RATIONAL FERTILIZER PRACTICE ON PUMICE SOILS

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Summary

The recommendations for fertilizer mixtures currently in use on established pastures in Taupo County were derived from the results of field experiments and soil analyses. The time of application, and the composition, of these mixtures is governed by such effects as: the leaching of sulphate because of the generally low retention of sulphate by pumice soils; the build-up of phosphorus in the soil allowing phosphate applications to be reduced; the decrease in soil magnesium status due to applications of potassium.

INTRODUCTION

IN THEIR undeveloped state, the weakly weathered soils derived from rhyolite pumice ash are deficient in some of the nutrient elements necessary for plant growth. Field research, carried out since 1930, and reported by Smallfield (1949), indicated that applications of superphosphate would overcome these deficiencies. Smallfield also suggested that potassic fertilizer might have to be used after one or two decades of-dairying.

In the early 1960s, however, many farmers reported unsatisfactory pasture growth despite regular topdressing according to recommendation. This stimulated further research, both in the field and in the laboratories at Ruakura.

In the field the experimental sites were chosen to give as wide a coverage of the Taupo district as possible (Fig. 1). The deficiencies found were phosphorus, sulphur, potassium, molybdenum, and magnesium.

Although this work is by no means complete some useful conclusions have emerged, and these will now be discussed.

PHOSPHORUS

In spring 1964, 8 experiments were started in which were compared four rates each of phosphorus, as monocalcium phos-

phate, and sulphur, as gypsum, equivalent to nil, 1 ½, 3 and 6 cwt/ac superphosphate.” The fields chosen had, as a rule, all been topdressed regularly in the past with 2 to 3 cwt/ac superphosphate in autumn.

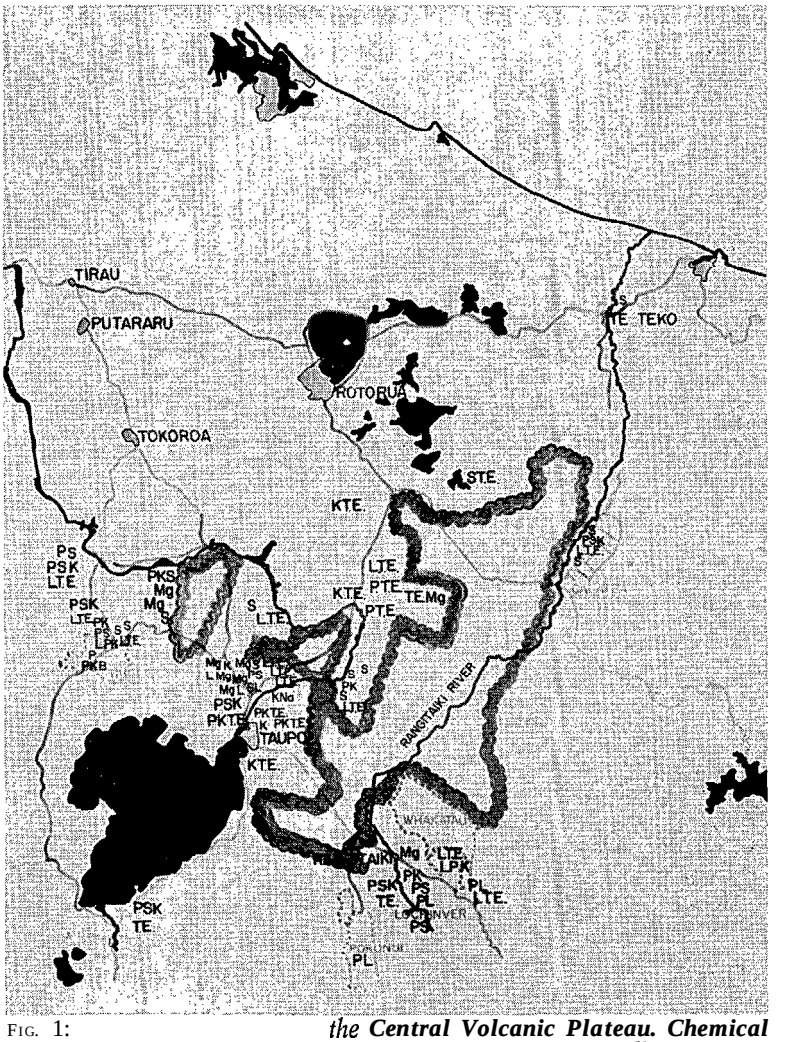

FIG. 1: *the Central Volcanic Plateau. Chemical symbols indicate the nutrient elements tested, except where limestone (L) or trace elements (T.E.) were used.*

*Superphosphate contains 9% P and 10-12% S (Lynch, 1966).

