PHOSPHORUS AND SULPHUR FERTILISATION : SOME RECENT INVESTIGATIONS IN CANTERBURY

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SULPHUR AND PHOSPHORUS

Although the importance of sulphur and its relationship to soil deficiencies has been realised for only the past 10 years in New Zealand, it is now history that it assumes equal importance with phosphorus for a very large area in the South Island.

In such a short period it is not possible to be sure of the proper extent of the deficiency, let alone study in any detail the necessary information for the longer term. Nonetheless a very worthwhile effort has been put into defining the extent of the problem in the South Island and this must lead to the conclusion that it is imperative to intensify and enlarge the effort into the more detailed aspects of the problem.

1 have no doubt that this will be done and no doubt that it will be done somewhat more expeditiously than, for instance, was so with investigation of phosphorus requirements over the past 40 to 50 years in New Zealand.

It has not been possible to draw many worth-while conclusions from the past topdressing trials concerned with the investigation of lime, phosphorus, and potash, in so far as they relate to our present problem. As the phosphorus factor in the very numerous experiments in the past studies was invariably superphosphate, we cannot now examine the relationship between the phosphorus and sulphur contribution from the results obtained.

Another intriguing factor in most fertiliser trials in New Zealand has been their short duration. This is understandable, as not much money has been devoted to the establishment of permanent research institutions to study long-term influences. It has been "sufficient unto the day" to find answers to immediate problems and this has, and still is, keeping us fully occupied for the most part.

However, this shortcoming may not be as serious as suggested, because in countries with a much longer history of fertiliser research the lack of exactness is much the same as here. In England, for instance, at Rothamsted, where fertiliser research originated, and at Cockle Park and such institutions, experiments on grassland and on crops have continued on the one site with the same treatments for from 60 to 110 years or more. Yet these experiments may not have given the answer necessary. They have,

however, provided a wealth of wonderful material for study and may yet answer many of the questions posed.

In New Zealand perhaps the oldest of our continuous fertiliser trials are those at the Marton Experimental Area in the North Island, where phosphate studies have continued on the one experiment for over 30 years. Such experiments, however, are the exception and not the rule, **but** more encouragement should be given to such studies of the long-term effects of fertiliser use for all types of deficiencies and problems.

The experiment I wish to deal with briefly at the moment is the superphosphate trial at Winchmore which was commenced in 1952. Although this trial is of comparative short duration, it is among the longest continuous ones on this class of soil.

The soil is a typical Lismore stony silt loam. It is in a 27 in. rainfall area about 550 ft above sea level and about 15 miles from the coast midway across the Canterbury Plains. These soils, and their allied types of greywacke origin, have a pH of about 5.2-5.3 in their unimproved state and are strongly responsive to phosphorus, sulphur, molybdenum, and/or lime. I do not intend to discuss the total deficiency problems in this paper, but mention could be made of the fact that the soils arc marginally deficient in potash, and possibly boron and manganese, although not too much emphasis should bc placed on these.

The intention is to deal with the relationship between sulphur and phosphorus and to this end we can eliminate the other factors as having been corrected.

In discussing the superphosphate trial we can in the first instance give the results as pertaining to one ratio of sulphur and phosphorus when applied in different rates of superphosphate. The rates under discussion are:

Nil
1½ cwt of super annually
3 cwt of super annually
4½ cwt of super annually
3 cwt of super annually in two I ½ dressings (spring and autumn),

Typical results from this experiment are summarised in the following table (1952-1959):

TABLE 1

Cwt/acre	D.M. lb/acre	Grazing Days per acre	Live-weight Gains lb/acre
0	4,634	2,307	471
I ½	8,783	3,691	675
3	9,564	4,089	742
4½	9,896	4,392	762
1½ + 1½	9.846	4,108	781

It will be seen from this there has been a doubling of production from the application of the phosphorus and sulphur in 1½ cwt of superphosphate. There has been a small but significant increase over these from the increased rates of 3 and 45 cwt, but the difference between these two rates is not significant. Nor has there been any advantage in applying the 3 cwt rate in separate 1½ cwt dressings in spring and autumn. In most years the yield from this split treatment is almost identical with the one application (autumn) of 3 cwt per acre.

Using this experiment, it has been possible to study a number of the effects of these superphosphate applications.

Topdressing of several of the treatments was discontinued after the 1957 autumn treatments. From this it was possible to measure the residual effects of the previous six years of topdressing at 3 and 4½ cwt of superphosphate.

The following table gives the production for the 1961-62 year (last topdressing in residual plots 1957).

