one end of the machine, and 2 ridges are thus sown at every bout. Where ridges are ploughed

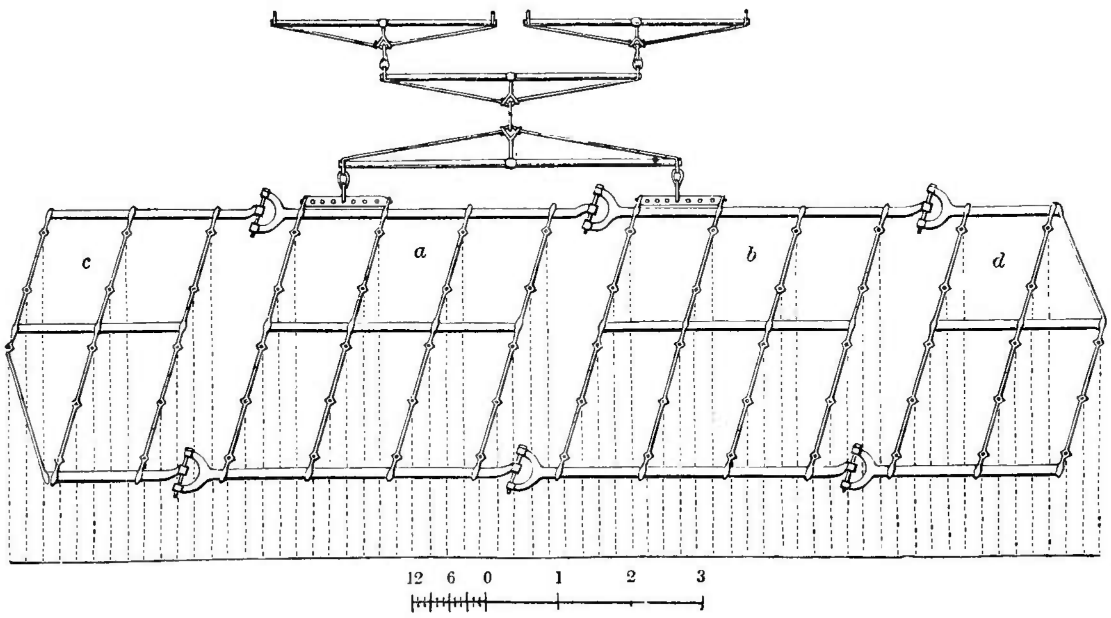


Fig. 299.—*Grass-seed iron harrows, with wings and swing-trees.*
a b Main leaves of the harrows. *c d* The 2 wings.

in breaks of 4 ridges in width, the furrow-brow is the guide in going and the crown in returning, while sowing 2 of the ridges; and the crown in going and the furrow-brow in returning, while sowing the other 2 ridges.

Speed of the Sowing-machine.—Were this machine to sow without interruption for 10 hours, at the rate of 2½ miles per hour, it would sow about 45 acres of ground; but the turnings at the landings, and the time spent in filling the seed-box with seed, cause a large deduction from that extent.

Grass-seed Harrows.—After the grass seeds are sown, the ground is harrowed to cover them in. For this purpose lighter harrows are better than the ordinary, which would bury clover seeds too deeply in the ground. These light harrows are arranged (with wings) to cover a large breadth at a time, so that the sowing of grass seeds is a speedy process. Fig. 299 is grass-seed harrows, with wings, covering a ridge of 15 feet wide at one stretch. The harrows have

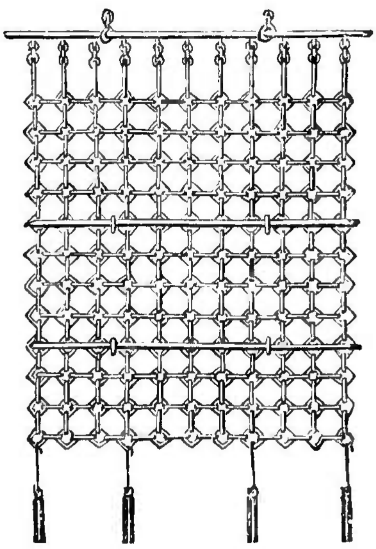


Fig. 300.—*Chain harrows.*

a set of iron swing-trees. Modern English harrows well suited for covering grass seeds are shown in fig. 300, made by Woodrooffe & Co., Rugeley.

Working wide Harrows.—Some dexterity is required to drive these wide grass-seed harrows. They should not be moved from one ridge to the adjoining, as part of the implement would then have to turn upon a pivot, which might wrench off a wing. Besides, it is inconvenient to *hup* the horses with these harrows. To avoid the inconvenience is to *hie* the horses at the end of the landings, round an intermediate unharrowed ridge.

Harrow Carriage.—Fig. 301 is a convenient and safe form of carriage for conveying harrows. This is much better for the purpose than the ordinary cart.

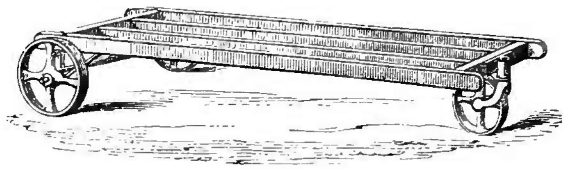


Fig. 301.—*Carriage for conveying harrows, &c.*

It consists of a frame of wood sparred in length to take on a pair of harrows coupled with their master-tree, and in breadth 3½ feet. The hind part of the frame rests on crutches supported upon the axle of 2 wheels, the upper part of the rim of which is below the top part of the frame; and the fore part rests upon a castor, which allows the carriage to be turned when desired. A horse, to draw the carriage, is yoked to 2 eyes of the fore-bar of the frame by the hooks of the plough-chains. The harrows are piled one above the other on the framing. Such a carriage may convey other articles to and from the fields.

Rolling for Grass Seeds.—The importance of thorough rolling in sowing grass seeds is not fully realised by the general body of farmers. It is of great moment that the small seeds should have an even firm bed, and this can best be secured by rolling, which also helps to retain the moisture in the soil, a matter of great importance in dry soils.

Rough land, if dry enough, should therefore be rolled before the grass seeds are sown. The rolling will reduce the clods before they become hard, and give a kindly bed to the small seeds. If the land is naturally dry, the roller is the more required to consolidate it after the winter's frosts. On light loams and turnip soils, the roller is often with advantage used, both before and after sowing, the ground getting a turn of light harrows after receiving the seed.

When strong land is in a waxy state, between wet and dry, the rolling had better be deferred, while sowing the grass seeds may proceed, if the season, or state of the crop amongst which the grass seeds are to be sown, is already sufficiently advanced.

Crops accompanying Grass Seeds.—The cereal crops, amongst which grass seeds are sown, are winter wheat, spring wheat, oats, and barley. Wheat on bare-fallow clay sometimes grows so strong as to injure the young plants of grasses before it is reaped, but in lighter soils they are always safely sown amongst it. There is little fear of spring wheat attaining to such growth as to injure the grasses amongst it. Oats are the usual vehicle by which to introduce grass seeds to the ground. Remaining but a short time on the ground, they permit young grass plants to grow considerably before winter, and become able to withstand the vicissitudes of that season. Barley, in some seasons, grows rank and thick, so as to endanger the existence of the grasses. Barley, treated as oats, receives grass seeds in the same way; but for some reason or other, grasses do not thrive so well with barley as with oats.

Unless the winter wheat is too forward, the latter end of March will be the best time to put the grasses in. If the plant is strong, the common harrows will be required to obtain a hold of the ground; if weak, and the ground tender, the grass-seed harrows will be better.

Harrowing the Wheat-braird.—Winter wheat will be all the better for a harrowing in spring, even although some of the plants should be torn up by the tines, as it loosens the ground compressed by the rains, and admits the air to the roots of the plants. After such a harrowing, rolling will press the weak plants into fresh earth, and induce an immediate tillering from the roots; but should the plants have grown rank, the rolling should be dispensed with, in case of bruising the stems. The difference between bruising and bending the stems of wheat by rolling should be considered, so that rolling be done or left undone. A cereal crop, on a rolled surface, affords great facility for being reaped at harvest.

Many farmers sow grass seeds without harrowing them in, trusting that they may find their way into the soil amongst the clods, and be covered by their mouldering. But the safe and correct practice is to cover every kind of seed when sown.

Sowing with Spring Crops.—Although double-harrowing across prepares the land on which spring wheat is sown for the grass seeds, these are not sown whenever the wheat is sown. The wheat may be sown any time during winter or early spring, when the state of the weather and soil permit. But when wheat is sown at the latest period, the grass seeds should not only be sown then, but also amongst the spring wheat previously shown; as also amongst the winter wheat, should there be any in the same field.

It is worthy of consideration, in fields in which wheat has been sown at different times, that the latest sown should first be sown with grass seeds, then the next latest, and so on to the winter wheat. The reason for this is that it is desirable to finish the land most recently worked, in case the weather should change, and prevent the finishing of the grass seeds over the whole field.

Frost Injuring Clover Seeds.—Frost injures clover seeds, and will even kill them when exposed to it, so they cannot safely be sown very early in spring, nor left without harrowing. But they run little risk of damage from frost in March when harrowed in, which is best done with the grass-seed harrows, the roller of course following.

If rolling the grass seeds amongst the corn cannot be done at the time of sowing on account of the raw state of the land, it should be done as soon as the state of the ground will permit, as it is of vast importance to have a firm bed for the grass seeds and a smooth surface in reaping the crop.

GERMINATION OF SEEDS.

It will be interesting at this stage to contemplate the phenomena by which the seeds we have sown germinate and produce plants.

The healthy seed of a plant is a living object. Though apparently lifeless to the sight and touch, it possesses the germ of life, and its vitality is capable of exerting great force when excited into action. What excites the vitality of seeds, we do not know, perhaps never shall—it is a secret which Nature has hitherto kept to herself; but we do know the circumstances in which seeds must be placed in order that they may begin to grow or germinate. The proof of the excitement is in their germination, which is the first movement towards the production of a plant.

Conditions essential for Germination.—Now, the circumstances which excite germination are the combined action of air, heat, and moisture. These must all be afforded in favourable conditions, before the seed will germinate and the plant grow satisfactorily. They may all be supplied to the seed, and its germination secured in the air as certainly as in the soil; but on the development of a root, most plants would die if kept constantly in the air. The soil supplies all the requisites of air, heat, and moisture to the seed in a better state than the atmosphere could alone; and it continues to supply them not only for the germination of the seed, but also for the support of the plant, during its entire life.

A vital seed placed in the soil is affected by three agencies—1, physical; 2, chemical; and 3, physiological—before it can produce a plant.