Small but significant responses in pasture yield were round to phosphorus, at rates corresponding to 1 ½-3 cwt/ac superphosphate, without any further increase from 6 cwt/ac. On these sites the soil P test ranged from 5 to 10. The absence of a response to P was associated with soil P tests above 10.

From the results of the field experiments, it seemed clear that the district rate of 2 to 3 cwt/ac superphosphate each year was adequate to maintain good pasture production on fields with a medium soil P test. It was apparent, however, that this rate could be reduced where the soil P test was high.

SULPHUR

Laboratory tests had shown that pumice soils under pasture generally had a low retention for sulphate (Hogg and Toxopeus, 1966) . This property seemed to have developed over a period of years as a result of regular superphosphate topdressing (During and Martin, 1968; Saunders and Hogg, 1971). In practice, this meant that sulphate applied as superphosphate in autumn might leach out of reach of pasture roots before the next application was due.

In spring 1964, a response in pasture yield to an application of sulphur was found in 19 out of 27 trials. These had been placed on obviously chlorotic pastures which in the main had been topdressed in the previous autumn. The responses were significant, at rates of sulphur equivalent to that in 1 ½ to 3 cwt/ac superphosphate.

In view of these results, alternative times of application of superphosphate were investigated in five experiments, begun in autumn 1965. The treatments compared superphosphate at 3 cwt/ac applied once in autumn or in spring, or at half rates twice a year. Also included were monocalcium phosphate (control), and 3 cwt/ac superphosphate fortified with 30 lb/ac sulphur, to see whether the additional elemental sulphur was necessary to ensure a full season of pasture growth not affected by sulphur deficiency.

Two experiments were discarded because of atypical soil profile characteristics which prevented free downward movement of sulphate (Toxopeus, 1970). Over a period of four years, the remaining three experiments were fairly consistent in showing that, when superphosphate was applied in autumn, the sward lost its vigour some months before the next topdressing was due. Pasture growth was satisfactory when superphosphate was ap

plied in spring. Split dressings tended to even out growth and, incidentally, to improve the sward. The effect of adding sulphur to superphosphate on pasture growth was small, and showed only towards the end of the autumn topdressing periods.

Although production data from experiments such as these are rather difficult to interpret, they suggest that no more than 3 cwt/ac superphosphate, applied in spring, should be adequate to maintain good pasture growth, on fields with a medium soil P test (5-10).

Where P test is high, less phosphate is needed, but requirements for sulphur are still the same. In this situation, the use of sulphur-fortified superphosphate would allow the reduction in phosphate, yet maintain the application rate of 30 to 40 lb S/ac.

POTASSIUM

Potassium deficiency was also thought to contribute to unsatisfactory pasture growth, in part because of the apparently irregular use of potassic fertilizer at the time of the investigations.

In a series of nine trials on pasture in spring 1964, nil, 1 cwt, and 2 cwt/ac KC1 were compared. On 7 sites, with a soil K quick test of 5 or less, a response to potassium was found, with little difference between the 1 and 2 cwt rates. This was irrespective of whether the field had been topdressed the previous autumn or the previous spring, The results suggested that a single dressing in autumn was insufficient to maintain pasture growth far a full season.

Therefore, this work was fallowed up on two sites with a trial evaluating time and rate of application of potassium. Applications of KC1 were made either once in autumn or spring, or twice a year, at ½, 1 and 2 cwt/ac. A control treatment of "nil K" was included.

Pasture yields were measured in both trials over a period at four years, and marked responses were found. Maximum production was attained with applications of 1 cwt/ac KC1 twice a year. However, the main period of responses was between October and March, and since little more was gained from the autumn application, 1 cwt/ac KC1 in spring seemed adequate to maintain good pasture growth under grazing.

On fields cut for hay, the removal of K would be greater than this, hence an application of 1 cwt/ac KC1 is advocated to follow.-each cut yielding approximately 40 bales.

Finally, in two fertilizer experiments with swedes, a response to potassium was found on soils with a quick test of 5. This

suggests that the fertilizer maintenance programme for pastures is also applicable to swede crops.

MAGNESIUM

Following earlier work by Moody (1962) and others on forest nursery sites, the first demonstration of magnesium deficiency in pastures on farmed pumice soil was near Rangitaiki in January 1967, on a site with a soil Mg quick- test of 3. Over the period of the trial annual applications of 1 cwt/ac kieserite*, 6 cwt/ac serpentine-supcrphosphate, or 2 cwt/ac dolomite had approximately similar effects on yield, Mg content of white clover, and soil Mg status.