TABLE 2

Superphosphate cwt/acre	D.M. lb/acre
Nil	3980
1½	9210
3 (last applied 1957)	6780
4½ (last applied 1957)	8570
3	9860

* Has previously had a total of 18 cwt.
† Has previously had a total of 27 cwt.

There has been a steady fall off in production following cessation of topdressing and this has been more rapid on the area in which the previous topdressing was lower. Indeed the residual effect of the 4½ cwt dressings is fairly good, this still being almost equal to the continuous application of 13 cwt of super.

From other information, which I will not quote, it is interesting to note that the live-weight gains in both these residual treatments have remained relatively high. There are several possible explanations for this, which will require further study.

It has also been possible to examine the separate residual effects of phosphorus and sulphur on this area. It may have been reasonable to assume that after the previous applications of 18 and 27 cwt of super (or approximately 200 and 300 lb of phosphorus and 216 and 324 lb of sulphur) either one of these may have had a greater residual effect than the other, It would have been reasonable to assume that as sulphur was applied in this case as

the anhydride of gypsum it may have been leached from the soil and that a residue of unused phosphorus would remain. Some evidence, which as yet is far from complete, has been obtained on this and similar problems.

In examining the residual effects of sulphur and phosphorus separately, the following table is of interest.

TABLE 3

	Previous Super Dressings		
	Nil	18 cwt	27cwt
	D.M. lb/ac.	D.M. lb/ac.	D.M. lb/ac.
No P or S . . .	3,285	5,780	7,575
P	4,320	6,130	7,715
S	4,390	7,155	8,500
S + P	8,350	9,495	9,890

It is interesting to note the very good response to the application of phosphorus and sulphur together (at equivalent to 3 cwt of superphosphate) on the area, which had had no topdressing for the preceding six years. This was essentially a browntop pasture (irrigated). This increase is well over twice the production from the untopdressed plots.

The response to sulphate alone tends to be greater than the response to phosphate alone and the two together give a markedly bigger response after the 18 cwt treatment than from the 27 cwt treatment. This is in accordance with the information given in Table 2. It should be noted that production on the 27 cwt residual plots is still good after five years without topdressing.

The residual effects to low rates of topdressing tend to bc small and both sulphur and phosphorus deficiencies remain.

Jt was noted from Table 1 that split dressings of superphosphate had little beneficial effect (on total yield) when applied to the Lismore soils. However, that might possibly be a benefit from a split application of one or other of its components. This was examined where each was used in this way.

TABLE 4

Treatment	D.M. lb/acre
Control	3,480
P : single	3,500
P : split	3,540
P : single + S : single	6,500
P : split + S : single	5,980
P : split + S : split	6,540
P : single + S : split	6,570
S : single	4,690
S : split	4,280
P : single + S : single (spring)	6,140

It can be concluded from this that there is no advantage in splitting the application of the component parts of superphosphate on these soils.

So far the ratios considered in these experiments have been those pertaining to equivalent rates of superphosphate. Work is now being done on variable ratios of sulphur to phosphorus, but only the section on topdressed irrigated pasture has been completed. This work is being done on dcyland and unimproved areas of the same soils to see if the same relationships hold.

For the well topdressed irrigated pasture there is an increasing response to the increasing rates of phosphorus but not to the increasing rates of sulphur. All rates of sulphur used (equal to ¼ cwt up to 3 cwt of super equivalent) corrected sulphuc deficiency. From this evidence it would appear that for such conditions super should be "fortified" with phosphorus rather than with sulphur.

This experiment is now being taken through a fertility-depleting cycle to examine the influence of this on the sulphur cycle. When this and the dryland and unimproved experiments are complete we will have a better understanding of the fertilisers to use for these areas.

Forms of sulphur, fineness of sulphur, and forms of phosphorus are also under study.

Of the forms of sulphur I quote only the completed trial with gypsum, flowers of sulphur, and coarsely ground sulphur.

TABLE 5

	D.M.	D.M. Yields lb/acre Relative		
Treatment	**1961-62**	**1961-62**	**1960-61**	**1959-60**
Control (P)	**6,250**	100	**100**	100
Gypsum ..	**8,130**	130	**122**	**107**
Flowers ...	**8,220**	**132**	117	**103**
Coarse	**6,720**	**108**	103	**100**

Whereas gypsum and flowers of sulphuc have given similar responses in this experiment, coarse sulphur has given little response. As the trial was irrigated, lack of moisture was not a limiting factor.

