INTERACTIONS BETWEEN POTASSIUM, SULPHUR AND PHOSPHORUS ON VOLCANIC SOILS OF GISBORNE/EAST COAST HILL COUNTRY

M.H. Gray[1], C.J. Korte[1], and M.B. O'Connor[2]
MAFTech, Ministry of Agriculture & Fisheries
[1]Gisborne and [2]Ruakura Agricultural Research Centre, Hamilton

ABSTRACT

Pasture responses to potassium (K), sulphur (S), and phosphorus (P) fertilizers were measured for four years on four East Coast hill country sites with volcanic soils. Potassium at 120 kg/ha and S at 33 kg/ha were applied annually as split dressings in spring and autumn. Phosphorus was applied at 4 rates annually (0, 20, 40, 80 kg/ha).

At one site (soil 0-75 mm quick tests: sulphate S 9; potassium 7) no statistically significant ($P<0.05$) pasture yield responses to K or S were recorded. At the other three sites (soil sulphate S range 7-10; K range 2-4) pasture yield interactions between K & S were measured. Yield responses to S in the absence of K were not significant. In the presence of K fertilizer, responses to S fertilizer were 11%, 6% and 8% at sites 1, 2, and 3 respectively. At all sites significant responses to P were measured, and at site 1 the P response was increased with K fertilizer application.

It was concluded that S responses were limited by lack of K on many pumice soils in the Gisborne-East Coast region, especially where rainfall was above 1500 mm/year. Because fertilizer used in the region usually lacks K it was suggested that farmers need to monitor K status and consider using K fertilizer when deficiency occurs.

INTRODUCTION

Sulphur and potassium-containing fertilizers are considered to be essential to maintain satisfactory pasture production on pumice soils (Toxopeus 1965, 1971). Published (O'Connor and Gray, 1984) and unpublished data from trials conducted by the Ministry of Agriculture and Fisheries (MAF) involving K and S fertilizers on high rainfall pumice soils in the Gisborne district showed significant responses to both these elements. Nguyen (1982) also obtained significant pasture responses to S fertilizer on Eastland volcanic soils.

Standard fertilizer practice in the Gisborne district has been to apply superphosphate, which contains sulphur. With the down turn in the rural economy along with the advent of reactive phosphate rocks, less sulphur is being applied. Potassic fertilizers are seldom used on pasture in the Gisborne district, use being largely restricted to specific situations (hay paddocks, finishing blocks).

The experiments reported in this paper were part of a series designed to define more clearly the nutrient requirements of Gisborne East Coast pastures. Preliminary results, which did not highlight all the trends noted here, were reported by O'Connor and Gray (1984).

MATERIALS AND METHODS

Treatments

Trials were laid down in the summer of 1980/81. Each trial consisted of four rates of phosphorus (0, 20, 40, 80 kg P/ha/yr), four rates of lime (0, 1250, 2500, 5000 kg/ha), two rates of sulphur (0, 44 kg/ha/yr), two rates of potassium (0, 120 kg K/ha/yr) and two rates of molybdenum (0, 56 g/ha) in a factorial arrangement. Sulphur was applied as a mixture of gypsum and elemental S at the first application, and thereafter as finely ground elemental S. Potassium was applied as muriate of potash. K and S were applied in spring and autumn as split dressings. Because of the experimental design (half a replication of $4 \times 4 \times 2 \times 2 \times 2$ factorial with 64 plots) only main effects and first order interactions could be estimated.

Sites

The four experiments reported in this paper were on volcanic soils (Table 1) with old established pastures typical of the region. One site was on a yellow brown pumice (YBP), two on composite yellow brown pumice on yellow brown loam (YBP/YBL) and one on a yellow brown loam (YBL) (Taylor, 1954). The YBL site had received no fertilizer for the preceding ten years while the other three sites had a regular history of fertilizer topdressing (Table 1). MAF quick tests (Mountier, 1966) on soil samples (0-75 mm) taken at the start of the experiments are shown on Table 1.

Measurements

Pasture production measurements were made on a seasonal basis for 4 years using a reel mower adapted for hill country. Clippings were discarded. For a seasonal cut the trial was trimmed, fenced to protect from grazing, and harvested when herbage reached 10-15 cm height. Except for the YBL site trials were under set stocking by sheep during spring and rotationally grazed for the rest of the year between production cuts. The YBL site was not grazed between cuts.

Pasture composition was assessed visually at each cut for legume content and vigour. Hand cut herbage was dissected into grass, legume species, weeds and dead components in autumn 1985.

TABLE 1: Trial Site Characteristics and Pasture Yields.

