THE USE OF PHOSPHATES ON SOME MAJOR WAIKATO SOIL TYPES

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Since the advent of topdressing with phosphates the productive capacity of the Waikato has enormously increased. Similar dramatic increases have become evident elsewhere where much the same conditions applied.

Arising out of this fact has been the assumption that to achieve still higher production heavy topdressing, with artificial fertilisers will be necessary. So frequently has this viewpoint been stated that it has stimulated many comments of an opposite nature, many of which tend to discount the role which might be played by phosphatic fertilisers in those areas which already have a history of heavy topdressing applications. The protagonists of the latter view draw support for their conclusions from W. M. Hamilton's survey of the dairy industry and from the often expressed opinion that during fertiliser rationing production did not decline.

To examine the evidence concerned with both viewpoints. is the purpose of this paper.

The position has perhaps been most clearly stated by A. H. Ward in his paper delivered to the New Zealand Society of Animal Production in 1953 in which he pointed out that the fertiliser bill footed by the dairy industry alone amounts to $5 or £6 million annually and constitutes the greatest single item of cost in dairy farm working and maintenance charges.

He goes on to say: "What is needed therefore is information of a more precise nature on the question of the economy of application of phosphatic fertiliser in place of the nebulous information available at present." Mr Ward apparently believes, therefore, that it should be possible to give more exact information.

In his very able and stimulating address to the Dairy Farmers' Conference at Massey College recently,

Dr. J. Melville said: "As you are all aware, up till a very few years ago the topdressing of dairy pastures meant only one thing to 98 per cent. of our dairy farmers, viz., the application of superphosphate. On the principle that you cannot have too much of a good thing, many dairy farmers have been applying annual dressings of 3, 4, 5 and, even 6cwt per acre. There is very good evidence that this wholesale use of phosphate is not increasing productivity in the slightest degree, and that in many cases severe reductions in rate would be entirely justified."

Two important aspects of the work carried out at the Rukuhia Soil Research Station have been the study of the critical phosphate response levels and phosphate maintenance requirements.

EVIDENCE FROM FIELD TRIALS

On a series of soil types close to Rukuhia Soil Research Station a number of trials were established with the objective of obtaining some information as to (1) the level at which no further response was obtained, and (2) the amount of phosphate necessary to maintain production.

The procedure which was common to all these trials was to compare a series of dressings at different rates where the phosphate levels had already been built up to a, high level by previous topdressings.

The first of these trials, 16/10/32, was established on Hamilton clay loam of moderate fixing capacity and on Ohaupo silt loam of high fixing capacity. The average soil test phosphate figure on the Hamilton clay loam plots was 10.5 and on the Ohaupo silt loam 8. Annual dressings of 0, 2, 4 and 6cwt. of superphosphate were applied.

There were slight increases in yield from all treatments when compared with control, but these did not achieve significance except in the winter of 1953 when 4 and 6cwt gave yields better than the other two.

A constant check on soil phosphate levels was kept during the two years, and though there was no increase in dry matter production, both soil phosphate and herbage phosphate increased, The following table sets- out the position relative to soil phosphate:

SOIL PHOSPHATE
(Mgs. of P_2O_5 per 100 gm. soil)

Soil Type	Original	Control	Zcwt	4cwt	6cwt
Hamilton clay loam	10.5	8.75,	10.5	12.25	14.75
Ohaupo silt loam	8.0	6.37	7.37	9.37	9.62

On trial 16/10/53, which was laid down in the autumn of 1953, with a soil phosphate test of 11 no significant response has been obtained from any of the treatments 0, 1½, 3, 4, and 6cwt of superphosphate.

On trial 16/10/47 on Hamilton clay loam no response was obtained to 0, 3, and 6cwt of superphosphate on a soil phosphate test of 9.