More information is being sought on availability and particle size of sulphur for both the dry and irrigated areas; IO-mesh screenings are being freely recommended as the sulphur to use in "fortified" fertilisers. This was based on a wild guess of mine that such a material would meet the main requirements of mixing,

distribution, and the correction of the deficiency. However, on examining lo-mesh screenings one finds they comprise a big range of particle sizes. For example, two lines gave the following analysis:

TABLE 6

Per cent:	A	B
Retained on 2 mm sieve	4	18
Passed 2 mm, retained 1 mm	17	28
Passed 1 mm, retained 0.5 mm	53	23
Passed 0.5 mm, retained 0.25 mm	14	6
Passed 0.25 mm retained 0.10 mm	6	10
Passed 0.10 mm	6	15

From these, four finenesses by four rates have been selected for trials. In the experiment quoted above the particle size of the coarse sulphur is not known.

Other work aims at examining the value of sulphur in various coals, and in comparisons of various forms of phosphorus.

Most of the work has been aimed at determining maintenance fertiliser practice for pasture land, and in a study of some of the fertiliser problems met in improving the lower fertility areas. A further study on the fertility demands of lucerne is, however, important, and since lucerne performance occupies a portion of this conference I would make the following brief reference to some aspects of this work.

Where hay is removed a good potash response develops.

TABLE 7

	No K	2 cwt	4 cwt	8 cwt
1959-60, 4 cwt	8,540	8,850	9,050	9,290
1960–61, 4 cwt	9,560	10,230	10,430	10,580

The crop responds to molybdenum, boron, sulphur, and phosphorus. On Lismore soils these and potash should all be suspect when lucerne stands are unthrifty.

This summary is intended to indicate some of the information available on the sulphur and phosphorus problem of the main area of greywacke soils of the South Island.

DISCUSSION

Q. Referring to Table 5 in the trials with gypsum, flowers of sulphur and coarse sulphur you say the differences were not significant. Would you explain this?

A. You will see that in the relative yields there has not been a response to the coarse sulphur used in this trial. This does not mean that you will not get a response to all lines of coarse sulphur. The missing information is that the particle size of this particular line of coarse sulphur is not known. From other evidence it is well revealed that the average line of 10 mesh screening will give reasonable responses; they are not as good as from flowers of sulphur or from gypsum. We are interested in what you do actually recover by way of sulphur response from the actual particle size used. If you look back at the table that gives you the fineness in 10 mesh screenings you will notice that there is a big range of particle sizes. We do not know from which part the response is coming. We do not know if it is more desirable to supply 40 lb to the ac. of a mixture containing a range of these particle sizes, or to apply 5 lb per ac. of one containing only the small particle size. Until we get this information we cannot tell you the long term effect of sulphur topdressing when using 10 mesh screening in superphosphate. There is reason to suspect that when you are using a variable range of particle sizes and some is not available to the plant that you are losing some of the sulphur or you may have some effect on pH from this fraction the plant is not using. Until we have concluded these trials we will not know the answer.

Q. (1. Wardell): Because of the importance of this matter would Mr Lobb be prepared to give one of his celebrated calculated guesses as to the fineness of grinding of sulphur that should be adopted for fertiliser put out by the fertiliser companies?

A. My calculated guess is that it is going to be a fairly good rate of the fine particle size.

Comment (Prof. Walker): There are quite a number of experiments showing a superiority of gypsum over flowers of sulphur. As long as one is comparing them at somewhere near optimum rates, say about 20 lb or equivalent per acre, then flowers of sulphur has always been inferior to gypsum. But if applied at higher rates there is no increased yield of dry matter from the extra gypsum, but there is an increase in the yield from flowers of sulphur. What quantities of gypsum and flowers of sulphur are being compared here? What rate would you specify'?

A. The rates of the trial quoted here are equivalent to 300 lb of super, so that you are fairly near optimum level at which you would expect differences to show. Other factors are involved, which do not allow generalisation. We are doing the trial under irrigation and dry conditions, and I do not think the results will be the same. There is evidence to suggest that when using gypsum under moist conditions you lose some sulphur by leaching and the plant is not able to utilise it. We are concerned with the influence of levels of moisture on the return of sulphur. Irrigation doubles the amount taken up in the sulphur cycle, and the removal of sulphur is rapid. However, maintenance is not going to be difficult, and this is shown in the trial, where, with increasing rates of sulphur on irrigated pasture, you are carrying 6–7½ ewes per ac. Here sulphur deficiency is corrected at quite low applications, but phosphate deficiency keeps on rising. We will have to have results from both the dry and wet, before we can determine the recovery of sulphur from the various particle sizes, and give recommendations for its use.

Comment (T. Ludecke): We have had very similar results in a trial in Central Otago with different rates and forms of sulphur under 16 in. rainfall.