Air and Germination.—When a vital seed is placed in pulverised ground, it is *physically* surrounded with air; for although the particles of soil may seem to the eye to be close together, on examination it has been found that the interstices between the particles occupy about ¼ of a given volume of soil. Hence, 100 cubic inches of pulverised soil contain about 25 cubic inches of air. Therefore, in a field the soil of which has been ploughed and pulverised, and cleared of large stones, to the depth of 8 inches, 1 acre of it may contain about 12,545,280 cubic inches of air; and hence also, as every additional inch of depth pulverised calls into activity some 260 tons of soil, at 1.48 of specific gravity, so the ploughing up of another inch of soil not before stirred and not hitherto containing any air, introduces into the workable soil an addition of perhaps nearly 1½ million cubic inches of air. Thus, by increasing the depth of pulverised soil, we can provide a depot of air to any extent for the use of plants. It should be noted that it is the oxygen of the air that is of chief importance in germination.

But this air must be above a certain temperature ere the seed will germinate—it must be above the freezing-point, else the vitality of the seed will remain dormant. It is also desirable that the soil should be well pulverised, and not as in fig. 302, where a seed is placed

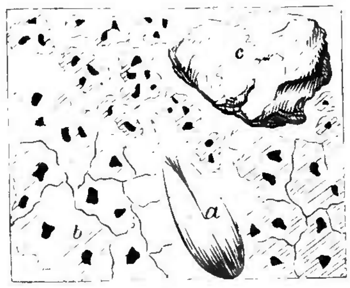


Fig. 302.—*Cloddy and stony soil.*
a The seed. *b* Hard clods. *c* A stone.

among hard clods on the one side, and near a stone on the other, conditions not likely to favour the development of strong regular plants.

Moisture and Germination.—Fig. 303 represents the seed placed in a pulverised soil, the interstices of which are entirely occupied by water instead of air,

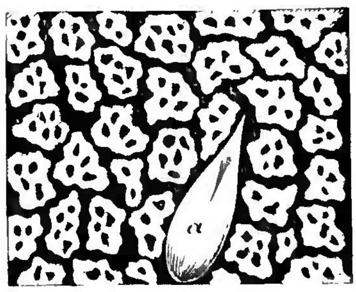


Fig. 303.—*Soil with water and without air.*
a The seed.
White spaces—pulverised soil. Black spaces—water.

as well as the interior of all the pulverised particles of it. It is clear that, in this case too, the seed, being deprived of air, is not placed in the most favourable circumstances for germination. Besides the direct exclusion of the air, the water, on evaporation, renders the earth around each seed much colder than it would otherwise be.

But total want of moisture prevents germination as much as excess. Fig. 304

shows the seed placed in pulverised soil, and the interstices filled with air, with no moisture present between or in the particles of soil. In such a state of soil,

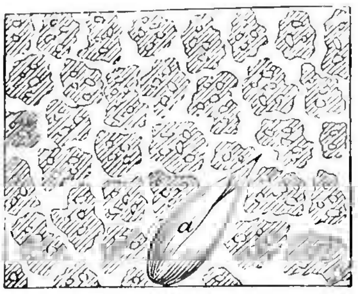


Fig. 304.—*Soil with air and without water.*
a The seed.
White spaces—air and heat.
Dark spaces—dry pulverised soil full of air.

heat will find an easy access to the seed, and as easy an escape from it.

Fig. 305 represents the seed in soil completely pulverised. Between every particle of the soil the air finds easy access to the seed, and in the heart of every particle of soil moisture is lodged. All that is here required in addition is a

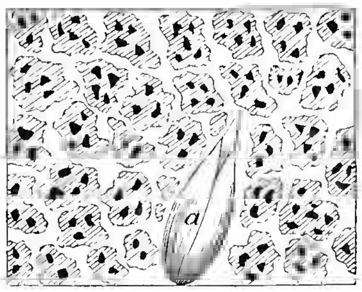


Fig. 305.—*Soil with water and with air.*
a The seed.
White spaces—air and heat.
Dark spaces—pulverised soil with darker water.

favourable temperature, which the season supplies, and germination proceeds.

Composition of Seeds.—The *chemical* composition of seeds consists of organic and inorganic substances. The organic are composed of 2 classes of substances, the nitrogenous and the non-nitrogenous; the inorganic, of earthy, alkaline, and acid ingredients. The nitrogenous substances consist of matter analogous to the caseine of milk, albumen of the egg and of blood, and of the fibrine of the flesh of animals; the non-nitrogenous consist of starch and mucilage, and of fatty and oily matters rich in carbon and hydrogen.

Changes incident to Germination.—When a seed is consigned to the ground, the first change which takes place in it is physical—it becomes increased in bulk by the absorption of moisture; and being also surrounded by air, it only requires the requisite degree of temperature to excite its vitality into action. If there is no moisture present, as in fig. 304, it will remain in a state of dormancy until moisture arrive, and in the meantime may become the prey of the many animals which inhabit the soil, eager for food, or be scorched to death by heat. If it is placed in excess of moisture, as in fig. 303, its germination is prevented by the exclusion of the air and its tissues are destroyed by maceration in the water.

When the seed begins to germinate, a substance named *diastase* is formed at the expense of its albumen. The function of diastase is important. It is to convert the insoluble starch of the seed into soluble dextrine and sugar; to effect which change it seems to possess extraordinary power, as one part of diastase will convert into sugar no less than 2000 parts of starch. The diastase converts the starch which it finds into a useful state for the support of the first efforts of vegetation, and after having performed this important function, it disappears.

The Embryo.—"Under fitting circumstances," says Lindley, "the embryo which the seed contains swells, and bursts through its integuments; it then lengthens, first in a direction downwards, next in an upward direction, thus forming a centre or axis round which other parts are ultimately formed. No known power can overcome this tendency, on the part of the embryo, to elevate one portion in the air, and to bury the other in the earth; but it is an inherent property with which nature has endowed seeds in order to ensure the young parts, when first called into life, each finding itself in the situation most suitable to its existence—that is to say, the root in the earth, the stem in the air."

The Young Plant.—When the germ has shot out from the seed, it is found to be possessed of a sweet taste, which is owing to the presence of grape-sugar in the sap which has already begun to circulate through its vessels. There is little doubt that the grape-sugar is formed sub sequently to the appearance of both diastase and acetic acid.[1]

Seed dissected.—A seed, considered *physiologically* in reference to its organisation, consists of an embryo, which includes the germs of the root and of the stem, and of a cotyledon or cotyledons. Fig. 306 represents a grain of wheat magnified, and so dissected as to show its component parts. It consists of two skins, an outer and an inner. The inner skin is also where the nutritive matters, called the starch and albumen, are situate. There is the little scale or cotyledon through which the nutritive matter passes in the sweet state, when the grain is germinating, and by which it is rendered most fit for the nourishment of the little plant; and there is the rudimentary plant, from the base of which roots or stems, or both, will afterwards proceed. All these parts are essential to the growth of the seed. If any one is absent the seed will fail to germinate.

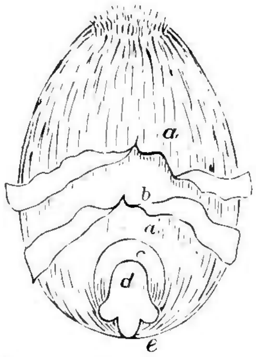


Fig. 306.—*Component parts of a grain of wheat.*

a a Outer skin.
b Inner skin.
c Scale or cotyledon.
d Rudimentary plant.
e Where nutritive matter, scale, and rudimentary plant unite.

Multiple Stems or "Tillering."—The seeds of most species of plants possess such a structure as that only 1 stem can proceed from them; but in many agricultural plants, particularly in the cereals, which yield human food, a remarkable departure from this structure is observed. In them the embryo plant is usually thickened towards its base, and is so organised that, instead of 1 stem, 3 or 4 may spring from 1 grain.

The peculiarity mentioned may be observed in fig. 307, where the rudimentary plant has 3 projections in the lower part, while in other kinds of seed there would have been only 1; and from each of these 3 projections a rootlet or a stem, or both, proceed when the grain is placed in the soil. The figure represents such a grain in a state of germination, one shoot having left the sheath, another just evolved, and a third

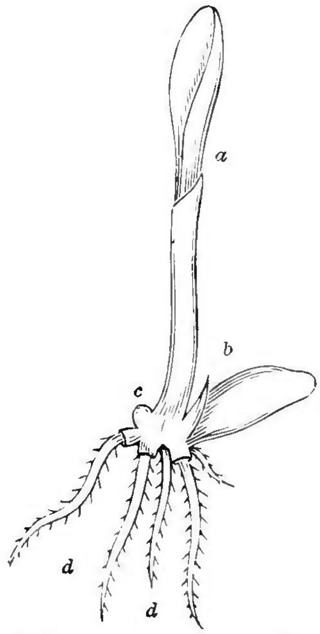


Fig. 307.—*Wheat plant in the state of germination.*

a Shoot leaving the sheath. *b* Another shoot just evolved. *c* Shoot yet unevolved. *d d* Rootlets.

remains unevolved, while the rootlets are seen extending downwards.

Different Methods of Sowing and Germination.

Disadvantage of Broadcast Sowing.—Of all the modes of sowing seeds, none requires so much seed as the *broadcast.* However regularly the land may have been ploughed, seed sown broadcast will braird irregularly—some falling into the lowest part, some upon the highest, some scarcely covered with earth by the harrows, some buried as deep as the ruts of tines have penetrated. To make the land smooth by harrowing, previous to sowing the seed, would not cure irregular covering, since it is impossible to cover a

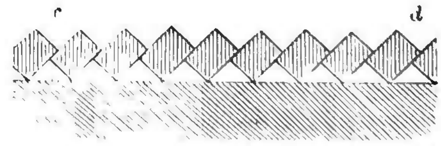


Fig. 308.—*Well-ploughed regular furrow-slices.*

c to *d* Regularly ploughed furrow-slices.

large seed as that of the cereals with tines without the assistance of a rough surface of mould. In fig. 308 the furrows are well and regularly ploughed; but while

[1] Johnston's *Lect. Agric. Chem.*, 2d ed., 221-228.

it is obvious that the seeds, when scattered broadcast from the hand, will fall mostly in the hollows between the furrows, yet some will stick upon the points and sides of the furrow-slices. The seeds will thus lie in the ground, as in fig. 309, those which fell into the hollows of the furrows being thicker than the seeds which

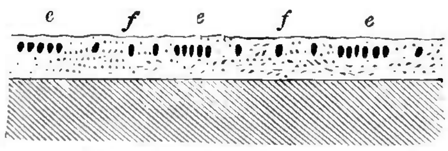


Fig. 309.—*Positions of seeds on regular furrows.*
e e e Seeds fallen in the hollows of the furrows.
f f Seeds scattered upon tops and sides of furrows.

stuck upon their tops and sides. But it is not at all likely that the seeds will be so regular as represented. Some will be too deep and others too shallow in the soil, whilst some will be left on the surface. From irregular deposition, plants will grow in irregular positions, as in fig. 310, where some are in clumps from the

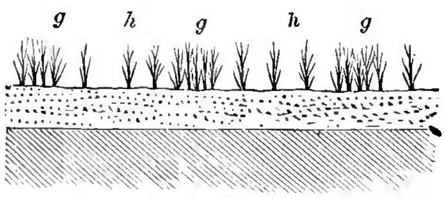


Fig. 310.—*Irregular braird upon regular furrows.*
g g g Plants growing in clumps.
h h Plants growing scattered.

bottom of the furrows, and others are straggling too far asunder. Where the seeds have been deposited at different depths, the plants will grow at more irregular heights than in the figure.

