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THOMAS J. LEWIS, Editor.
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AGRICULTURAL.

ON THE LIMING OF LAND.

Lime has been directly applied to the land in the agriculture of this country for a very long period of years. The object of applying it has always been the same—to increase the crops by stimulating the action of the soil. It was supposed to act in two ways—directly upon the vegetable matter in the soil, and directly upon the soil itself, by altering its texture. When wanted to act upon vegetable matter, it was applied to boggy soil after it had been drained, or to dead soil that had long been under an exhausting course of husbandry, and which had never been limed, for it is known that soil never becomes dead that had been occasionally limed. When the texture was desired to be altered from a stiff to a friable state, or from a very loose to a firmer state, lime was applied. Still, lime was those which were rendered pulverible by lime, and those gravelly soils were rendered firmer by its action. The most convenient period for applying lime to the land was when the soil had been bare-fallow; and as that process was extensively practised, the lime was always laid on in summer. It was the most favourite practice with farmers to apply lime in a caustic state, because, being then in a state of finest powder, mixed best with every sort of soil.

Experience having confirmed all these practices in regard to the application of lime, it is doubtful that many farmers of the present day know more about the nature of lime and its action than what is implied in the above statement, and consequently the practice now is what it was then.

When lime is obtained direct from the kiln, or from shipboard it is in lumps, called shells, and light in weight. Limestones are differently treated by different farmers in their preparation of it for the soil. Some lay down the shells in small heaps upon the furred ridges, while others lay them in large heaps upon the upper head-ridge. It is clear that the mode of laying shells at once upon the land cannot be adopted until the land has previously been sufficiently fallowed; and as following occupies a considerable time to be done in a proper manner, it is also clear that no considerable quantity of lime can be driven, after the fallow is ready, unless the kilns happen to be near; and, at all events it is unnecessary to lay the lime upon the fallowed land until only a short period before the wheat is sown. Besides, when shells are placed in heaps on the ridges, they must remain a considerable time there to be reduced to powder by the air, when the lime will have lost a considerable portion of its causticity by union with the carbonic acid of the air, unless a good deal of rain shall have fallen to hasten its slaking. To preserve the shells intact, till needed, they should be put in large heaps, the outer surface of which may become neutralized by the action of the air, but the interior of which will not be so affected. While the shells are thus occupying a head-ridge, the land may be worked as an opportunity offers. A week or so before the lime is applied, water should be poured on the large heaps of shells to reduce them to a state of fine powder. The water will all be absorbed by the lime, which nevertheless continues quite dry, thereby indicating that it has been taken up in chemical union with the lime, which then becomes in the state of a hydrate. A great heat is evolved during the time the lime takes to fall to powder; and when it attains that state, the shells will have swelled to more than three times their former bulk. The lime is then said to be slaked, and is in its most caustic state.

While the slaking is proceeding, the land that was manured in drills (4172) is cross-harrowed a double time, to make it flat; after which the ridges are furred; and the lime is then spread along the furred ridges.

The lime is spread in this manner:—Frying-pan shovels, fig. 233, are the best implements for filling carts with, and spreading lime upon land. A man may be chosen for the purpose, but should there be a head wind, the single-horse carts should be so placed at the heaps as that the lime-powder which rises into the air should be blown away from the horses and men. Powdered lime is heavy; but all that can be upon a shovel is so light in weight that each ploughman takes a heap, and with one of his horses in a cart, for a yoking at a time, fills his own cart and spreads the lime from it upon the ridges allotted to him. The direction in liming should have the wind a little ahead; and when a number of men take from different heaps, they should so arrange themselves along the ridges as that the cart farthest down the wind take the lead in spreading. In spreading lime, the man walks along the middle of the furred ridge, and casts the shovelfuls right and left from the middle towards the furred ridges, which will become, by ploughing for the purpose of the future ridge. The man who can cast the shovelful with either hand will spread lime better than one who is right or left handed only. The lime should be spread evenly over the surface; but it may be spread thicker on one part of the field than another according to the wants of the soil. On light knolls it may be spread thinner than in hollows, where the soil is either deeper or stronger. Whenever rain falls, the liming should be discontinued.

