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THE BENEFICIAL EFFECTS OF LIME

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When asked about the beneficial effects of lime on the land, the writer of this bulletin calls to mind a vivid impression received when visiting a downlands farm in Canterbury a year or two ago. The farmer, a keen progressive man, had been improving his downlands over the past ten years by a steady programme of ploughing, heavy liming, and resowing followed by liberal topdressing with phosphate. His grasslands were about as splendid an example of good pasture as could be seen anywhere, and they have featured recently in provincial pasture competitions. Against the background of the adjoining undeveloped browntop country they stood out like green postage stamps on brown paper wrapping. It was not this, however, that impressed the writer, since such contrasts are a common enough illustration of the invigorating effects of adequate liming. What was so striking was the effect of the liming on the porosity and drainage of the soil. These downland soils, which occur widely down the east coast of the South Island, are generally compact, stiff and poor in their drainage, especially where they were over-cropped in their early days, and they have consequently won the reputation of being cold and wet in winter. Winter poaching of pastures is a common trouble, and experience has taught that it is unwise to venture over them with anything on wheels at that time of the year. Well, the contrast between that general situation and the conditions obtaining on these lime-improved pastures was remarkable. The top soil was full of earth worms; their casts were everywhere, and so much had they opened up the soil by their burrowings that when a soil sampling tube was pressed into it the cores of soil were found to be telescoped to two-thirds or less of their original length. The whole soil was literally puffed up to that extent, principally by the activity of earthworms, which always thrive most in a lime-rich soil. The farmer confirmed that of recent years his land had improved immensely in drainage, poaching had ceased to be a serious trouble, and he could often take a car over paddocks where such means of transport would have been quite out of the question before. A more valuable consequence of this opening up process was that the soil warmed up more quickly in the spring and pasture growth commenced a week or two earlier.

These beneficial physical effects of liming are seen, too, when well-limed pastures come to be ploughed. This was well illustrated a number of years ago on the Lincoln College farm. Shortly after Professor E. R. Hudson took over as director in 1936 he inaugurated a regular and full liming programme on all pastures on the College lands. A few years later when the first of these went under the plough, the improvement in the tilth of the land was noticed at once and is still talked of by some who remember the occasion. Land that used to turn up "like bars of soap," as one man put it, now presented a strong granular appearance and only required half the working down to produce a much better seed bed. The economic benefits associated with these two improvements in the physical properties of soils, if they were the only ones derived from liming, might well be sufficient to justify the cost of liming.

There are of course many other recognised improvements credited to lime, but these **physical** improvements have been emphasised first because they appear to stand quite unquestioned by the present wave of doubt that has assailed many minds following the demonstration of the magical effects of small traces of molybdenum. One cannot talk about the benefits of liming **today** without mentioning the fact that on certain acid soil types, in certain districts, two ounces of sodium molybdate per acre have been shown to produce as marked an improvement in the growth of clovers (and various arable crops too) as is commonly obtained by dressings of as many tons of lime per acre. Now, the improvements in pasture quality and cropping power brought about from one end of New Zealand to the other by adequate liming are so considerable that New Zealand farmers have come to use over one and a quarter million tons of limestone every year; and the suggestion that perhaps after all a trace of molybdenum included in the super would have done as much good is a bit unnerving, especially to those with money and time invested in the lime industry. Can it be that all this money and effort in the production and spreading of lime is being wasted? The writer of this bulletin does not think so. We have much to learn yet of the effects of molybdenum and its interactions with liming, so we cannot be dogmatic; but lime benefits the soil and its organisms and the plants and animals growing thereon in so many different ways that it hardly seems possible that molybdenum could serve as an all-round substitute for lime.

Although it is impossible as yet to give a definite and final answer to this important question, farming carries on, and decisions have to be made on whether or not to continue (and perhaps extend) the liming programme that has till now been found so profitable. It is with a view to helping farmers to weigh up this question in their own minds that this bulletin is attempting in its short space to review our present state of knowledge on the beneficial effects of lime.

In the first place, lime supplies an essential element, calcium, required in appreciable quantities as a nutrient not only by plants but also by growing and milking livestock. Molybdenum is no substitute for that essential element. Clovers and lucerne take up more calcium from the soil than most other farm crops, and there is no evidence, as yet, that this heavy withdrawal of calcium from the limited reserves of unlimed soils could be continued for long by clovers that are stimulated into greater activity by phosphate and molybdenum alone. In other words, we do not yet know how long this apparent lime-replacing action of molybdenum will last on any given soil. On the other hand, liming introduces soil and plant changes that often persist for a very long time. An extreme example of this is seen in some experimental plots on West Coast pakihi soils, which were heavily limed in 1916 and were reported to be still discernible after 30 years.

Lime reduces the acidity of acid soils (raises their pH) to those feebly acid levels nearer neutrality that are preferred by most farm crops and improved pasture species. The practical effect of this is a considerable increase in yields, often as much as twofold or more, and an improvement in uniformity and quality. It was long thought that it was the acidity itself that was suppressing growth. It is now known that most crops, even the lime-loving species, will tolerate a high level of acidity provided their nutritional requirements are fully met. But this is just where the naturally acid soil fails them, for in such soils a majority of the twelve essential nutrients are liable to be in short supply, either due to their being locked up in unavailable forms or to their being present in much reduced quantities owing to the intense leaching the acid soil has undergone. Liming sets in operation soil changes, both chemical and biological, which tend to remedy these deficiencies. The fixation of phosphorus is decreased; nitrogen, sulphur, calcium, magnesium and potash are made more freely available; and trace elements locked up in undecomposed vegetation are brought into use again.