When the land is ill-ploughed, the case is still worse. Fig. 311 shows the irregular furrows from bad ploughing. Bad

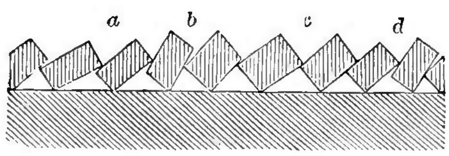


Fig. 311.—*Ill-ploughed irregular furrow-slices.*
a Furrow-slice too flat. *c* Furrow-slices too wide.
b Furrow-slice too high. *d* Furrow too deep.

ploughing entails bad consequences in any crop, but especially in cereal ones, inasmuch as irregularity of surface cannot be amended by a series of future operations, as in green crops. In the irregular furrow-slices of fig. 311, some are narrow and deep, some shallow, some too large, some of ordinary depth, and some too high and steep. The seed sown on these irregular furrows is shown in fig.

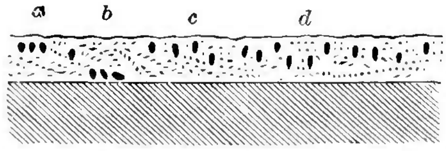


Fig. 312.—*Irregular positions of seed on ill-ploughed furrows.*
a Seed clustered and covered shallow.
b Seed clustered and buried deep.
c Sced scattered and covered shallow.
d Seed scattered and covered deep.

312, where some are clustered together with a shallow covering, others also clustered, but buried deeply, whilst many are scattered irregularly at different depths. Such a deposition of seed must make the braird come up irregularly; and the plants have not the chance of reaching maturity at the same time.

In fig. 313, where the seed was covered deeply, the plants will come up late;

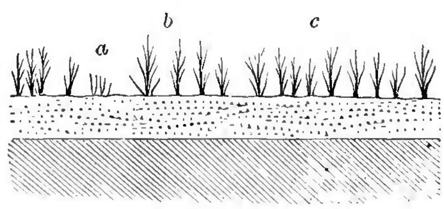


Fig. 313.—*Irregular braird on ill-ploughed furrow.*
a Late plants. *b* Early plants.
c Regular growth of plants.

with shallow covering, they will come up early, and will push on in growth; while the remainder, coming up regularly, will form the best part of the crop. Where a crop of cereals does not mature at the same time, the grain cannot be equal in the sample.

Advantages of Drill Sowing.—One obvious advantage of sowing with a *drill* over a *broadcast* machine, is the deposi-

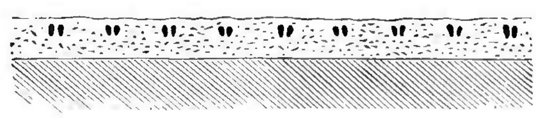


Fig. 314.—*Regular depth of seed by drill-sowing.*

tion of seed at the same depth, whatever depth may be chosen. Fig. 314 shows the seed deposited at regular intervals. The braird is shown at the same regular intervals in fig. 315, and its produce will reasonably be of the same quality. For drill sowing the land has previously received all the harrowing it requires for the crop, and by the coulter or tongue of the machine the seed is deposited regularly at a uniform depth and thickness.

Still there are many who prefer broadcast sowing, and, with careful preparation

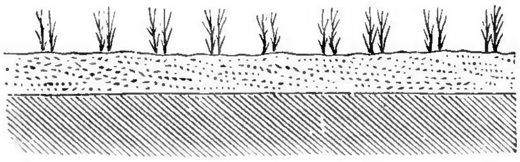


Fig. 315.—*Regular braird from drill-sown seed.*

of the seed-bed, and skilful performance of the work of sowing, it will usually give satisfactory results.

Drill sowing leaves a blank between the rows of plants, which encourages the growth of weeds. On the other hand, this system permits of hoeing after the plants are advanced considerably, and if this operation is carefully performed by hand or horse-hoe it is usually found to be beneficial to the crop.

Dibbling.—*Dibbling* is distributing seed by means of a dibble at given distances, and at a given depth in the soil. The distribution by this system may either be in rows or broadcast. The difference betwixt dibbling and drilling is, that in drilling the seed is placed in lines, while dibbling places it at uniform distances in the line. The object of dibbling is to fill the ground with plants with the smallest quantity of seed. The seed planted in lines with the dibble appears as in fig. 314, and the plants like those in fig. 315. The depth of the seed and brairding of the plants are as uniform as in drilling, but the plants stand independent of each other in dibbling.

As would be readily understood, dibbling is not suitable where any considerable extent has to be sown, but it is very useful in filling up blanks.

Waste of Seed. When sown in all these ways in equal quantities, the *waste of seed*, as determined by experiment, is surprising. *Wheat* at 63 lb. the bushel gives 87 seeds to 1 drachm, avoirdupois weight, or 865,170 to 1 bushel. Now, 3 bushels of seed sown broadcast on the acre, gives a total of 2,595,510 seeds. Suppose that each seed produces 1 stem, and every stem bears 1 ear containing the ordinary number of 32 seeds, the produce of 1 acre would be 96 bushels. How far this exceeds the usual return need hardly be stated. Rarely, indeed, have we known the produce of wheat to exceed 64 bushels on 1 acre, so that in this case 32 bushels, or 33 per cent of the seed, would be lost, while in an ordinary crop of 40 bushels the loss of seed would be 58 per cent.

The waste in *barley* seed is estimated thus: Chevalier barley at 57 lb. the bushel, and 75 grains to 1 drachm, avoirdupois weight, gives 665,242 seeds; 4 bushels of seed sown on 1 acre, gives 2,660,968 seeds; and allowing 1 stem from each seed, and 1 ear of 32 seeds, the produce would be 128 bushels! Even with an exceptional crop of 64 bushels there would be a loss of 50 per cent, while on the ordinary crop of 48 bushels the loss would be nearly 69 per cent.

In like manner the loss upon *oats* may be estimated, and will be found to be often more than one-half the quantity of seed sown.

In all these cases only 1 stem from 1 seed is reckoned, but many of the seeds produce 2 or 3 or more. The *actual* loss of produce sustained is thus not so great as of seed.

Another view of the waste of seed is this: 2,595,510 seeds of wheat on 1 acre give 536 seeds to 1 square yard; 2,660,968 seeds of barley give 550 seeds; and 5,879,808 seeds of oats give 1214. In wheat and barley the proportion of seed is in proportion to their respective weights, but in oats the seed is more than double in proportion to the weight, because of the thick husk of the oats.

Waste of Seeds by different Methods of Sowing.— P. M'Lagan of Pumpherston made experiments to ascertain the waste of seed in sowing oats in the three different ways of dibbling, drilling, and broadcast. The oats weighed 42 lb. the bushel. The dibbled holes were made 6 inches apart, and 6 inches between the rows, making 36 holes in 1 square yard, and each hole was supplied with from 1 to 4 seeds, making the quantity sown from 1 peck to 4 pecks on 1 acre; and the seeds sown drilled and broadcast were in the same proportion. In drilling and dibbling, the seed was inserted 3½ inches into the ground. The results were as follows:—

	Dibbled.	Drilled.	Broadcast.
From 36 grains sown	26 plants	32 plants	19 plants came up.
72 "	49 "	53	52 "
108 "	75 "	78	68 "
144 "	120 "	94	87 "
360	270	257	226
Percentage	.750	.714	.628

There is not much difference in the brairding of seed dibbled and drilled, which might have been expected, since the seeds were deposited much in the same position in the soil.

It is not easy to explain the disparity when so many as 144 seeds were sown, involving a loss of about 34 per cent.

The *broadcast* involves a loss beyond the others of 16⅔ per cent—an anticipated result, since many of the seeds were unburied on the surface, or buried too deeply. The seeds were sown on the 19th March, and the thickest sown of the drilled and broadcast brairded first on the 16th April. Thick-sown seeds always braird earliest.

The experiments were extended by sowing 7 pecks of oats drilled, or 252 seeds to the square yard, and from these 208 plants came up, giving a percentage of .825. There were also sowed 24 pecks to 1 acre broadcast, or 864 seeds to 1 square yard, which produced 570 plants, giving a percentage of .671, only a little more than in the former case of broadcast, .628. Thus, the smallest number of seeds gave the largest return of plants brairded.

G. W. Hay of Whiterigg, Roxburghshire, also made similar experiments at the same time, by dibbling and drilling wheat, barley, and oats, and sowing oats broadcast. The *dibbled* seeds were put into holes within 3 inches square to the number of 1, 3, and 6 grains in each hole, which gave respectively 144, 432, and 864 grains to the square yard. The seeds were sown on the 16th March, and the plants counted on the 8th May. The results were these:—

	After 144 seeds.	After 432 seeds.	After 864 seeds.	
Of Wheat	97	296	616	1009 plants came up.
Barley	95	335	687	1117 "
Hopetoun oats	129	403	800	1332 "
Potato oats	135	407	823	1365 "
Birley oats	125	413	777	1315 "
Sheriff oats	132	405	751	1288
Percentage of				
Wheat came up	.67	.69	.71	average .69
Barley	.66	.79	.79	.75
Oats	.90	.94	.91	" .92

On the 25th March similar seeds were sown in *drills* at the same rates per square yard, and the plants counted on the 8th May, when the results were:—

	After 144 seeds.	After 432 seeds.	After 864 seeds.	
Of Wheat	105	327	652	1084 plants came up.
Barley	86	318	747	1151 "
Hopetoun oats	139	408	798	1345 "
Potato oats	137	407	795	1339 "
Percentage of				
Wheat came up	.73	.73	.75	average .74
Barley	.60	.73	.86	" .73
Oats	.96	.94	.92	.94

On comparing the brairds of the drilled with the dibbled seeds in the barley and oats little difference is apparent, while the wheat incurs less loss of plants when drilled than when dibbled, in the ratio of 1009 to 1084. Comparing the results obtained by both experimenters, we find that Mr Hay obtained a braird of $^9/_{10}$ of the seed in dibbling and drilling; while Mr M'Lagan obtained only $^7/_{10}$, and, in oats broadcast, $^6/_{10}$.

Tillering.—After a lapse of ten days, on the 18th May, when rain had fallen in the interval, the plants after broadcast were counted, and were unexpectedly found greater in number than the seeds sown. The plants must have tillered after the rain, and the tillering was ascertained to be from:—

Seeds.		Plants.		Tillering.
315	Barley	360	=	one-sixth.
325	"	405	=	one-fourth.
471	Sherriff oats	930	=	double.
520	"	648	=	one-fifth.
666	Potato "	704	=	one-sixteenth.

The advanced state of the plants after the rain indicates that in spring oats tiller very strongly and rapidly.