It is proper to put a cloth over the horse's back and the harness; and the men should cover their face with wraps, to save it from the caustic effects of the quicklime. The horses, whenever loosened from work, should be thoroughly washed down with branched, to free the hair of any lime that may have found its way into it; and should the men feel a smarting in their eyes or nose, sweet thick cream is the best emollient.

Progressively as the lime is spread, ridge after ridge, it is harrowed in a double way, and mixed with the soil; and immediately the entire field being limed, the ridges are ploughed with a light furrow, to bury the lime as little as possible, and which constitutes the seed-furrow of the future crop.

The quantity of lime that should be applied depends on the nature of the soil, the lighter soils requiring the less, and the stronger the greater quantity. On light turnip soils, some think 120 bushels per acre sufficient, whilst I have used 180 bushels, with benefit. I have seen as much as 510 bushels applied to the acre of wheat land, with manifest advantage. But perhaps from 150 to 240 bushels

may be considered average quantities, from the lightest to the heaviest soils. On weak moory soils, 75 bushels are enough with which to commence its improvement.

The sort of lime should determine the quantity applied, the stronger being used in less quantity than the weak. The English lime is much more caustic than the Scotch. Lime with any magnesia in it is unfit for the land.

It is not customary to apply lime often to land, it being inexpedient to apply it oftener than once in a lease of 19 years, on account of its expense.

Its common price is 2s. per boll of 6 bushels, consequently its entire cost, at the above quantities, will be from £3. 15s. to £6 per acre for the best seaboard English lime, exclusive of carriage; the Scotch sells for 10s. per cart-load of 4 bolls of 6 bushels each, including carriage for 5 miles, which makes the cost from £3. 3s. 6d. to £3 per acre.

Lime weighs from 75 lb. to nearly 1 cwt. per bushel, which indicates that it ought not to be laid on by the measure alone, but by measure and weight combined, giving the preference to the lightest weight.

Lime is applied at different periods of the year, according to the state of the land. On summer-fallow it is applied immediately before the wheat is sown in autumn. It is also used for wheat immediately after taking up the potato crop in autumn. It is applied to the land cleared of turpins by sheep, just before the sowing of the barley-seed in spring. It is also applied before the turnip-seed is sown in the beginning of summer. It may be applied to oats immediately before being ploughed for lea in early spring. I do not say it is immaterial to the proper use of lime to choose the season in which it is applied, convenience often determining the point as much as propriety; but experience has decided that it is used to the best advantage on summer-fallow, and after turpins have been eaten off by sheep.

The effects of lime are manifested in a rather remarkable manner. When ploughed down with an ordinary furrow by itself, no effect is observed on the first crop; and when ploughed in deep, a rotation may pass before it shows any effect. When harrowed in, and the land ridged for barley after turpins eaten off by sheep, it has effect at once. When ploughed with a light furrow above the dung in summer-fallow, even after the lapse of a few weeks it has a sensible effect on the first crop. It has the best effect on the grass of any crop in the rotation and most upon the clover. It has an injurious effect on the potato crop. It loses its effect on the same land after several repetitions. It has little effect on soils in the neighbourhood of large towns. It has always a good effect on fresh soil, as also on moss that has been thoroughly drained. It has a good effect on all drained soils, and is wasted on undrained ones.

Lime is usually procured in summer and autumn, as the kilns are only kept in activity in those seasons; so when it is intended to apply it in spring, it is necessary to procure it in autumn, and keep it all winter. And we present to our readers the following table.

The effects of shells should be covered with a thick coating of earth, and every coveit that appears in it should be immediately filled up. I am aware of the opinion of some farmers, that lime is equally efficacious in the soil in the caustic state, and in the state of a hydrate; and, therefore, precautions to preserve it in a caustic state in winter may, by them, be deemed unnecessary; but as the general opinion is in favour of quicklime, and which I support, I have treated the subject accordingly, until experience shall instruct us better. There is the advantage, however, in using quicklime, that it is more easily spread upon ploughed land, and mixed with the soil than effete lime; and if pulverisation be of any use to it, it should mix with the soil, and act with it more quickly than in an effete state.