	Site 1	Site 2	Site 3	Site 4
District	Matawai	Waimata	Tokomaru Bay	Ruatoria
Map Reference[1]	N88871686	N89423644	N80528037	N72702325
Slope (°)	15	20	15	0-5
Aspect	Northwest	North	East	South
Altitude (m)	610	460	550	120
Rainfall (mm)	1770	1670	1540	1880
Soil				
Group[2]	YBP	YBP/YBL	YBP/YBL	YBL
Type	Matawai hill	Makiri sa.l.	Makiri sa.l.	Matakaoa sa.l.
Fertilizer History (10 yrs)				
Rate (kg/ha/year)	375	250	250	Nil
Type	Serp. Super	Super	Super	—
Soil Test[3]				
pH	5.4	5.7	5.5	5.8
Ca	2	3	4	4
Olsen P	7	9	22	4
K	2	4	4	7
SO_4-S	6	8	8	9
Pasture Yield (kg DM/ha)				
First year total				
Control	6800	5400	7500	7200
S	6700	5400	7500	7200
K	7300	5700	7900	7100
S & K	8200	6200	8600	7700
SED[4]	270	180	270	240
Four year total				
Control	11200	15200	18900	20400
S	11100	15200	19000	21100
K	12100	15700	20300	20900
S & K	13400	16600	21900	21600
SED[4]	390	320	455	826

[1]Department of Lands and Survey NZMS1 Topographical Series.
[2]YBP = Yellow brown pumice, YBL = Yellow brown loam.
[3]Quick Test for 0-75 mm soil depth.
[4]Standard error of difference.

RESULTS

During the first year of measurement 4-5 cuts were taken on each trial and over the four years between 9-13 cuts. A severe drought in the region prevented cuts being taken from November 1982 to November 1983. Cumulative yields for these periods are in Table 1.

Trial site 4 at Ruatoria did not respond significantly to either K or S fertilizers. At the other three sites there was a statistically significant ($P<0.05$) interaction between S and K fertilizers for pasture production over the 4 years of measurement. Sulphur applied alone did not result in a significant increase in yield. Potassium alone resulted in small but significant increases in yield (8%, 3%, and 7% at sites 1, 2 and 3 respectively). Where K & S were applied together, much larger responses were recorded (21%, 9%, 15% for sites 1, 2 and 3 respectively). These trends were apparent in the yields from year 1, although not always statistically significant ($P<0.05$). Pasture yields for individual cuts at sites 1, 2 and 3 gave similar trends to the 4 year total, with main effects (K or S) often being significant, but significant interactions occurring only rarely.

Significant interactions between K or S and other elements occurred only at site 1. Phosphate (80 kg P/ha) in the absence of K resulted in a 22% increase in pasture yield, and a 46% increase in the presence of K.

Clover vigour and clover percentage scores were both significantly increased by S and K at sites 1, 2, and 3. Legume percentage in cut herbage was significantly increased at sites 1, 2, and 3 with the application of K, and at site 2 with the application of S. Statistically significant ($P<0.05$) interactions were not detected.

DISCUSSION

Research reviewed in the introduction of this paper has consistently shown pasture production responses to either S or K fertilizer use on volcanic soils when the other element was applied as a basal treatment. This series of experiments illustrate similar responses. Responses to K fertilizer were recorded when soil Quick test K levels were 4 and below, a result consistent with other data (Campkin and Cornforth, 1984; Smart, 1987). Sulphur responses were recorded at the three sites with the lowest soil test sulphate S levels. However, responses were smaller than recently obtained in similar MAF experiments on volcanic soils in the Bay of Plenty (Thorald, pers. comm.).

The interaction between K and S fertilizers have not been highlighted previously, and physiological reasons for such interactions are not obvious (Dibb and Thompson, 1985). O'Connor and Gray (1984) noted that K was more important that S on Gisborne East Coast volcanic soils, but the interaction was not well defined in the preliminary results (Table 1). It is concluded that S responses can be severely restricted where soil K quick test levels are below 4 on high rainfall volcanic soils. Also data from site 1 indicate that P responses can be restricted when soil quick test K levels are 2 or less.

TABLE 2: Percentage of MAFTech consultancy soil samples with different potassium quick test levels. Samples were taken from Gisborne hill country with volcanic soils during 1985-88.

Annual rainfall	Less than 1500 mm	More than 1500 mm
K quick test		
2	2	13
3	6	28
4	9	25
5	15	16
6	15	12
7	14	3
8	6	2
9 and above	32	0
Number of samples	173	137

Soil quick test data taken from farms on volcanic soils in the Gisborne region indicate that a high proportion of these properties have soil K at a level where S responses would be severely restricted (Table 2). In situations where annual rainfall was above 1500 mm 66% of the samples were K deficient (K test 4 or less) and S responses would be restricted. On volcanic soils where annual rainfall was below 1500 mm, 17% of the samples were K deficient. The data also indicated that limitation of phosphate responses by K deficiency (K test 2 or less) is likely on 13% of high rainfall volcanic soils. The differences in K status reflect the greater amount of K leaching with increased rainfall (Metson, 1968).