Quantity of Seed.—Taking the respective quantities of seed sown on 1 square yard by both experimenters, they will be as follows on 1 acre:—

Seeds.			Seeds.	Per acre.
36	per square yard	=	174,240	= 1 peck.
72	"	=	348,480	= 2 "
108	"	=	522,720	= 3
144	"	=	696,960	= 1 bushel.
288	"	=	1,393,920	= 2
432	"	=	2,090,880	= 3 "
576	"	=	2,787,840	= 4
720		=	3,484,800	= 5
864	"	=	4,181,760	= 6 "

Produce from different Methods of Sowing.—Kenyon S. Parker made a comparative experiment between drilling, dibbling, and broadcasting wheat on clover lea, and the results show that drilling produced more grain than dibbling; while the straw was longer and stronger, the ears larger, and the seeds heavier in the dibbled, thus:—

	1 acre. bush.	1 acre. peck.		1 acre. qr.	1 acre. bush.	1 acre. gal.	Weight per bush. lb.
Broadcast	1	3	produced	3	7	1	62
Drilled, at 12 in.	1	2		4	3	1	63
Dibbled	1	0	"	4	3	0	63½

Importance of economising Seed.—The questions to which such results give rise are, What quantity is too thick and what too thin sowing? and, What is the least quantity of seed to yield the largest crop? The inquiry assumes much importance when we consider that from $^1/_{10}$ to $^1/_{14}$ of all the grain grown in the country is every year put into the ground as seed. A small fraction of either of these proportions saved would add a profit to the farmer to that extent. If 1 bushel of seed could be saved on each acre, a simple calculation would show that the gain to the farmer would amount to a vast sum of money.

Thick and Thin Sowing.—Thick and thin sowing of seed is a subject of controversy among farmers. The saving of seed would be a sufficient argument in favour of *thin* sowing, provided the same return were received. But the results have been found to vary. There are many conditions to be considered in deciding as to the quantity of seed to be sown. The nature and condition of the soil, the climate, the quality of the seed itself, and even the character of the season, must all be kept in view.

Hewitt Davis, Spring Park, Croydon, who occupied 800 acres of high-rented poor soil, upon a warm subsoil of chalk, stated that "the practice throughout England is to sow 2 or 3 bushels of wheat to 1 acre, and the yield seldom reaches 40 bushels, and more commonly less than 20 bushels, so that $^1/_{10}$ at least of the crop grown is consumed as seed, whilst 1 single grain of wheat, planted where it has room to tiller out, will readily produce many 100-fold. The knowledge of these facts has induced me, in the course of years, to make a variety of experiments, the results of which have clearly shown me that, independent of the waste, a positive and serious injury of far more consequence is done to the crop from sowing so much seed. I bear in mind that, if so much be sown as to produce more plants than the space will allow to attain to maturity, the latter growth of the whole will be impeded, and a diseased state will commence as soon as the plants cover the ground, and continue till harvest." The quantities of seed Mr Davis determined on sowing, in accordance with these reasons, are, for—

Rye	1¼	bushel	sown	in August and September.
Winter barley	2		"	September.
Tares	1½	"		3 sowings in Aug., Sept., and Oct.
Oats	6	pecks	"	January, February, and March.
Barley	5	'		January, February, March, and April.
Wheat	3	"		September and October.
Peas	9	'		December, January, and February.
Beans	9	"	"	September and October.

The returns obtained by Mr Davis, after these scanty sowings, were 5 quarters of wheat, 13 quarters of oats, and 8 quarters of barley per acre on "very inferior land," from the manure available on the farm.[1]

Mr Barclay, Eastarch Farm, Surrey, *drilled* 2½ bushels of wheat at 9 inches apart, and obtained 37 bushels at 64¾ lb. per bushel, and 70 trusses of straw, value £16, 6s. He *dibbled* 1 bushel 3 pecks at 9 inches apart, and had 37 bushels at 64 lb. per bushel, and 72 trusses of straw, at a value of £15, 12s. 9d. He sowed *broadcast* 2½ bushels, and had 40 bushels at 65 lb. per bushel, and 84 trusses of straw, the value being £18, 1s. Here broadcast and thick sowing prevailed. Soil, deep loam on chalk subsoil.[2]

Mr Mechi, Triptree Hall, Essex, gave 4 pecks by Bentall's Dropper, and obtained 40 bushels of wheat. He gave 4 and 5 pecks on the same field by Bentall's Dropper and hand dropping, and obtained 48 bushels of wheat. He gave 9 pecks by *drill* and *dibbles*, and obtained 32 bushels of wheat. "The quality of the wheat was good, weighing 63 and 64 lb. per bushel; the straw strong and bright. The straw was larger and longer, and the ears largest, when thin sown. I had only a ½ acre laid on 80 acres."[3] Here thin sowing prevailed.

W. Loft, Trusthorpe, Lincolnshire, *drilled* marigold wheat at 5 pecks, and obtained 56 bushels 3 pecks, at 63 lb. per bushel; and in the same field drilled 8 pecks, and they yielded rather more than 57 bushels per acre, at 63 lb. per bushel. "This result," W. Loft says, "is at variance with the opinions of the advocates of thin sowing as to quantity of seed; and indeed I do not believe that any specified quantity of seed can be laid down as the proper quantity for all descriptions of soil anc climate—practice and experience alone must be the guide; for although I an willing to admit that wheat tillers wel on this soil—loamy clay on tenaciou clay subsoil—I find from repeated trial that it is not safe to sow much less thar 8 pecks on an average. I now generally begin seed-time with 7 pecks as th minimum, gradually increasing, as th season advances, to 9 pecks."[4]

On the comparative merits of thicl and thin sowing, it has been contendec that experience has established that,— thick sowing is advisable on newly broken-up land, containing a larg amount of vegetable matter in an activ state of decomposition, when it is bene ficial in repressing, by its numerou roots and stems, that exuberance o growth which produces soft and succu lent stems, which are easily lodged, anc produce unfilled ears. Thin sowing ha a tendency to make the roots descen deeply; and where a ferruginous subsoi exists, thick sowing keeps the root nearer the surface, away from it. Thi sowing develops a large ear, grain, an stem, but delays maturity. Thick sow ing on old land in high condition render the plant diminutive, and hastens it maturity before the ear and grain hav attained their proper size. Thin sowin in autumn affords room to plants to tille and fill the ground in early spring, whil thin sowing late in spring does not affor time to the plant to tiller. Thick sow ing in autumn makes plants look best i winter, but gradually attenuates them i spring. Thin sowing makes plants loo worst in winter, but to look better an fuller as the harvest approaches.

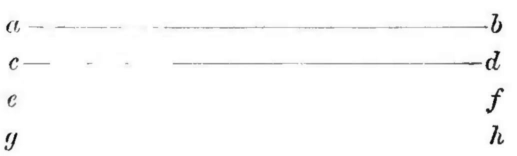
Different Methods of Sowing Con pared.—On comparing the broadcas drilled, and dibbled methods of sowin the cereal grains, it must be owned tha the *broadcast* incurs a loss of seed b

[1] Davis's *Waste of Corn by Too Thick Sowing*, 6-12.
[2] *Jour. Eng. Agric. Soc.*, vi. 192.
[3] *Ibid.*, vii. 537.
[4] *Ibid.*, ix. 283.

some being exposed on the surfaee, and others sent too deeply into the soil. Such effects are produced whether by hand or machine sowing, and cannot be avoided until a machine is contrived to sow corn broadcast at a uniform depth.

The *drill* does not work well in stony ground, which easily jolts the coulters to one side, or they displace small stones, or ride over large ones; while where land-fast stones or subjacent rocks are near the surface, they would be broken. Where there are many stones the drill should not be used. Where the soil is fine, drilling has the advantage of having the land smooth before the seed is sown, and then seed escapes disturbance by cross-harrowing.

Dibbling may be done by a hand-dibble, or with an implement having pins attached to the bottom of a spar of wood, and which pins are thrust into the ground with a pressure of the foot. Another method is, to thrust small hand-dibbles through holes formed in a thin board of wood. In all these modes the seed is deposited in the holes at stated distances—perhaps 7 inches between the rows, 4 inches apart in the rows, and 2½ inches in depth. The earth is put over the holes with the foot. When a man uses a small dibbler, a convenient mode of keeping the lines straight is this: Take 2 long lines and stretch them along the side of the field, at a determinate distance between them; *a b* and *c d* are the 2 lines at a distance between them of *a c* and *b d*.



Let him dibble in the seed along *a b*, and when at *b*, let him shift that end of the line from *b* to *f*, and then dibble the seed in from *d* to *c*, where let him shift the end of the line at *a* to *e*, which brings the line straight from *f* to *e*. Before starting with the dibbling from *e*, let him remove the end of the line at *c* to *g*, and then dibble the seed from *e* to *f*, where he shifts the end of the line from *d* to *h*, which brings the line straight from *g* to *h*. Shifting the line from *f* to *i*, he proceeds as he did at *b*, and so on alternately from one side to the other.

Dibbling-machines.—The dibbling-machine first brought into notice was invented by James Wilmot Newberry, Hook Norton, Chipping Norton, Oxfordshire. It is ingenious and elaborate in construction, and deposits every kind of corn at given distances, in any quantity, with the utmost precision. Fig. 316 is a view in

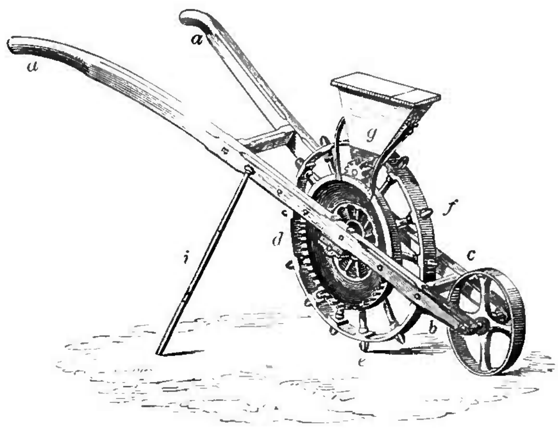


Fig. 316.—*Newberry's one-rowed dibbling-machine.*

a a Stilts.	*e* Projecting points or dibbles.
b Fore part of stilts.	*f* Large outer ring.
c Fore-wheel.	*g* Hopper.
d Hollow flat disc.	*i* Stay to support the machine.

perspective of a 1-rowed machine. It consists of a hollow flat disc, which contains the machinery that directs the eorn from a hopper into hollow tubes, 18 of which are connected with and project from the circumference of the disc like the spokes of a wheel from its nave, and their points pass through a large outer ring, which retains the hollow tubes or distributors of corn in their respective places, and prevents them sinking into the ground beyond the requisite depth. A fore-wheel, which is placed between the extremities of the stilts or handles, prevents the large outer ring being pressed closer to the ground than needful. A man pulls the machine forward by means of a rope attached to the fore part of the stilts, or, what is better, a bridle and shackle might be mounted there, for yoking a pony or horse to draw the maehine. As the wheel is drawn forward by the horse, it turns round by contact with the ground, the projecting points of the hollow tubes acting as dibbles and making holes in the ground; a portion of the dibbles, before leaving the ground, slides up upon the upper part, making an opening through which the corn is deposited in the holes. The corn descends of the requisite number from the hopper by means of feeding-rollers, moved by a pinion, which is set in motion by teeth placed on the circumference of the flat disc. The disc is supported in its centre by an axle revolving in its ends on plummer-blocks. In using this machine, a man holds by the two stilts, while a man or horse draws the machine in the given line. The line not being in the line of the body of the drill, a rigger is required for the horse to be yoked to. A stay supports the machine when at rest. This 1-rowed dibble is said to be well suited for sowing mangel seed on the top of the drill.