To the ordinary use of lime, as I have described it, chemistry might object to its application so close to farmyard manure as it is in summer-fallow. It is entirely right avoiding to apply it with or near guano, as it will entirely deprive it of its ammoniacal ingredients. But it is not easy to avoid its proximity to manure, when it is considered that it cannot be applied at any time in the course of a rotation, and that a considerable time is required to collect so much of it as will spread over a large space of ground; and that if a large space is not limed when it is applied, time will not be afforded the tenant to lime all his farm, and derive all the advantages from it, in the course of a 19 years' lease. Suppose that he limes entire fallow-break every year, he cannot go over his farm in less than four or five years, and this space is as much as he can lime in the course of a year and carry on the culture of the farm at the same time.

If we take the time the farmer has to apply lime, we shall see that he can scarcely avoid applying it near a recent period of manuring. When it is applied on bare-fallow, it must be immediately above the manure, when placed below it, the lime sinks out of reach. When applied to the potato land after the crop has been lifted, it follows the large manuring the potatoes had received late in the spring. The liming land after turpins in spring follows the large manuring which the turpins received in the early part of the preceding summer. When put upon land that has been manured by sheep eating off turpins, it is placed still nearer the manure. Liming land in preparation of the turnip crop, is the early part of summer, places it as near the manure. Lime cannot be applied to any of the cereal crops when they are growing, and it cannot be put on grass land that is to be sown or pastured in the same season.

Thus, neither in spring, summer, nor autumn lime is applied to the soil without coming into near contact with manure; and as to applying it in winter, it is out of the question, when a large quantity is to be used. The rain and snow which prevent its being harrowed in after being applied, and which may prevent the liming proceeding at all after a portion of the field has been limed. After all, as lime is applied only once in a lease, it matters little that it be put upon the land near a manuring; the important point is to apply it at the best and most convenient time, which is in the fallow; and experience has obtained the best return from its use, both in grain and straw.

A top-dressing of chalk is one method adopted in several districts of England—in Essex, Hampshire, Wiltshire, Lincolnshire, Yorkshire, for affording calcareous matter to the soil. It has a striking effect at first, par-

ticularly upon fresh new broken up land; but at length it seems to lose its efficacy. It is applied again whenever its effect becomes inert.

The solid chalk of the lower stratum is preferred to the more porous substance near the surface. It is taken out of pits in lumps, which are put upon the ground to be limed; and, the lumps being wet, the frost in winter causes them to fall down into a powder, which is then spread over the surface of the ground. Dry chalk will not fall down, and is therefore useless for the purpose. Chalk is used in Hampshire to render the soil more loose, and in the woods of Yorkshire more firm. I would conclude from this that the Hampshire soil is clayey, and that of the woods of Yorkshire silicious.

The quantities applied vary in different districts. In Essex, in the clayland district, about 15 cart-loads, of 40 bushels each, are considered a full dressing per acre, at 6s. per load, and 3s. 6d. for carting one mile; but here the expense does not bear carriage farther than four or six miles, beyond which lime is preferred. In Lincolnshire 80 cubic yards of chalk are applied to the acre, at a cost of 60s. In Hampshire it is dug out of pits as deep as 20 feet, and 2000 bushels are wheeled on the land in barrows at a cost of about 45s. per acre. In the district of Windsor, where it has to be carted ten miles, it cost about £8 per acre.*

I have already referred to shell-marl as a manure, in (4099). The composition of peat shell-marl of Logie, in Forfarshire—a county which at one time afforded and used a large quantity of this substance in its agriculture, to a degree to be positively detrimental to its soil, some of which has not recovered its effects to this day—is as follows:—

Top of the bottom of the bed.