These results have important implications for fertilizer recommendations in the Gisborne-East Coast region. In particular the need for K fertilizers on deficient soils should be considered. Potassium fertilizers have not been used extensively on Gisborne-East Coast hill country. This reflects the high cost of K fertilizers, the relatively extensive scale of sheep and beef farms in the region, and the increased risk of grass staggers in breeding cattle with K use. Generally K fertilizers have only been recommended for hay paddocks and finishing areas, but not for more general use.

Recommendations on K use need to be made after considering S and phosphate needs of pasture. Phosphate is invariably required to maintain pasture production in the region. Pasture responses to P fertilizer were obtained at all sites (O'Connor and Gray, 1984) and within grazing systems, fertilizer P inputs are required to replace P lost in soil and via animals (Cornforth and Sinclair, 1984). Similarly S fertilizer is usually required to replace losses on volcanic soils (Sinclair and Sanders, 1984). Thus K, if required, would normally be applied in addition to P and S.

It should be noted that 3 of the experimental sites had received regular superphosphate topdressing. It is possible that where no fertilizer has been applied for several years, and available sulphur was depleted, the relative responses to S and K could be different from these experiments.

Based on these experiments the following recommendations are made for K use on volcanic soils in the Gisborne-East Coast region:

Soil K quick test 4 or less:

K needed for S and P to be fully effective. Only apply P and S with K. P may be effective applied alone at test 4; but S should be applied with K, or not at all.

Soil K quick test 5 or more:

K not needed, except on high loss areas such as hay or silage paddocks. At present, stocking rates are not high enough to justify K use under normal sheep and beef cattle grazing.

CONCLUSIONS

(1) Sulphur responses on volcanic soils of the Gisborne-East Coast region can be limited by lack of K. Such limitations appear to be widespread on volcanic soils with more than 1500 mm/yr precipitation.

(2) Phosphate responses can be reduced with severe K deficiency, a situation mainly limited to volcanic soils with more than 1500 mm/yr precipitation.

(3) Farmers should monitor K requirements carefully so that the most cost effective fertilizers are used.

ACKNOWLEDGEMENTS

W.M. Christieson and S.J. Quilter for technical assistance and B. Dow for biometrical assistance. Also Messrs M. Briant, P. Chrisp, P. Rhodes and A. Goldsmith for their cooperation and for use of their properties.

REFERENCES

Campkin, R., Cornforth, I.S. 1984. Pasture maintenance: potassium. *In:* Cornforth, I.S., Sinclair, A.G. (ed.) *Fertilizers and lime recommendations for pastures and crops in New Zealand.* Second revised edition, MAF, Wellington. p18-19.

Cornforth, I.S., Sinclair, A.G. 1984. Pasture maintenance: phosphorus. *In:* Cornforth, I.S., Sinclair, A.G. (ed.), *Fertilizers and lime recommendations for pastures and crops in New Zealand.* Second revised edition, MAF, Wellington. p10-13.

Metson, A.J. 1968. Soils of N.Z. *New Zealand Soil Bureau Bulletin 26:* (2) 82-95.

Dibb, Thompson, 1985. Interaction of potassium and other nutrients. *In:* R.D. Munson (ed), *Potassium in agriculture.*

Mountier, N.S., Grigg, J.L., Oomen, G.A. 1966. Sources of error in advisory soil tests. I. Laboratory sources. *New Zealand Journal of Agricultural Research 9:* 328-338.

Nguyen, M.L. 1982. An evaluation of S topdressing strategies on Eastland pastures. Unpublished M.Agr.Sc. thesis, Massey University.

O'Connor, M.B., Gray, M.H. 1984. Fertilizer requirements of Gisborne-East Coast hill country. *Proceedings of New Zealand Grasslands Association 45:* 83-91.

Sinclair, A.G., Saunders, W.M.H. 1984. Pasture maintenance: sulphur. *In:* Cornforth, I.S., Sinclair, A.G. (ed.), *Fertilizers and lime recommendations for pastures and crops in New Zealand,* Second revised edition, MAF, Wellington. p15-17.

Smart, C.E. 1987. Potassium requirements. *In:* S.F. Ledgard (ed.), *Te Kuiti Research Area June 1987 Field Day,* MAF. p 6-7.

Taylor, N.H. 1954. General Survey of Soils of North Island, New Zealand. *New Zealand Soil Bureau Bulletin 5.*

Toxopeus, M.R.J. 1965. The nutrient status of pumice soils. *Proceedings of the Ruakura Farmers Conference.* p. 150-156.

Toxopeus, M.R.J. 1971. Rational fertilizer practice on pumice soils. *Proceedings New Zealand Grasslands Association 33:* 35-41.