In a subsequent series of 12 experiments on 'Waipahihi sand, with Mg soil tests ranging from 3 to 10, statistically significant responses to an application of 30 lb/ac Mg (as kieserite) were obtained with a soil 'test of 4, or less.

Field observations indicate that the' Mg status in pumice soils decreases under a system of continuous herbage removal, for example hay-making.

Applications of potassic superphosphate will also cause a decrease in soil magnesium. This problem may be overcome by adding magnesium to potassic fertilizer mixtures, and the cheapest effective form appears to be serpentine-superphosphate.

Where soil Mg tests are very low, and a fast-acting Mg fertilizer is required, 1 cwt/ac kieserite or 25 lb/ac magnesium oxide† (calcined magnesite) may be applied. The latter fertilizer, because of its lightness, could further reduce the cost of treatment.

TRACE ELEMENTS AND LIME'

Six experiments were also started in 1963 to evaluate the effects on pasture growth of molybdenum, copper, zinc, iron, boron, and lime, applied either singly, or in all possible combinations.

Some responses to molybdenum, copper and lime were found, but, although boron was also included in many trials conducted later, only molybdenum consistently stimulated pasture growth.

*A source of Epsom salt, $MgSo_4.H_2O$.

†Total Mg 15% and 56%, respectively.

MOLYBDENUM

The response in pasture yield to an application of 1 to 2½ oz/ac of Mo was of the order of 20 to 40% on the water-sorted pumice soils of the flats. Responses were also observed in one area of rolling hill country, after soil fertility generally had been raised to a high level. However, yield measurements afterwards failed to show significant differences. Borderline cases such as these are still under study. So also is the residual effect of a single application of Mo. Present indications are that this will be at least three years.

LIME

Although liming a pumice soil caused a change in pH in every case, only small responses in pasture yield were found, in 9 out of 18 trials conducted since 1964. These responses were of the order of 10 to 20%, and were found mainly on the water-sorted flats. They could not be attributed to the increased availability of molybdenum, as would usually be the case in other soils. Therefore, the use of lime on pumice soil pastures is at present not considered to be economically justified. However, research on this aspect is continuing.

CONCLUSIONS

(1) Because in pumice soils the reserves of major elements available-for plant growth are small, deficiencies of one or more of these can easily develop on soils not adequately fertilized.

(2) Although phosphate is the first requirement at the land development stage, the soil phosphorus status on established. pastures may be maintained at a satisfactory level by applications of 1 ½ to 3 cwt/ac super-phosphate, according to whether the soil P test is high ‘or medium.

(3) Sulphur deficiency can be prevented if superphosphate is applied either in spring or twice a year. An annual rate of 30 lb S/ac is needed, hence superphosphate should be fortified with sulphur when its rate of application falls below 3 cwt/ac.

(4) With satisfactory soil phosphorus and sulphur status, and soil potassium tests of 5 or less, responses to an application of potash fertilizer have been demonstrated in pastures and swedes. A maintenance rate of 1 cwt/ac KCl in spring each year will correct K deficiency and, where a field is cut for hay, 2 to 3 cwt/ac of 50% potassic serpentine-super-phosphate will replace most of the major nutrients thus removed.

(5) Magnesium deficiency is likely to begin affecting production of pastures on soils with a quick test of 5 or less. One or more applications of a fast-acting Mg fertilizer such as calcined magnesite, or kieserite, will correct this condition. To help maintain a satisfactory Mg status in the soil, the use of serpentine-superphosphate in potassic fertilizer mixtures is recommended.

(6) Molybdenum is likely to be deficient on the water-sorted soils of the valley floors and former lakebeds. An application of 1 oz/ac of sodium molybdate should last 3 years.

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DISCUSSION

Brougham (Palmerston North) asked if any comment could be made on the cost of the elaborate mixture mentioned. Gordon said it would be approximately $6/acre, but he stressed that it was absolutely essential to supply all the necessary nutrients to obtain optimum responses. Toxopeus stated that potassium and sulphur had to be applied annually, while a dressing of molybdenum every three years sufficed. As for cobalt, Gordon said that it was still applied annually. It was not certain that this was necessary, and studies were being begun to test this. White (Lincoln College) thought the average production of 5,000 to 8,000 lb DM/acre was rather low and wondered what the potential would be if advice. was followed. Toxopeus considered the present potential to be 8,000 to 10,000 lb DM/acre. Lack of earthworms and poor nodulation were still factors limiting production — remedying these would lift the potential to that of the Waikato. However, Gordon disagreed with this because of the climatic limitations of the area.