Carbonate of lime,	77.4	81.7
Oxide of iron and alumina,	1.8	0.6
Organic matter,	11.0	14.6
Insoluble, chiefly silicious matter,	6.0	3.1
	100.0	100.0

Bog-marl retards the ripening of the grain crops, while lime hastens their maturity. The prices of marling as practised in England is very similar to that of gauting or claying, already described in (2110).—The marl is a clay containing particles of chalk, which are quite visible in the mass of clay. The marl is applied both to heavy and light land. On heavy land it is used on new broken up pasture and mixed with farmyard manure in compost. On light soils it is more extensively employed, and its benefits are derived from an improved texture of the soil. From 40 to 50 cubic yards are applied per acre, at a cost of 7s. per cubic yard if not dried, or 9s. further than a fulling and beyond that distance one penny per furlong is paid. Its action produces better quality of grain and regularity of crop. The excess of organic matter in a new soil loosens it, which the marling corrects; the dry and loose texture of sand is rendered more adhesive by consolidation, and is benefited by consolidation.

The following analysis may give a fair idea of the composition of clay marl. This specimen was found in Ayrshire.

Carbonate of lime,	84.7
Oxide of iron and alumina,	2.2
Organic matter,	2.8
Chalk and silicious matter,	84.9
Water,	1.4
	96.7

The lime used in the agriculture of this country is chiefly derived from the mountain limestones of the carboniferous series, as also that of the coal formation. The rock forms a broad belt across the centre of Scotland, along the centre of England, and in the whole of the centre of Ireland. Lime in Scotland is mostly derived from the coal formation, where it is associated with shales, sandstones, and ironstones.

In Ireland large beds and knolls of limestone nodules, in the form of gravel, are found in many districts. The gravel, when laid upon the land, acts as lime in the course of time; and it affords a very ready means of reclaiming drained bogs, and of reducing their vegetable to earthy matter, (5891).

The composition of some good limestones for agricultural purposes is here given:—

Carbonate of lime,	95.71	91.55	93.59	92.97
Sulphate of lime,	0.83	0.23	0.22	..
Phosphate of lime,	1.14
Carbonate of magnesia,	2.06	1.70	0.54	1.32
Alumina and oxide of iron,	1.53	0.73	1.28	1.57
Silica,	0.41	2.92	2.95	3.11
	100.00	100.00	100.00	100.00

Limestone, on being broken into handy lumps, is packed in alternate layers with coal in kilns and burned, when a very material effect is produced upon its appearance and character. From being a close-grained, hard, heavy stone, it is reduced to a porous, light, splintery cinder. One ton of limestone, when thus burned, yields 11 cwt. of the cinder. The cinder is called *lime-shells*. The burning has the effect of driving off water and carbonic acid from the limestone; of forming gypsum with the sulphur of the coal, and with the pyrites of the limestone; and silicates of lime with the silicious matter present in the limestone and the coal.

Lime-shells have a strong affinity for water; they will extract it from the atmosphere and become in time slaked, which is the end aimed at in putting lime-shells on the land in small heaps along the ridges; but they are more commonly slaked by water being poured upon them. The pouring water too quickly upon the shells causes the lime to be gritty, and to contain many small lumps which refuse to be slaked. The spontaneous slaking is attended with the least trouble as usually practised, but in effect it chills the surface and produces much gritty lime; and it gives sufficient time for much of the powdered lime to absorb carbonate acid from the air, and so go back to the state of carbonate and become effete. To succeed well with the spontaneous mode of slaking, the heaps should be covered with straw, which is a requisite which no farmer will undertake with heaps lying on the field. Farmers will willingly cover large

heaps of lime-shells that are to remain over winter, to be spread upon the land in spring, by which time most of the lime will be found slaked in an excellent state for mixing with the soil.