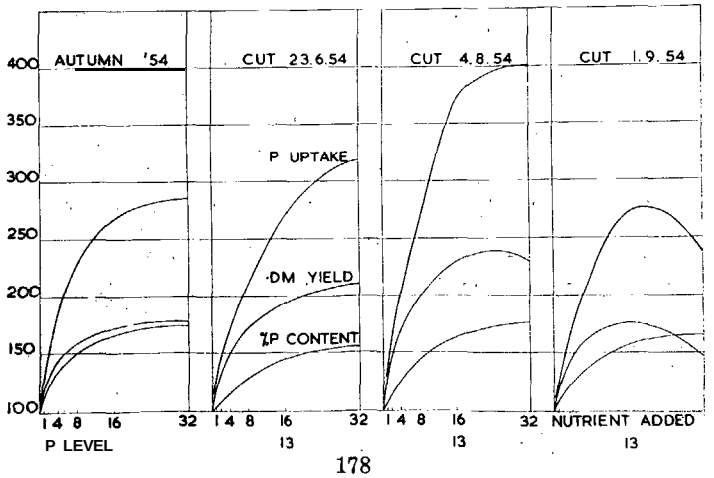
Trial 16/10/49 was established on Hamilton clay loam in the winter of 1952 at the soil phosphate level of 10.25 under mowing and clippings returned technique. An application of 4cwt of superphosphate increased the production 5 per cent. above control and the soil phosphate level to 11, but the latter dropped in two years on control plots to 7.

Trial 16/10/45 was established on Horotiu sandy loam in the spring of 1952 at different phosphate soil levels (from 4 to 8). Treatments: 1½, 3, 6 and 12cwt of superphosphate. This trial indicates that above the soil P level of 11 there is no further response to phosphatic fertilisers. The soil phosphate level on the highest treated plots has been built up in four years (1949-1953) by two tons of superphosphate from the original P level of 1.5 to the level of 14.

Trial 16/10/59 was established on Horotiu sandy loam in the autumn of 1953.

Treatments : Increasing applications of superphosphate from 0 to 32cwt. The soil phosphate level

THE RELATIONSHIP BETWEEN THE HERBAGE %P CONTENT, D.M. YIELD, P UPTAKE, AND THE ADDITION OF INCREASING AMOUNTS OF SUPER



on the heaviest treated plots has been built up in four years by three small applications (2, 3, and 3cwt) of super compound) and one heavy application of 32cwt of superphosphate. Similarly, as in the case of the previous trial, soil phosphate level of 13 has been attained by applying two tons of phosphate fertiliser. This trial shows very clearly that above the soil phosphate level of 13 the increase in yield, occurs only during the least favourable weather conditions (May, June, and July), but during the spring a depression in production follows.

Trial 16/10/53 was established on Horotiu sandy loam in the autumn of 1953 at the soil P level of 18.

Treatments: 0, 1½, 3, 4½, 6cwt of superphosphate and 2½ and 5cwt of fine ground Nauru. At the commencement of the trial all treatments showed a significant increase in production (winter 1953), which disappeared completely during the spring of 1953, summer of 1953-54, and autumn of 1954.

The soil phosphate reserves have been slightly decreased on control, 1½ and 3cwt of superphosphate treatments, and 4½ and 6cwt of superphosphate slightly increased the soil phosphate status.

The above high phosphate level was attained by seven annual applications of 6cwt of superphosphate and basic slag, excepting 1948, when 3cwt of superphosphate and 3cwt of North African phosphate was used. The latter fertiliser and the high pH (6.5) may partly account for the extremely high Truog test figures and an increase in production at this high level. In other trials on this soil type each hundredweight of North African phosphate increases the soil phosphate level by one unit.

Trial 16/10/31 was established on Horotiu sandy loam in the autumn of 1951 and shows that an annual application of 2cwt of superphosphate maintains the soil phosphate status at the level of 4. This trial is being grazed with dry stock and the drain on phosphorus is therefore at the minimum.