Another dibbling-machine, presented to public notice by Samuel Newington, of Knole Park, Frant, Kent, is shown in fig. 317—a view in perspective of one

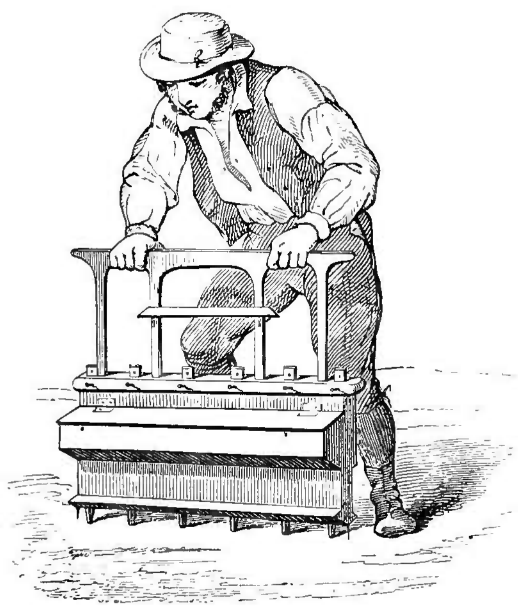


Fig. 317.—*Newington's 6-rowed dibbling-machine.*

having 6 depositors. The box in front contains the corn, and the points of the depositors are seen to rest upon the ground, which has been harrowed smooth for the purpose. The depositors place the seeds at the desired depths, deeper or shallower, being kept in their places by pinching screws. The machine is worked by taking hold of the upper rail by both hands, and, on pressing upon it, the depositors, when withdrawn, leave the requisite number of seeds in each hole the depositors have made, by the machinery in the interior of the machine. By pressing down the upper handle, the depositors press every seed firmly into a solid bed, which is so small as to preclude the fear of its containing water, and yet completely buries the seed. By changing the cups, the quantity of the corn is regulated, as well as the description of corn. With a machine having 6 depositors, 1 man can dibble 1 acre in 10 hours, so that the cost of dibbling may be easily ascertained by the rate of wages in the district.

In using the machine after the first line is laid off straight next the fence, the workman continues to keep the other lines straight at the stated distance by the mark left on the ground by the machine. The seeds are put in at 4 inches apart in the rows, and the quantity is varied by either altering the distance between the rows, or increasing the number of seeds in each hole, but it is not desirable to exceed 3 seeds in 1 hole. The cups which contain the grains are of 4 sizes, and can be easily removed or replaced by means of screws.

As already indicated, dibbling is too slow a process for the modern necessities of farm practice, but on a small scale, and for filling up blanks, it may be pursued with advantage.

Deep and Shallow Sowing.—Another circumstance which affects the relation between the grains sown and the plants produced, is the *depth* to which the corn is buried in the ground. In ill-ploughed land, when the corn is sown broadcast, falling between ill-assorted furrows, some of it may sink to the bottom of the furrow-slice, where it will be buried, to become dormant or lose its vitality. Corn is differently affected by depth in soil, some sorts germinating at a considerable depth, whilst others become dormant or die if placed at a smaller depth below the surface of the ground. A stem of barley has been traced to a depth of 9 inches, while oat seed buried 7 inches cannot be depended on to germinate. This accounts for oats which had slipped to the bottom of the furrow-slices of lea and perished. The risk of thus losing seed in fresh-ploughed lea induces us to recommend partial harrowing of ploughed old lea before the seed is sown.

Wheat possesses a peculiarity in the growth of the root. The grain will bear to be deep-sown — not so deep as barley, but deeper than oats. Most wheat seeds may germinate at a depth of 6 or 7 inches, but sowing at that depth is risky, for the crop will likely be thin. After the germ of wheat has become a stem, it puts out another set of roots about 1 inch below the surface. The deeper may be called the *seminal*, and the upper the *coronal* root of the wheat plant. Fig. 318 shows the position of the roots under the surface, where *a* is the seed with its seminal roots *c*, and the germ *b* rising from it to the surface of the ground at *f*, above which is the stem, with its leaves. About 1 inch below the surface *f*, at *d*, are formed the coronal roots, *e e*, the office of which is to form the site from which the tillers are sent forth. At whatever depth the seed may have been sown, the coronal roots are formed at 1 inch below the surface.

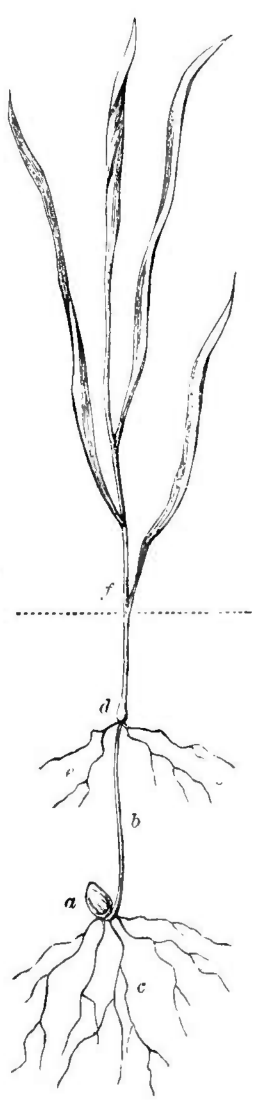


Fig. 318.—*Double roots of deep-sown wheat.*

"As the increase and fructification of the plant depends upon the vigorous absorption of the coronal roots, it is no wonder that they should find themselves so near the surface where the soil is always the richest. I believe I do not err when I call this *vegetable instinct*. In the N. counties wheat is generally sown late. When the frost comes, the *coronal* roots, being young, are frequently chilled. This inconvenience may, however, be easily prevented by sowing more early, and burying the seed deeper. The seminal roots, being out of the reach of frost, will then be enabled to send up nourishment to the crown by means of the pipe of communication."

Now the form which the plant assumes, when sown near the surface, is different, as in fig. 319, where *a* is the seed with its seminal roots; *b* the pipe of communication between them and the coronal roots *c c*, a little beneath the surface *d*. The coronal root *c* being at a short distance from the surface, the pipe of communication is shortened to the smallest degree. "Hence it is obvious," continues the same writer, "that wheat sown superficially must be exposed to the frost, from the shortness of the pipe of communication placing the seminal root within reach of the frost. The plant, in that situation, has no benefit from its double root. On the contrary, when the grain has been properly covered, it depends almost entirely on the coronal roots, which, if well nourished during the winter, will send up numerous stalks in spring; and on the tillering of the corn the goodness of the crop principally depends; but if not well nourished there will be no tillering. A field of wheat dibbled, or sown in equidistant rows by the drill, always makes a better appearance than one sown with the harrow. In the one the pipe of communication is regularly of the same length, but in the other it is irregular, being either too long or too short."[1] The conclusions these statements would warrant in practice are: That wheat sown before winter should be deeply covered with earth, to be beyond the reach of ordinary frost; that in spring the coronal roots will set up abundance of tillers or stools; that wheat sown in spring should be lightly covered, the tillers being few; that autumn wheat should be drilled to secure the pipes of communication be-

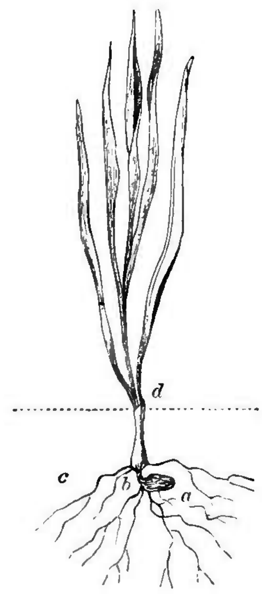


Fig. 319.—*Roots of shallow-sown wheat.*

[1] *Georgic. Ess.*, i. 67-69.

tween the seminal and coronal roots being long and uniform; that spring wheat should be sown broadcast; and that autumnal wheat should have a smaller quantity of seed than spring wheat.

Depth for Grass Seeds.—Depth of sowing affects no plants so sensibly as the grasses. Some experiments were made at Glenbervie, Falkirk, to ascertain the depth which the common grass and clover seeds should be covered, to produce the greatest number of plants. The same weight of seed was sown of each kind, and as different seeds differ in bulk and weight, the numbers of each kind differed materially. A better plan would have been to have sown the same number of seeds of each kind whatever their weight, and the proportion which came up of the plants would have been more easily ascertained than by the method adopted. Each kind of seed was covered from ¼ of an inch to 3 inches of depth in the soil. They were sown on the 1st of July, and counted on the 1st of August, and the results are shown in the following table:—

KINDS OF SEED EXPERIMENTED ON.	No. of seeds sown altogether.	COVERED AT												No. of plants that came up.	Proportion of plants that came up.
		¼ in.	½ in.	¾ in.	1 in.	1¼ in.	1½ in.	1¾ in.	2 in.	2¼ in.	2½ in.	2¾ in.	3 in.		
Perennial ryegrass (*Lolium perenne*)	348	29	30	27	19	16	19	14	21	11	9	8	4	198	.57
Italian ryegrass (*Lolium Italicum*)	276	24	21	20	13	13	10	11	8	9	6	5	5	145	.51
Cocksfoot (*Dactylus glomerata*)	300	30	22	15	15	10	9	7	5	2	..	..	..	115	.38
Large fescue (*Festuca elatior*)	312	20	24	20	16	13	13	11	9	4		1	..	142	.42
Meadow fescue (*Festuca pratensis*)	324	28	28	16	12	10	6	9	4	2		..	..	117	.36
Varied-leaved fescue (*Festuca heterophylla*)	348	31	23	20	18	12	9	6	4	1	..	..	..	124	.35
Hard fescue (*Festuca duriuscula*)	300	30	23	10	15	10	8	5	3	1	..	..	..	114	.38
Meadow foxtail (*Alopecurus pratensis*)	192	17	17	16	15	12	7	6	3	1	..	..	..	94	.49
Timothy grass or meadow cat's-tail (*Phleum pratense major*)	528	52	39	37	19	16	15	7	5	..	..	..	..	190	.36
Evergreen wood meadow-grass (*Poa nemoralis sempervirens*)	228	24	14	4	1	..	..	..	..	..	..	..	..	43	.18
Rib-grass (*Plantago lanceolata*)	252	22	25	19	17	14	11	10	8	6		..	..	134	.53
Red clover (*Trifolium pratense*)	192	17	16	14	11	11	8	4	4	..	..	..	..	85	.44
White clover (*Trifolium ripens*)	144	13	11	6	4	3	1	..	..	..	..	..	..	38	.26
Yellow clover (*Medicago lupulina*)[1]	96	12	10	8	6	4	2	..	..	..	..	..	..	42	.43
	3840	349	303	232	181	144	118	90	74	37	21	14	9	1581	.46

In only 3 cases did the number of plants exceed ½ the seeds sown, those being perennial and Italian ryegrass and large fescue—the average of the whole being under ½—viz., .46. The clovers came up in small proportion, particularly the white, which is considered a hardy plant in this climate. Of the depths, the ¼-inch covering gave the largest return of plants, and 16 per cent more than ½ inch.