One important exception to this dearth of nutrients in acid soils is the case of manganese, which, together with aluminium, sometimes becomes too freely available in strongly acid soils. The result is that plants absorb too much of these elements, the intake of other nutrients is upset, and growth is checked. Liming overcomes this trouble by reducing the solubility of manganese and aluminum to below the toxic level.

Thus it may be said that the liming of acid soils benefits plant growth not only by the direct action of reducing the degree of acidity of the soil, but also by a whole chain of indirect effects that go hand in hand with reduced acidity and benefit the nutrient status of the soil. Indeed it is doubtful if any one of the twelve essential nutrients is exempt from this influence. The considerable influence lime has in making other nutrients more available to plants has been strikingly demonstrated in some experiments carried out in Sweden. In that country the successful farming of large areas of strongly acid soils has been made possible by the practice of heavy liming. Recently, however, an investigator, starting with raw, acid soils and growing a variety of crops, has shown that the use of lime may be dispensed with altogether if the crops are nourished with fertilizer mixtures at unusually heavy and costly rates in addition to liberal applications of farmyard manure. Whatever may be the practical value to Swedish farming of this demonstration, the interest it has for New Zealand farmers lies in the evidence it provides of the power of lime to mobilise and put to use the soil's own reserves of plant nutrients, and so cut down on the more costly use of the fertilizer bag.

Perhaps the most important influence lime has on soils is in its effects on the beneficial living creatures that inhabit the soil, ranging from the visible earthworms down to the invisible bacteria and fungi. Earthworms do not thrive and multiply in acid soils, and one of the results of the neutralising powers of lime is that it enables the worms to increase in numbers and acivity, with the valuable results that were described on the first page of this bulletin. Less noticeable but even more important in fertile soils is the activity of a number of different species of soil fungi and bacteria, whose team work results in the decay and breakdown of dead plant tissues, first into humus and finally into the simple and soluble plant foods or nutrients, including all the major and trace elements, that those plants originally acquired from the soil. By this microbial activity, nutrients once taken up by plants are restored into circulation and a high level of fertility is maintained. In acid soils, however, these processes of decay are sluggish or even absent and fertility in consequence settles down to a low level, with little growth and a slow turnover of nutrients. The liming of such soils revitalises them by enabling the decay process to speed up. More nutrients are set free, more growth results, and more organic matter is returned to the soil. The wheels are turning faster, so to speak; the soil is more fertile. A good practical example of this is the way in which an acid sod of browntop when ploughed may be induced to rot down and yield its locked-up nutrients to the succeeding crop much more readily if the old turf is given a moderate dressing of lime before ploughing under. When this has been done a remarkable improvement in soil tilth and in the growth of the following crop has been obtained.

This action of lime in stimulating the beneficial processes of decay and promoting soil fertility, though set in train by artificial means (e.g., topdressing) is by no means an artificial or unnatural action, for it finds its counterpart in the more fertile virgin soils of all temperate lands. Wherever the combined influences of climate, vegetation and parent rock have in the course of time produced a highly fertile soil, we find that soil to be richly endowed with calcium (i.e., lime) as its predominant basic element, its reaction deviates but little from neutrality, microbial decay processes are active and plant nutrients are being liberated and taken up copiously by the established types of vegetation. An abundance of calcium is thus a normal characteristic of naturally fertile soils. In contrast to this there are situations in which the soil-forming processes have produced strongly leached highly acid soils of low fertility. These soils are deficient in calcium and display all the characteristics of deficiency or unavailability of nutrients, impeded decay and absence of earthworms already described. It will be appreciated therefore that the addition of lime to an acid soil inaugurates a series of chemical and biological changes which bring its condition nearer to that of nature's most fertile soils.

The foregoing observations on the processes of microbial decay apply to the nutrition of all kinds of plants; but, as is well known, there are in addition certain special types of soil bacteria that invade the roots of legumes, such as the various clovers and lucerne, where they cause to develop those little root-nodules in which nitrogen from the air is fixed or combined into forms useful to plants and to animals. It is a well-established principle of good pasture production that it is the nitrogen thus put into circulation by vigorous clovers that leads to an equally invigorated growth of grass coupled with a corresponding increase in the manurial return by the stock to the land. It has long been thought that it was the combination of lime and phosphate, supplied as topdressing, that was the dominant factor in stimulating that nitrogen fixation; and certainly practical experience has given ample support for the belief. It now seems fairly certain that molybdenum, too, comes into the picture at this point. Molybdenum serves not only as an essential nutrient required in minute traces by all plants, but also as a special requirement of the legumes, for it has been shown to play an essential part in the nitrogen-fixing process of the nodules. It has also been discovered in recent years that liming increases the availability of the very small amounts of molybdenum which most soils contain. These facts appear to offer at least part if not the whole explanation of the effects molybdenum has been giving in the absence of lime. They may be summed up as follows :—

Clovers have a special need for molybdenum to enable their nodule activity to proceed; but in acid soils molybdenum is held in an insoluble form. In such soils clovers are enabled to obtain their minute but essential trace of molybdenum either as a result of the soil being limed, (in which case heavy applications may be necessary if the molybdenum content of the soil is on the low side) or as a result of the direct application of the soluble salt, sodium molybdate.

This intriguing interaction between the effects of molybdenum and lime is being closely studied; in a few years' time it may be possible to give a more definite answer to the practical question it raises. In the meantime one feels fully justified in stating, with all due scientific caution, that lime exerts so many different beneficial influences on the fertility of acid soils that it is hardly conceivable that molybdenum could take the place of lime at every step. There is certainly no sufficient body of evidence as yet to warrant any general decline in the practice of liming. Lincoln College is continuing its normal liming programme.

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