From the field evidence to date, which is admittedly still incomplete, the following tentative conclusions can be drawn:

1. That the critical phosphate response level is about 8 to 10 for Ohaupo silt loam; 10 to 12 for Hamilton clay loam, and a figure of 12 to 14 may be acceptable for Horotiu sandy loam.

2. At the above levels pasture production and

soil phosphate levels can be maintained on Hamilton clay loam by about 2cwt of super-phosphate and by 3cwt of superphosphate on Horotiu sandy loam and Ohaupo silt loam.

The above figures of the critical phosphate response levels are based on total annual production.

EVIDENCE FROM SOIL ANALYTICAL DATA

For some years now the Department of Agriculture has provided a soil analytical service for the farmer. Until the beginning of 1954 the service was free, but since that time it has been a paid service. Altogether something more than 12,000 samples are analysed annually and numbers continue to increase. Set out below is a table showing the available phosphate in mg per 100 gm in Truog extractant for about 9000 samples. They have been arranged in the order of samples showing the greatest deficiency being placed at the top:

Soil P. level	o-5 %	5-10 %	10-20 %	>20 %
Whangarei	181(74)	42(17)	16(6)	5(3)
Te Kuiti	412(67)	130(21)	55(9)	16(3)
New Plymouht	355(67)	111(21)	54(10)	10(2)
Stratford	245(66)	95(25)	30(8)	2(1)
Masterton	160(60)	40(15)	39(15)	27(10)
Hastings	222(57)	60(15)	43(11)	65(17)
Tauranga	333(50)	187(28)	116(17)	31(5)
Hamilton	1232(41)	1057(35)	571(19)	162(5)
Palmerston Nth.	258(41)	205(33)	141(22)	19(4)
Warkworth	171(37)	156(33)	111(23)	28(9)
Pukekohe	550(29)	693(37)	488(26)	160(8)
	4119(45.4)	2776(30.6)	1664(18.3)	525(57)

If it is assumed that the soil test procedure does extract a certain proportion of plant available phosphorus, and if due allowance is made for the occurrence of high fixing soils, it seems possible to draw the following general conclusions:

1. About half the samples examined revealed a definite low phosphate level, which must in general be well within the level at which phosphates could be expected to give good responses. Here the problem seems to be to continue the fairly heavy dressings, at present being used in the effort to build up soil phosphate levels,

2. About 30 per cent. of samples ranged between 5 and 10. Here the phosphate level can be regarded as reasonably good and the problem of these soils is largely one of raising the phosphate reserves of the

soils below the level of 8 and maintaining them within the optimum level.

3. 18 per cent. of the samples ranged between 10 and 20. Here the topdressing can be reduced or omitted for a few years.

4. There is a small percentage of samples (5.7. per cent.) where the level is very high and where topdressing should be stopped for several years until the level is within the recommended optimum.

Before the soil testing service was placed on a paid basis the demand for the service was heavy and could not be met by staff then available. It was therefore decided to run a group scheme in which samples from all farms in a group were collected and analysed. The following table sets out the position as revealed from these farms :

Soil P. level	o-5	5-10	10-20	>20	Tl.
Hamilton clay loam .	42(35)	53(44.5)	15(12.5)	9(7.5)	1 1 9
Horotiu complex .	49(42)	39(33.3)	27(23)	2(1.7)	117
Whatawhata clay loam	29 (24.2)	52 (43.3)	30 (25)	9(7.5)	120
Total . .	120	144	72	20	356
	34%	41%	20%	5%	