Mr John Speir, Newton Farm, Newton, Glasgow, states that, in a series of trials with grass and clover seeds sown at different depths up to 1½ inch, he obtained results which do not agree with these recorded at Glenbervie. Mr Speir remarks that his experience does not favour so shallow a covering as is likely to be got by first rolling, then sowing, then harrowing with a light-toothed or chain harrow, and finally rolling. He is thus opposed to rolling prior to sowing grass seeds.

In such soil as prevails on Mr Speir's farm, which is not difficult to reduce to a fine tilth, there will rarely be any necessity for rolling before sowing. Rolling is unquestionably beneficial when by the harrows a fine smooth surface cannot be prepared for the grass seeds. If chain or light-toothed grass-seed harrows will not provide a sufficiently deep covering for the seeds after rolling, then ranker-toothed harrows may be used. The object aimed at in using the roller before sowing is to secure for the small seeds a firm level bed, where their regular germination will not be interfered with by clods and heights and hollows. Where

[1] *Trans. High. Agric. Soc.*, Jan. 1845, 341.

this can be obtained without prior rolling, there is no need to occupy time with this operation.

Depth of Sowing Turnip-seeds.—The author of this work made an experiment on turnip-seeds, to ascertain the effects of deep sowing in comparison with shallow in the most favourable circumstances for vegetation—a loose soil in the temperature of 75° in a vinery. Seeds of swedes, yellow Aberdeen, and white globe turnips were sown, 40 of each, in friable soil taken from under fine old pasture, at 1, 2, 3, and 4 inches in depth in pots, and the plants which came up in time and in numbers were:—

	Inches in depth.	Plants came up.	In days	In hrs.	In proportion.
	Swedes.				
From 40 seeds,	1	31	4	12	·77
"	2	29	5	18	.72
"	3	20	6	21	.50
"	4	10	8	18	.25
	Yellow Aberdeen.				
"	1	28	4	10	.70
	2	25	4	18	.62
"	3	14	5	13	·35
	4	5	8	14	.12
	White globe.				
	1	22	4	10	·55
"	2	18	4	13	·45
	3	12	7	0	·30
	4	7	7	13	·17

On comparing these results, the large proportion of plants coming from seeds at 1 and 2 inches in depth, compared with 3 and 4 inches, is very apparent; while there is not much difference between 1 and 2 inches in depth. The proportion that came up at 4 inches was so small, it is possible that had the experiments been made in the open air, no plants would have come up at all, since those which did come were puny. Of the seeds the swedes gave the most vigorous plants, the white globe the weakest, though the yellow Aberdeen showed more weakness in penetrating 4 inches than the globe. The conclusions drawn are, that no turnip-seed should be sown deeper than 2 inches. In many cases the coulters of sowing-machines place turnip-seeds too deeply in the soil.

Tillering.—The property of the cereal plants to *tiller* or *stool*—that is, to send up a number of stems from the same root—is a valuable one in an economical point of view. But for this property, when the seeds of the cereals happen to be destroyed by insects under ground, or by the unfavourable state of the ground or air for vegetation, or from the destructive effects of frost, or when young plants are injured by insects as they appear above the surface, the crop would be so scanty that it would be ploughed up by the farmer, and another substituted in its stead. The extent of tillering depends in some circumstances on the state of the soil and weather, and the space allowed the plant to spread in. A loose soil, admitting the shoots of the radicles to penetrate easily, encourages tillering more than a stiff hard soil. Yet wheat tillers best on a moderately firm clay soil in good heart. The weather when moist and warm promotes tillering.

Unless plants have space for their roots, they will not tiller. Tillering implies an instinctive faculty in plants to search for as much food as they can, and this is strikingly exemplified in the stronger or tillering plants overcoming and killing the weaker.

The question which such an occurrence gives rise to is, Whether it is better to allow few plants to fill the ground by tillering, or to fill the ground at once with the requisite number of plants? The answer to this question must be given conditionally. In naturally fertile soils, and in those rendered fertile by art, tillering will take place, and should be encouraged, inasmuch as the straw and ears of tillered plants are much stronger and larger than those of single plants. In such conditions of soil, a small quantity of seed will suffice in early spring, and it is in that season that tillering takes place in a sensible degree; but the seed must not be sown so deeply nor so late as to deprive the plant of time for tillering, so as to occupy the ground fully.

The extent of tillering is sometimes remarkable. Le Couteur mentions a downy variety of wheat which tillers to the extent of 32 plants,[1] and from 5 to 10 stems are a common tillering for ordinary varieties of wheat. Barley also

[1] Le Couteur's *Wheat Plant*, 29.

tillers, though late and thick sowing, with quick growth, overcomes that tendency. Oats indicate fully as strong a tendency to tiller as wheat. In weak soils, and soils in low condition, the tendency to tiller is much checked, each single root being conscious of its inability to support more than its single stem. Hence the practice is to sow more seed in low than in high conditioned land, and yet the ability to support the larger number of plants is in an inverse ratio. Yet what can the farmer do but sow as many seeds as will produce as many plants as will occupy the soil? The best way for him to escape from the dilemma is to put the soil in high condition, and reap the advantages derivable from tillering.

Destruction of Seed.—The great loss in plants compared with the numbers of seed sown may be accounted for from natural causes. Birds pick up seeds exposed on the surface after broadcast sowing. Many vermin, such as the rabbit, devour the young germ as it penetrates the soil, and many insects subsist on the stems and roots of young plants.

Transplanting.—A mode of saving seed to a greater degree than by dibbling and drilling, is by *transplantation.* This is done by sowing a small portion of ground with seed early in the season, taking up the plants as they grow, dividing them into single plants, and transplanting them. By thus dividing the plants as they tiller into single plants, at four periods of the season, a very small quantity of seed will supply as many plants as would cover a large extent of ground. Though wheat no doubt bears transplanting, yet the amount of manual labour which the scheme would entail would be so great as to render it impracticable upon any considerable scale.

This method, however, has been pursued with a certain measure of success in the formation of permanent pastures.

When it is desired to propagate a new variety of grain quickly, this process of transplanting might perhaps be useful. It may therefore be interesting to preserve the following record of the details and costs of the operation: Suppose 440 grains of wheat are sown widely on the 1st of July, and that every seed germinates by the beginning of August, each seed will afford four plants, or in all,

	1,760 plants
At the end of August these will produce	5,280 "
In September these again	14,080 "
And in November these last will produce	21,120

The time occupied in sowing the 440 grains, and dividing and transplanting their produce, stands thus:—

				Hours.	min.
July sowing,		440	grains,	0	20
August, beginning,	taking up	440	plants,	0	20
	dividing into .	1,760			10
	planting.	1,760		3	30
August, end,	taking up	1,760		1	28
"	dividing into .	5,280		3	30
"	planting.	5,280		10	33
September,	taking up	5,280		4	24
	dividing into .	14,080		9	23
"	planting.	14,080	"	28	9
November,	taking up	14,080		11	44
	dividing into .	21,120		14	4
"	planting.	21,120		42	14
				130	49

Equal to 13 days 49 minutes' work at 10 hours a-day. Of these 13 days, 5 days may be reckoned for women and boys occupied in taking up and dividing the plants, which, at 1s. 6d. per day, will cost 7s. 6d. The remaining 8 days are for men transplanting, at 14s. per week, which will cost 18s. 8d. more; both 26s. 2d. per acre. The seed for the plants, ½ bushel at 48s. the quarter, or 6s. the bushel, would cost 3s. The entire cost would be £1, 9s. 2d. The saving of seed from the ordinary quantity sown would be the difference of cost between ½ bushel and 3 bushels, 15s. So that the loss on the transplanting over sowing would be 14s. 2d. Of course the cost of transplanting would vary with the rate of wages.

The best way of executing this plan is to dibble in the seed two grains in a hole, about 4 inches from each other, the plants to be taken up when in a proper state, and divided into five, which would be as many at that time as could be had, and then planted out at once, where they are to remain, thus getting rid of all the intermediate dividings.

FORAGE CROPS.

Forage crops may be defined as those which are grown for the sake of their leaves and stems, as distinct from crops grown for seeds and roots. Chief amongst the forage crops are the grasses and clovers. These have already been described, and here will be given some information regarding several other forage crops which may be grown to provide wholesome green food for farm live stock. These are vetches, lucerne, sainfoin, rye, cabbages, rape, mustard, kidney-vetch, gorse or whin, buckwheat, maize, sorghum, and prickly comfrey. Sainfoin, lucerne, buckwheat, maize, and sorghum are confined to southern parts, where the climate is mild; the others may be grown in almost any part of the kingdom.

Importance of Forage Crops.—The growing of forage crops, particularly of crops to be cut and used as green food, has not yet received from British farmers so much attention as it deserves. Our acquaintance with forage crops is still very imperfect, and the extent to which they are capable of contributing to the saleable produce of the farm is not fully understood or appreciated. Providing a plentiful supply of green succulent food coming into use in succession all through the year is one of the greatest objects of the stock-owner. The forage crops at present in use, as they are now known and cultivated, are far from adequate for this purpose, and assuredly no subject could more worthily engage the attention or employ the resources of our great agricultural and experimental bodies than furnishing to farmers the knowledge and the means which would enable them to grow a more abundant supply of green food for stock throughout the year.

Forage Crops as Substitutes for Turnips.—In a very useful paper upon this subject in the Journal of the Royal Agricultural Society of England' (vol. xxv. part I., 1889), Mr Joseph Darby writes:—

"Cabbages, thousand-headed kale, and kohl-rabi may be made use of as substitutes for turnips and swedes as well as mangels, and the cost of growing kale and kohl is not usually considered to be more than that for swedes. Further, while requiring less manure than mangels, they are equally sure in succeeding well. Farmers who find it difficult to rely on turnip crops can also fall back on vetches, trifolium, rye, and winter oats, which, when autumn-sown, occupy the land at a period when it would probably otherwise be either fallow or growing weeds. These crops, if cut for green fodder just when they have attained their maximum growth, might be converted into silage, and the soil be still available for growing swede and turnip crops the same year. There appears to be great gain, from several points of view, in taking this course, and no doubt it has been adopted largely since the ensilage system was introduced some four or five years since. In the first place, the tillage expenses need not be increased, and on tolerably clean land there would be many less weeds by two croppings taking place instead of one. In nearly all cases where land intended for swedes and turnips is kept idle throughout winter and spring, three, and sometimes four, ploughings are given, the amount of additional cleaning being very great indeed.