In slaking lime-shells, an intense heat is produced, a large quantity of water is absorbed, much increase of bulk ensues, and a fine powder is obtained, which is called *quick-lime, caustic-lime, hot-lime*. It is called in some cases *white lime* or *gunpowder*; the lime absorbs about one fourth of its weight of water; it increases from 2 1/2 to 3 times its bulk; and the powder has strong caustic and alkaline properties. The ultimate results are, that the slaked lime consists partly of caustic lime, partly of carbonate of lime, and partly of hydrate of lime, somewhat in these proportions in the ton:—

Carbonate of lime,	Per cent.	Wt.
Hydrate of lime,	37.4	111
Caustic lime,	32.1	97
	100.0	308

The composition of the limes obtained from the limestones mentioned above, (6035), with the exception of that of Relig. is as follows:—

Carbonate of lime,	89.78	89.77	88.84
Sulphate of lime,	1.45	0.38	0.51
Phosphate of lime,	1.52	1.02	0.42
Magnesia and oxide of iron,	2.70	1.23	1.98
Silica in the state of silicate,	0.79	1.24	3.39
Carbonic acid and moisture,	1.09	2.68	3.87
	100.00	100.00	100.00

The purer lime, it is considered, the better for agricultural purposes; it is then said to be in the finest and strongest state. The limes whose analysis appears above, it would seem to me that the Kidhead is the best for applying to the land. Plasterers like fat lime, as it runs best and makes the strongest putty. When a considerable proportion of sand occurs it is the better adapted for common building purposes, as it then requires less sand to convert it into good mortar, and the natural union of silicious matter is much better than any artificial method of adding it can be devised. Of these the Cockerthorpe is the best for buildings. Much magnesia in lime is hurtful to vegetation, and is therefore unsuited for the land; but it is a useful ingredient in lime intended for buildings under water, such as piers and docks, where it becomes very hard, and on that account is called hydraulic lime. Of these limes the Carlisle would seem best suited for building piers; but the proportion of magnesia in it is but small compared to many of the magnesian limes of England, as at Hardopole, where it contains about 45 per cent of the carbonate of magnesia, a ton of which affording no less a quantity of the calcined magnesia of the shops than 9 1/2 cwt.

The practice hitherto has been to apply a large dose of lime at once, and not to repeat it during the lease. The motive for this practice I would not venture to conjecture; but the tenure of his farm, than to any reasonable expectation entertained by him of the action of lime upon the soil in large quantity. It is felt with the application of lime as with the draining of the farm—the sooner it is done, and the sooner done, the greater profit to him who does it. The opinion is gaining ground, however, that it is better for the tenant's interest to lime in less quantity at a time, and more frequently. It would appear, taking the average of the quantities of lime applied in different districts of the country, that about 9 or 10 bushels per acre per annum are applied to supply the supposed requirements of the land. It might, therefore, be better for the tenant, and more productive for the owner, to lime the soil every year during the lease than 160 to 200 bushels per acre at one time at its commencement.

There is no doubt that lime is an exhausting substance for the land. Long ago it was quite common in Scotland for tenants, who grudging to purchase manure, to procure lime and apply it as manure, just as the bog-marl was used, until the land was rendered almost incapable of growing any crop, when it was laid down to grass to rest for a number of years. The various substances of the soil, organic and inorganic, are more rapidly set free after lime has been applied than before; and, on being set free, the roots of plants obtain them the more readily and in greater abundance; and then, as the plants themselves grow more rapidly and to a larger size, and perfect all their parts more completely, they will carry off a larger quantity of matter from the soil, which if not replaced in some way, the soil must become exhausted. If more lime is applied to correct the evil, the exhaustion will become the more severe.

Over-liming was an evil which the land suffered in a former generation more than in this; and when it occurred was confined to poor weak soil, that was soon rendered too loose by the use of the plough. It is therefore quite correct what Professor Johnston says, that "the evil called overliming is a mechanical, not a chemical one." The extreme openness of the soil has been brought on by prolonged ploughing, and too frequent cropping of corn. An opposite procedure must therefore be adopted, and mechanical means employed, by which a gradual solidification may be effected, among which none is more effective than the casting off turpins by sheep on the land.

A compost of lime and earth is a better top-dressing for grass land than either separately. Such a compost is usually made one cubic yard of lime to three cubic yards of earth. The mixing of such a compost costs 1d. per cubic yard of the mixture.

The appearance of the white clover, *Trifolium repens*, on top-dressing healthy soil with lime, is a well-known and remarkable phenomenon. Lime extricates the corn nodule, *Chrysanthemum setigenum*, but it encourages the red poppy, *Papaver Rhoeas*; and on sowing in strong clay soil it favors the growth of cut's foot, *Tussilago farfara*.