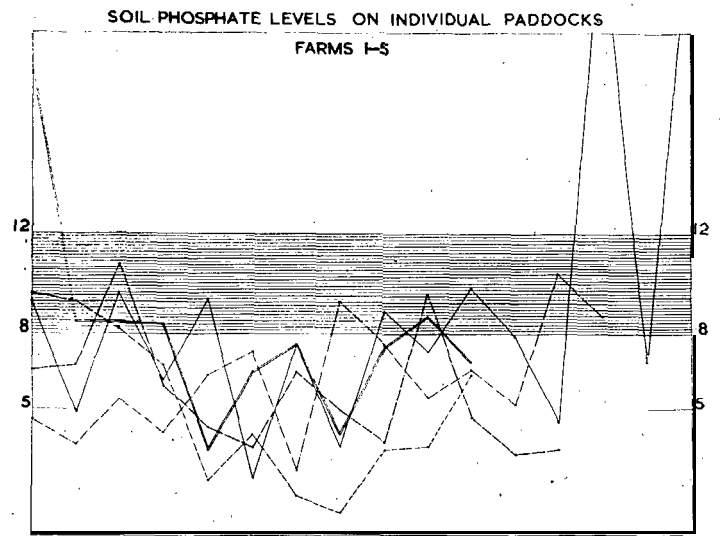
Here again it will be noted that one-third of all samples were definitely very low and would show high response to phosphate. The majority of samples ranging between 5 and 10 requires still more than maintenance requirements to build up soil phosphate reserves. The balance-about 25 per cent.-were at a high level, and here topdressing should be reduced or even omitted for a certain period.

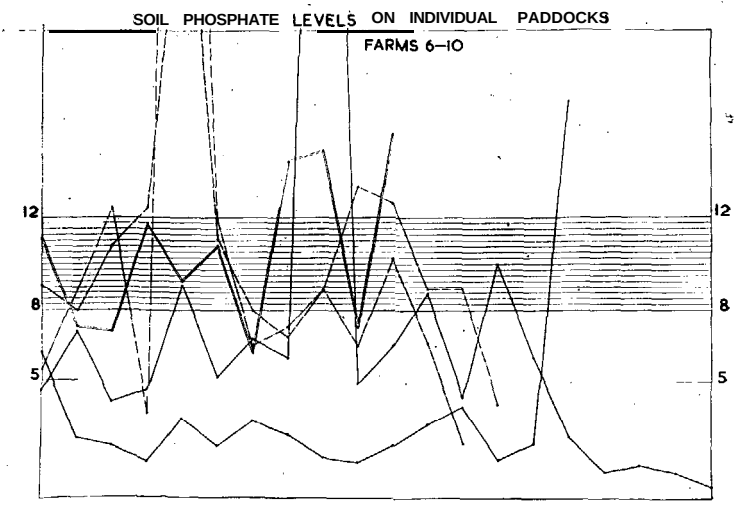
The highest percentage of low phosphate samples came from the Horotiu loam complex, the highest fixing soil type.

The following table sets out the phosphate levels on each paddock of the first 10 farms included in the Te Kowhai scheme:

Farm	Total Paddocks	Soil P. level o-5	5-10	10-20	>20
A	21	11(52)	9(43)	0(0)	1(5)
B	14	2(14)	7(50)	4(29)	1(7)
C	13	1(8)	7(54)	4(30)	1(8)
D	11	0(0)	5(45)	6(55)	0(0)
E	16	14(88)	1(6)	1(6)	0(0)
F	16	4(25)	10(62)	0(0)	2(13)
G	13	7(54)	5(38)	1(8)	0(0)
H	14	4(29)	9(64)	1(7)	0(0)
I	11	2(18)	8(73)	1(9)	0(0)
J	11	7(64)	4(36)	0(0)	0(0)
	140	52	65	18	5
		37%	47%	13%	3%

If the last two tables are considered together, it is obvious that the degree of variation within any farm is greater than the variation between soil types. This brings into sharp focus the effect of management on phosphate status and the importance of the previous history of treatments applied to the paddock. To illustrate this point still further the phosphate levels of individual paddocks have been graphed.