Forage Crops for Heavy Land.—"The assertion has often been made that catch crops can only be advantageously grown when the land is perfectly clean as well as in a good state of fertility; but, in the course of correspondence with practical farmers on the subject of this paper, I have been informed by a gentleman of great skill and excellent judgment that he considers it by far the most economical and remunerative course on all heavy or medium soils to sow vetches in the autumn if the stubbles are foul, to ensile the crop in June, and give the land fallow working for six weeks, then to take a crop of mustard, to be sown about the last week in August, for sheep feeding or for a second silage crop, as may be most convenient.

"Many cases could be mentioned of the heavy Weald clay district of East Sussex, and a portion of Surrey, having been greatly benefited by the introduction of the ensilage system. On the farm of Major Cazalet, near Dorking, 300 acres being arable, no roots whatever are grown, some 400 tons of green fodder affording sufficient silage for them to be dispensed with. Lieut.-Colonel Coussmaker, at Westwood, Guildford, in cropping 112 acres of arable, depends on mangels and thousand-headed kale, by appropriating $5\frac{1}{2}$ acres to each, which, with 3 acres to cabbages and carrots, and about 15 acres of trifolium and vetches, and a still larger area to Italian rye-grass for silage, make up his winter supply of succulent food, unless able to grow some swedes and turnip after the catch crops. On Mr R. Whitehead's farm, at Old Paddockhurst, nearly 500 cattle and 400 sheep, besides horses, are wintered chiefly on silage, the manager, Mr Abbott, giving it as his opinion that from 10 to 12 tons of silage per acre can be obtained at less than half the cost the growth of any kind of roots would entail on this kind of land."

Vetches.

The vetch or tare belongs to the natural order of *Leguminosæ*, and the cultivated tare or vetch is named *Vicia sativa.* In the wild state it is a native of Europe, in corn or cultivated fields; plentiful in Britain; also in North America, about Fort Vancouver. Flower purple. This is a very variable plant in the form of its leaflets, in the size of the stems, and in the colour and size of the seeds. The *Vicia narbonensis*, Narbonne vetch, and the *Vicia serratifolia*, serrate-leafleted vetch, are cultivated on the Continent. Anderson has recommended the culture of the *Vicia sepium*, hedge-vetch; and a writer in the Bath papers advocates that of the *Vicia cracea*, tufted vetch. These are eminently beautiful native plants, but too tiny in the leaf and attenuated in the stem to make them worthy of cultivation. There are 108 described species of *Vicia*—a name said to be derived from *vincio*, to bind together, because the species have tendrils by which they bind themselves to other plants. The Romans took care not to sow tares in dew or moisture, the period of the day being some hours after sunrise, and no more was sown than could be covered up before night.

The vetch is a most valuable forage crop. It is hardy and prolific, and affords palatable and wholesome food for stock. There are two varieties, the winter and the spring vetch. The former, through repeated sowing in winter, has acquired a hardiness that is quite remarkable.

Winter Vetches.—The winter vetch is often sown along with rye or oats, to provide green food in spring before a full supply of grass is available. Sown before the winter frosts set in, usually during September or October, this crop will generally afford a good cutting from the second week in May till end of June in northern parts, and still earlier in warmer counties. Vetches are often consumed on the land by sheep, this practice being confined mainly to southern counties. The importance of having a supply of fresh succulent food at this season of the year, when roots are wholly or nearly exhausted, and before the pasture fields can sustain the animals, will be readily acknowledged by all farmers, and it is surprising that winter vetches are not sown much more extensively than they are, especially when it is remembered that they are off the ground in time for a root or potato crop in the following season.

Spring Vetches.—Vetches should be sown at different times in spring, so as to afford a succession of cuttings when green food is likely to be most urgently required. If the weather and the state of the land permit, the first sowing may be made in February, and successive sowings may take place every second or third week up till towards the end of June. It is advisable to sow small breadths at a time, so as to have a succession of cuttings when the crop is in full bloom. By judicious sowings at different times in autumn, winter, and spring, supplies of fresh-cut tares may be had from the end of April till October.

Information as to the feeding value of vetches, with analysis of vetches *made into hay*, is given in pp. 276 and 377, vol. i.

Use of Vetches.—The value of vetches as a forage crop for supplying green food in summer and early autumn is not sufficiently recognised. Where, from drought or other causes, there is likely to be a scarcity of food for stock in summer or autumn, a few successive sowings of spring vetches will come in very opportunely. Then, in carrying stock from the grazing season to the winter rations, vetches will also be found most valuable.

Vetches for Horses.—Horses eat vetches with a keen relish, and thrive well upon them. They should be provided for horses during the harvest work, and given in moderate quantities along with dry food. It is considered by many that on strong land there is no better or cheaper way of keeping farm-horses in summer than by feeding them in the stable or yards with vetches and a little dry food.

Land for Vetches.—Vetches usually follow a grain crop. They thrive best on strong loams and tenacious clays, just the sorts of soil upon which turnip culture is most difficult. But they also afford a good return on lighter soils. In some cases vetches are sown upon strong land, which is fallowed in summer as a preparation for wheat. In other cases turnips or potatoes succeed winter vetches, so that the latter come in as a sort of "catch crop"—and a most useful one it is.

Seed.—The seed of vetches is usually sown broadcast, but often in rows about 8 inches apart. The quantity of seed varies from 2½ to 3½ bushels per acre. The seed is harrowed in the same way as a corn crop. In many cases, a little rye or oats is mixed with the vetches. The grain helps to support the pliant bine of the vetch. About 2 bushels of vetches to 1 of oats or rye per acre would be sufficient seed.

Cutting Vetches.—Vetches are most valuable for feeding when cut just in full bloom, and before the seed has begun to form. It is thus important to sow small quantities at a time, so as to be able to use the crop as it comes into bloom. When vetches are grown for seed they are, of course, allowed to ripen, and are cut and harvested in the same way as peas.

Manuring Vetches.—Land for vetches may be easily and cheaply manured. Mr John Speir says: "If the land is in moderately good condition, it may receive a light dressing of farmyard manure, which it is preferable to let lie on the surface for a few weeks previous to ploughing in. Along with the dung, or at any suitable time before it or after it, 3 or 4 cwt. of kainit should be sown over the unploughed land, and the same or more on the surface, as soon as the land is ploughed and before it is harrowed."[1]

Vetches and cleaning Land.—"With such a system of manuring, vetches seldom fail to do well with any sort of moderate season, and with a full crop they smother root-weeds well out, and owing to the early cutting of the crop, seed-weeds have no time to ripen their seeds. The land being bare comparatively early may be bastard fallowed, cleaned, and sown with wheat or other winter growing crop. Vetches, therefore, if well done to, offer an excellent opportunity of keeping down weeds, and of cleaning the land after the removal of the crop, thus leaving it in good condition for what is to follow."[2]

Lucerne.

In warm climates, notably in the southern counties of England, lucerne is a prolific forage crop. It is the *Medicago sativa* of botanists (Nat. Order *Leguminosæ*); roots sub-fusiform, stem erect, flowers large and violet-coloured. Its name is derived from that given by Dioscorides to Median grass. Lucerne is said to have been brought to Greece from Asia. The Romans were well acquainted with its properties as a forage plant, particularly for horses. Hartlib endeavoured to introduce its culture into England in the time of the Commonwealth, but did not succeed. It is cultivated in many parts of Europe in the field; but "it is very remarkable that this species of forage, to which so much importance was attached by the Romans, has altogether disappeared from Italy. We are assured by M. Chateauvieux that not a single plant of it is now to be seen."[3]

When well laid down in suitable soil—deep calcareous loam, clean and in good heart—lucerne affords several cuttings every year of excellent green food, which is relished by both cattle and horses. If kept free from weeds, the crop may remain productive for six or seven years. Weeds, however, are liable to disturb it, and may cause it to be ploughed up earlier. Land should therefore be prepared with great care for lucerne. It should be well cultivated, and as thoroughly as possible cleared of weeds of all kinds. Occasionally the year's produce amounts to 30 tons per acre, and 20 tons are by no means rare.

[1] *Farming World Year-Book*, 1889.

[2] *Ibid.*

[3] *Dict. Gr. Rom. Anti.*—art. 'Agricultura,' New edit.

The seed is sown in April, in rows 10 or 12 inches apart, at the rate of 10 to 20 lb. per acre. One cutting will be obtained in the autumn of the same year, but it is advisable to leave a rank growth to protect the roots from the winter's frosts.

The Crop for Dry Seasons.—Lucerne withstands drought wonderfully. It thrives best in a dry climate, and is therefore cultivated extensively on the continent of Europe. It is an exceptionally deep-rooted plant, and is thus comparatively independent of rain. Sir John Bennett Lawes has found it the best of all the forage crops for a drought.

Lucerne is not suited for extended cultivation in our moist climate. Professor Wrightson remarks that, as a special crop for odd corners, it is well enough, but that as a competitor with our established fodder crops, it is nowhere.

Sainfoin.

Upon the calcareous soils of the southern counties of England, sainfoin has proved a most useful and reliable forage crop. Belonging to the Natural Order *Leguminosæ*, it is the *Onobrychis sativa*, the cultivated sainfoin of botanists; roots sub-fusiform, stems erect, flowers in spikes or long foot-stalks, of a beautiful pink or flesh colour. Its generic name is derived from the Greek, signifying plants grateful to the ass; its ordinary name is evidently from the French, meaning consecrated hay—from its property of producing an excellent hay.

Sainfoin Hay.—The sainfoin yields by much the finest quality of hay when cut before the blossom comes out. "This hay, so cut before blossoming," says Jethro Tull, "has kept a team of working store-horses, round the year, fat without corn, and when tried with beans and oats, mixed with chaff, refused it for the hay. The same fatted some sheep in the winter in a pen, with only it and water; they throve faster than other sheep at the same time fed with peas and oats. The hay was weighed to them, and the clear profit amounted to £4 per ton. They made no waste, though the stalks were of extraordinary bigness; they would break off short, being very brittle. This grew on rich land in Oxfordshire. The second sort of sainfoin hay is cut in the flower; and though much inferior to the virgin hay, it far exceeds any other kind as yet commonly propagated in England; and if it be a full crop by good culture, may amount to above 3 tons on an acre. This is that sainfoin which is commonly made, and the larger it is the more nourishing for horses. I have known farmers, after full experience, go three miles to fetch the largest stalky sainfoin, when they could have bought the small, fine, leafy sort at home, for the same price, by the ton. The next and last sort of sainfoin that is cut only for hay is the full-grown, the blossoms being gone or going off: this also is good hay, though it falls short, by many degrees, of the other two sorts. It makes a greater crop than either of them, because it grows to its full bulk, and shrinks little in drying." [1]

Sainfoin, like lucerne, is a deep-rooted plant, and thrives best on dry soils in a dry warm climate. It is grown extensively, and with great success, on the chalky soils of the southern counties of England. It is useful as an ingredient in mixtures for temporary grass and hay, but is perhaps still more valuable as a forage crop grown by itself.