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Johnston On the Use of Lime in Agriculture, p. 11.

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In slaking lime-shells, an intense heat is produced, a large quantity of water is absorbed, much increase of bulk ensues, and a fine powder is obtained, which is called *quick-lime, caustic-lime, hot-lime*. It is called in some cases *white lime* or *gunpowder*; the lime absorbs about one fourth of its weight of water; it increases from 2 1/2 to 3 times its bulk; and the powder has strong caustic and alkaline properties. The ultimate results are, that the slaked lime consists partly of caustic lime, partly of carbonate of lime, and partly of hydrate of lime, somewhat in these proportions in the ton:—

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	100.0	308

The composition of the limes obtained from the limestones mentioned above, (6035), with the exception of that of Relig. is as follows:—

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Carbonic acid and moisture,	1.09	2.68	3.87
	100.00	100.00	100.00

The purer lime, it is considered, the better for agricultural purposes; it is then said to be in the finest and strongest state. The limes whose analysis appears above, it would seem to me that the Kidhead is the best for applying to the land. Plasterers like fat lime, as it runs best and makes the strongest putty. When a considerable proportion of sand occurs it is the better adapted for common building purposes, as it then requires less sand to convert it into good mortar, and the natural union of silicious matter is much better than any artificial method of adding it can be devised. Of these the Cockerthorpe is the best for buildings. Much magnesia in lime is hurtful to vegetation, and is therefore unsuited for the land; but it is a useful ingredient in lime intended for buildings under water, such as piers and docks, where it becomes very hard, and on that account is called hydraulic lime. Of these limes the Carlisle would seem best suited for building piers; but the proportion of magnesia in it is but small compared to many of the magnesian limes of England, as at Hardopole, where it contains about 45 per cent of the carbonate of magnesia, a ton of which affording no less a quantity of the calcined magnesia of the shops than 9 1/2 cwt.

The practice hitherto has been to apply a large dose of lime at once, and not to repeat it during the lease. The motive for this practice I would not venture to conjecture; but the tenure of his farm, than to any reasonable expectation entertained by him of the action of lime upon the soil in large quantity. It is felt with the application of lime as with the draining of the farm—the sooner it is done, and the sooner done, the greater profit to him who does it. The opinion is gaining ground, however, that it is better for the tenant's interest to lime in less quantity at a time, and more frequently. It would appear, taking the average of the quantities of lime applied in different districts of the country, that about 9 or 10 bushels per acre per annum are applied to supply the supposed requirements of the land. It might, therefore, be better for the tenant, and more productive for the owner, to lime the soil every year during the lease than 160 to 200 bushels per acre at one time at its commencement.

There is no doubt that lime is an exhausting substance for the land. Long ago it was quite common in Scotland for tenants, who grudging to purchase manure, to procure lime and apply it as manure, just as the bog-marl was used, until the land was rendered almost incapable of growing any crop, when it was laid down to grass to rest for a number of years. The various substances of the soil, organic and inorganic, are more rapidly set free after lime has been applied than before; and, on being set free, the roots of plants obtain them the more readily and in greater abundance; and then, as the plants themselves grow more rapidly and to a larger size, and perfect all their parts more completely, they will carry off a larger quantity of matter from the soil, which if not replaced in some way, the soil must become exhausted. If more lime is applied to correct the evil, the exhaustion will become the more severe.

Over-liming was an evil which the land suffered in a former generation more than in this; and when it occurred was confined to poor weak soil, that was soon rendered too loose by the use of the plough. It is therefore quite correct what Professor Johnston says, that "the evil called overliming is a mechanical, not a chemical one." The extreme openness of the soil has been brought on by prolonged ploughing, and too frequent cropping of corn. An opposite procedure must therefore be adopted, and mechanical means employed, by which a gradual solidification may be effected, among which none is more effective than the casting off turpins by sheep on the land.

A compost of lime and earth is a better top-dressing for grass land than either separately.