CONCLUSIONS

Evidence has been presented from certain field trials and from soil analyses which serve to indicate the danger of making generalised statements about topdressing practices. It has been shown, for instance, that even in the Waikato where heavy topdressing has been practised for many years many soils are still lamentably low in phosphate level and need the heavy dressings which are sometimes frowned upon. At the same time it has been shown that there exists a relatively small number of places where phosphate topdressing could be either reduced or omitted altogether for a period.

The problem is therefore not one calling for any generalised statement to the effect that "the Waikato should reduce the level of phosphate used," but rather that much more discrimination must be exercised in where and. how we use our fertilisers. In the opinion of the authors the soil testing service will form the basis to a more rational approach in the future than has ever been possible in the, past.

There is a tendency in New Zealand to judge the economy of fertiliser applications entirely on the basis of immediate response. It is exceedingly dubious whether this approach is sound. The heavier applications build soil phosphate reserves and the fact that these reserves are available becomes obvious when experiments are conducted to study residual effect. If the Waikato had not used fairly heavy dressings of fertiliser in pre-war years, it is certain that the impact of fertiliser rationing would have been much more severe than it was. It is hard to know just what we should be prepared to pay to maintain phosphorus reserves in the soil, but we should at least regard soil fertility as being as important as farm buildings and machinery; even these require a certain amount of maintenance.

Several surveys have shown that there is little, if any, correlation between rate of topdressing and production. While one must accept the evidence presented, it seems likely that part of the explanation must lie in materials other than phosphate being in limited supply, or in the fact that the use of phosphate on the individual farm is badly misdirected.

It is difficult to see any chance of the Dominion fertiliser bill becoming any lighter. We don't need less phosphate; we need more. We need more potash. We may even use much more nitrogen. By rationalis-

ing our approach we may, however, materially increase the efficiency of fertiliser practice, but to do this it would appear necessary to extend to other parts of New Zealand an intensified, programme of research designed to give more information on critical phosphate response levels and on necessary maintenance rates. If this information is used in conjunction with soil testing and the experience of local instructors gained largely from field trials, then the whole farming industry should benefit.

DISCUSSION

Q. In the trials was adequate moisture available ? There was an increased response in the wetter months, when presumably it was colder and production was falling off. This suggests there was not enough moisture in other periods.

A. There was not enough moisture all the year. But for the vast part of the trials moisture was not the determining factor. There was no additional response during spring and summer under irrigation.

Q. Was a basic potash dressing. applied or was consideration given to the application of different levels of potash in relation to the application of phosphate?

A. On Hamilton and Otaupo soil types there is no need to supply potash, as the level is high. Horotiu is deficient in potash and we have been applying 2cwt so that it is appreciably high.

Q. How was the phosphate fixation determined ?

A. Only on the basis of the Truog test extractant. We are doing it in the laboratory and can do it in the field by applying increasing quantities of superphosphate and measuring the phosphate level. Some soils fix phosphoric acid to a very great extent. Horotiu sandy loam is a high fixing soil and its maintenance requirements are high. On low fixing soils only low maintenance dressings are required.

Q. Could the speaker give an opinion on the practical value of heavy phosphate applications for short-term responses for out-of-season growth and on the effect of time of application ?

A. The virtue of heavy applications of phosphate for out-of-season growth is affected by the level at which you start. The return from that particular trial was related to the time at which the phosphate was applied. The levels of application and the returns depend on the levels at which you start. If levels are low at the start, there are bigger immediate returns. If they are high, returns are smaller.

Q. Can the scientists give us some catalyst to enable us to milk back some of the phosphate we have already paid for?

A. It's a good thing we can't tell you how to unlock the reserves of phosphate, because the extent to which it would be exploited would be to the utmost detriment of New Zealand.

Q. Was any work done on evaluation of phosphate and sulphate responses in the superphosphate trials ?

A. Trials were carried out with many other materials not containing sulphur and the level of responses was of the same order exactly.

Q. Were there any trials with reverted superphosphate to see if there was any addition to the build-up and retention of phosphate ?

A. There was not much evidence that this is so.