If well laid down in clean suitable land, it will endure, and yield liberally for six or seven years. It should not be resown upon the same land for some twenty or more years. Indeed it is a common saying that land will not successfully carry sainfoin more than once in a lifetime. Sainfoin is both cut and pastured, and especially for sheep a run of old sainfoin is much esteemed.

It is not a reliable crop on strong lands or in wet climates.

Land intended for sainfoin should be thoroughly clean and in good heart. The seed is best sown with barley or oats, and it may be mixed and drilled with the grain seed. In other cases it is drilled separately at the same time across the rows of the grain seed. The quantity of sainfoin seed used per acre is usually about four bushels of unmilled seed; rough seed in the pod. Sainfoin does not develop fully until the second year, and it is therefore considered a good plan to sow from 6 to 8 lb. tre-

[1] Tull's *Husb.* 174, 175 (1762).

foil (*Medicago lupulina*) per acre along with it.

It would be well to defer grazing the sainfoin until after the first cutting has been removed. Young sainfoin is liable to be damaged by being grazed too soon by sheep.

Rye

Rye makes a very useful forage crop. It is wonderfully hardy, and may be sown in autumn or winter for spring use as forage in northern parts, where even vetches cannot be depended upon. It throws up a rank growth, and although it is not so succulent as the vetch, it is, nevertheless, a valuable forage plant, affording, as it does, the earliest green food for sheep or cattle in spring. As already mentioned, it is often sown along with winter vetches.

For spring forage, rye should be sown in autumn immediately after the removal of a grain crop, at the rate of about 3 or 4 bushels per acre. If the land is in good heart, or the crop well manured with dung or superphosphate, and nitrate of soda or sulphate of ammonia, the rye will afford a large produce in the following April, when it may be consumed on the land by sheep, or cut and fed to cattle in the house.

Cabbages.

The cabbage is a most suitable plant for field culture. It is not grown so extensively as might be expected, when one considers the vast amount of wholesome food which it is capable of producing. The variety most largely used is the Drumhead or common cattle cabbage. It is the *Brassica oleracea* of the Natural Order *Cruciferæ.*

The cabbage succeeds best on deep good loams, with porous or well-drained subsoil, and it also does well on well-farmed strong clays. It is a gross feeder, and requires liberal manuring and deep tillage. Land to be planted with cabbage in spring should be deeply cultivated in the autumn or early in winter, and should be well cleaned of root-weeds.

In a paper on "Forage Crops" in the *Farming World Year-Book*, 1889, Mr John Speir says:—

"Probably no ordinary farm green crop admits of growth in a moderately successful way, in a greater variety of soils or climates, than the Drumhead cabbages. With suitable manuring they may be grown on sand, loam, or clay, and on the sea-shore, or well up the mountain-side.

"The seed should be sown in a seed-bed about the middle of July, and the plants transplanted from it to the field in spring. Planting may be done in any suitable weather during March or April, the best crops being usually obtained from the earliest plantings, all other things being equal. By planting moderately early few plants fail to catch root, and as they are rarely hurt by frost after being planted out, they have thus a much longer season in which to mature a full crop.

"Where possible, cabbages should always have their farmyard manure applied to them in the drill. The cabbage is such a gross feeder that it is almost impossible to spoil it by excessive manuring. Any available quantity of farmyard manure, from 20 tons per acre upwards, may therefore be applied, and whatever assistance the crop afterwards requires can be made up by surface manuring with artificials.

"The drills should not be less than 28 or 30 inches in width, and the plants about 2 feet apart in the drill. Planting is best done by the dibble, although some people prefer the spade.

"As soon as the plants have thoroughly taken with the ground, and have begun to spread their leaves across the drill, they should receive from 1 cwt. to 2 cwt. of nitrate of soda or sulphate of ammonia per acre. For a first manuring this is best applied by dropping a little at the root of each plant, 1 cwt. doing as much good at this date, applied in this manner, as 2 cwt. applied broadcast, the plants being so far asunder that a large proportion of such a soluble manure runs to waste. Before the crop is earthed up for the last time, it is always advisable to apply 1 cwt. or 2 cwt. of nitrate of soda or sulphate of ammonia, no matter how much manure may have been applied in the drill. This is best sown broadcast, after the drills are grubbed and before the crop is earthed up. By this means the whole nitrate is turned over on the top of the roots of the plants, and under their wide-spreading leaves, so that it is protected from washing, no matter whether the season prove wet or dry. Manured in this way, an enormous crop of cabbages can be grown almost any year, on nearly any kind of land.

"Few who have not seen a crop thus manured can form any idea of the weight which may be produced, even under unfavourable circumstances; and certainly for autumn consumption no other crop will produce anything like the same weight of leaves and of an equal feeding value.

Utilising Cabbages.—"Cabbages are well suited for consumption by any kind of farm stock, but for dairy cows they are particularly valuable. They are usually given to the animals raw, although a few people give them boiled or steamed; this, however, is generally considered to be unnecessary. In ordinary seasons the Drumhead cabbage will be ready to use from the beginning of October till the New Year.

"In consuming the crop it is always best to begin by using the largest and ripest cabbages first, as these are the ones to suffer most by frost. In the interval the smaller and greener ones increase considerably in size, and the labour so spent is doubly repaid by the better preservation of the crop, as the small green cabbages suffer little from even severe and protracted frost.

"Where early cabbages are grown for table use, a crop of considerable value is got in autumn from the second growths. Along the sea-shore of the southern counties, thousand-headed cabbages may be grown after early potatoes. Those come in very handy in spring for feeding ewes and lambs, when other green food is extremely scarce."

The storing of cabbages is dealt with at p. 159, vol. i. Cabbages are usually regarded as an exhausting crop. This, however, is only partially true. They are certainly gross feeders, and require heavy manuring; but if they are consumed on the farm the exhaustion does not arise.

About 7000 cabbage plants are required to plant an acre. The produce on good land under liberal and skilful treatment may reach from 50 to 80 tons per acre.

Thousand-headed kale is another Brassica of the cabbage sort, which is much esteemed as food for the sheep-fold. This variety may be sown about the end of April, on rich well-prepared land, at the rate of 4 or 5 lb. of seed per acre, and will produce a bountiful yield of excellent food for sheep in the autumn.

Mr Russell of Horton Kirby, Dartford, Kent, writing of thousand-headed kale, says: "The least known and most desirable of any green crop I have ever seen; it is a plant that produces more food per acre than any other; does not disagree with any stock, nor does it impoverish the land. With me it has never caused sheep or lamb to blow or scour. Eighteen perches a-day with a little oat-straw have kept 270 sheep for three months, without the loss of one." Mr Russell sows the bulk of his crop towards the end of April for use in autumn and early winter, and in August he sows about 20 acres, to be fed off in April and May of the following year. From 4 to 5 lb. of kale-seed is sown per acre.

Transplanting Kale. — Thousand-headed kale gives the best return when the plants are raised in a seed-bed, and planted out like ordinary cabbage. A common plan for feeding purposes is to sow in a seed-bed, early in August, and transplant into well-prepared land, well dunged, in October and November. This should afford an abundant growth for folding in the following summer. If required, a moderate dressing of nitrate of soda would force on the growth of the plants.

Consuming Kale.—Thousand-headed kale thus grown, may either be consumed by sheep being folded upon it, or by the heads being cut off and consumed by sheep on pasture-land. If by the first method the stems are not too closely eaten or peeled by the sheep, the plants will throw out new leaves, and afford a supply of delicious green food in the following spring. In cutting off the heads the bottom leaves should be left, and by taking care not to injure the stocks by either eating or cutting, and not allowing them to run to seed, the plants will endure, and supply useful fodder for several seasons.

Rape.

Rape (*Brassica napus*, Natural Order

Cruciferæ) is grown to a considerable extent as autumn food for sheep in the fold. The main crop is usually sown in June, but small patches may be sown as early as April, to afford successive folds of green food as they may be required. Rape is usually ready for consumption about three months after being sown. About 5 lb. of seed per acre is sown in rows about 15 inches apart. The land should be well dunged, and a dressing of from 2 to 4 cwt. per acre of superphosphate along with the seed will be useful.

Rape delights in fen or peaty soils rich in vegetable mould. It is sometimes sown upon reclaimed peaty land, and consumed by sheep, thus helping to reduce the rough soil to a useful condition. In some cases rape is sown after an early crop of potatoes, and consumed early in winter.

Rape should be hand-hoed like turnips, but is not so carefully thinned, although it undoubtedly affords the largest yield when the plants are thinned out to from 12 to 14 inches apart. Between the rows weeds must be kept down by the horse-hoe or drill-harrow.

Rape is sometimes sown along with vetches, the vetches being sown broadcast over the rows of rape. This mixed crop affords admirable green food for sheep. Rape is also, in some cases, sown in seed-beds, and planted out like cabbages. It is well suited for clay lands when it is sown early and consumed in summer and early autumn, when these lands will bear sheep without injury. Then the early removal of the crop admits of the land being prepared in good time for wheat.

Rape will afford a second crop if the plants are not destroyed, or too closely eaten down when first folded. The second crop however, although often almost as bulky as the first, is not so wholesome for sheep. It is considered injurious to ewes in lamb, and lambs do not thrive well upon it.

Rape is known to possess high fattening properties. It is better to give it along with other foods, such as aftermath, cabbages, vetches, &c., than by itself.

Mustard.

Mustard (*Sinapis albi*, Natural Order *Cruciferæ*) makes a very useful catch crop. It grows up very rapidly, being ready for consumption on the land by sheep in about eight or nine weeks after being sown. The white mustard may be sown in southern counties after an early corn crop, about a peck of seed being sown broadcast. It is sometimes also sown in spring before a late crop.

In many cases it is sown to be ploughed under as a green manure. For this purpose it is also very useful. Besides affording useful manure itself, it helps to prevent the waste of nitrates, which, instead of being washed away in drainage-water —which would probably happen if the soil were bare—are stored up in the growing plant.

Other Forage Plants.

Furze, *gorse* or *whin* (*Ulex europæus*, Natural Order *Leguminosæ*) as a forage crop has been noticed in vol. i. p. 268.

The kidney-vetch is regarded by some as a useful forage plant. Professor Wrightson thinks it worthy of a trial, and says that it ought to form an ingredient in mixtures of permanent pasture seeds intended for light and thin soils, in which this plant finds its most suitable position.

Maize and *sorghum* are both recommended as forage plants for southern counties. They are undoubtedly unsuited to northern districts, and until they have been more firmly established in this country we think it well to speak of them with caution in this work. As to their feeding properties, and in regard to the attempts to grow them in England, some information will be found in vol. i. pp. 276, 277 and 320-322.

The character of *prickly comfrey* (*Symphytum asperrimum*, Natural Order *Boragineæ*) as a forage crop is also referred to in vol. i. p. 277. For odd corners it is undoubtedly a most useful crop. It requires heavy manuring. It is perennial, and the plants are dibbled in 18 inches apart, in rows from 18 inches to 2 feet apart.

Buckwheat is also of some use as a forage crop. It is very susceptible of injury from frost, and can seldom be sown with safety earlier than May.