Effects of lime on n and s uptake and herbage production in north-eastern NSW

Z. Hochman, W. Fulkerson, K. Moore, C. Rolfe, K. Slack and J. Hindmarsh

NSW Agriculture, Wollongbar Agricultural Institute, Wollongbar NSW 2477

Summary. This study summarises two field experiments designed to quantify the effects of lime on utilisation of nitrogen (N) and sulfur (S). In the first experiment seven rates of lime were applied prior to sowing Saia oats, *Avena strigosa,* into a degraded pasture on a Red Basalt soil. The second experiment was a study on the effects of lime and N application on the establishment of an irrigated ryegrass, *Lolium perenne/white* clover, *Trifolium repens,* pasture on clay soil subject to waterlogging. In both experiments lime improved herbage yields and N and S concentration in herbage.

Introduction

Liming acid soils usually results in increased nitrification and mineralisation of organic nitrogen (1,2,3,4,6,8) and sulfur (3,8,9). Increased plant uptake of nitrogen and sulphur has also been observed in some of these studies. Our interest was to quantify these increases in two contrasting situations: On a Krasnozem soil with a highly aluminium tolerant crop and no added fertiliser without irrigation, and on a Chocolate clay soil with an irrigated ryegrass/clover pasture and with contrasting treatments for N fertiliser.

Methods

Experiment 1

The site was located on Krasnozem soil supporting a degraded pasture near the Wollongbar. Soil analysis gave pH ($CaC1_2$) of 4.2, ECEC of 6.1 cmol(+)/kg with 1.47 cmol(+)/kg exchangeable Al and 0.26 cmol(+)/kg Iv1n (1:5, soil:0.01 M $CaC1_2$ extract). The experiment was a randomised complete block design with three replicates of seven rates of lime (0,1,2,4,6,8, and 16 t/ha CaCO3; neutralising value = 98.3%, 96.8% less than 250 micrometres) broadcast and rotary hoed on 30 May 1986. Saia oats were sown eight days later at 80 kg/ha. No fertiliser was added and harvests were taken, using an Allan Auto-scythe, on 28 August (H1) and 14 October 1986 (H2). Plant N and S analysis was of total above ground herbage. Rainfall in May was 135 mm (long-term average is 156 mm) and from June to October 178 mm (long-term average is 474 mm).

Experiment 2

The site was located on a Chocolate clay soil subjected to prolonged waterlogging. Soil analyses gave values of pH ($CaC1_2$) =4.6; N =0.38 (%); P = I65 ppm; K = 1.33 cmol(+)/kg; Al =0.16 cmol(+)/ kg. The area was sprayed with 7 L/ha of glyphosate and disced two weeks later before sowing with 8 kg ryegrass (cv. Ellett) and 4 kg white clover (cv. Haifa) on 21 March. At sowing, 250 kg/ha molybdenum superphosphate and 100 kg/ha muriate of potash were applied.

Plots were irrigated every three to four days for the first eight weeks and then every six to seven days to replenish water loss. Harvest dates 1, 2 and 3 refer to DM yield obtained from sowing to eight weeks, eight to 12 weeks and 12 to 16 weeks, respectively. Measurements at each harvest were of above ground dry matter yield (rotary mower), botanical composition of herbage, and leaf and soil analysis of N and S.

The plots (2x2 m) were laid out in a randomised split-plot design with nitrogen as main plots and lime as sub-plots with three replicate blocks and treated as follows:

- Nitrogen: 80 kg/ha urea at sowing then 100 kg urea/ha (N_1), or 100 kg/ha urea at sowing, only (No).

- Lime: 5 tonne/ha (microfine lime, 98% less than 75 micrometres) disced into top 10 cm of soil three weeks before sowing (L_1) or nil (L0).

Plots were artificially flooded on 1 and 2 May and again by heavy rain on 6 to 9 June with soil being waterlogged in the intervening period.

Results

Experiment I

Liming increased soil pH by 0.25 units per tonne for the first eight tonnes, with a much smaller increase of 0.06 units per tonne for the next eight tonnes. Both harvests showed an increase in herbage yield and nitrogen concentration in herbage. Sulfur concentration increased with liming on the first harvest only (Table 1). The combined harvest data shows an increase in herbage produced (84%), nitrogen uptake (55%), and sulfur uptake (122%).

Table 1. Effect of lime on soil pH, herbage yield, nitrogen and sulfur concentration in Saia oats.

Lime (t/ha)	Soil pH (Jan.'87)	Herbage yield H1 (kg/ha)	Herbage yield H2 (kg/ha)	%N H1 (w/w)	%N H2 (w/w)	%S H1 (w/w)	%S H2 (w/w)
0	4.17	599	350	2.33	2.37	0.226	0.396
1	4.39	566	338	2.34	2.49	0.226	0.356
2	4.71	994	468	2.24	2.55	0.238	0.373
4	5.25	896	437	2.11	2.49	0.274	0.388
6	5.62	1261	511	2.64	2.71	0.301	0.408
8	6.15	1291	531	2.50	2.74	0.289	0.373
16	6.66	1221	524	2.82	3.19	0.317	0.424
l.s.d. (P=0.05)	0.10	380	99	0.21	0.30	0.037	n.s.

Experiment 2

Application of lime raised soil pH from 4.6 to 5.7 and consistently increased DM yields by 27 to 35% over all harvests (Figure 1).

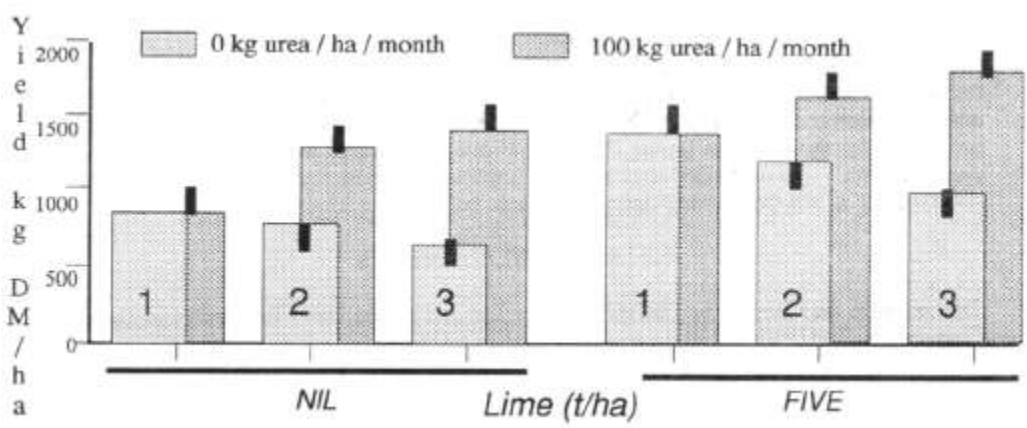

Figure 1. DM yield (kg/ha) at nil and 5 t/ha lime with nil or 100 kg urea/ha/month at harvest 1, 2 and 3 (indicated on histogram); s.e. are shown as vertical bars.

The effects of lime and nitrogen on herbage production were additive. Lime affected the clover and grass equally - the proportion of clover and grass was not significantly changed by lime treatments at any harvest date.

There was a consistent positive interaction between lime and nitrogen on ryegrass plant density but this reached significance ($P<0.05$) only between extreme treatment combinations.

Tissue analysis of total herbage showed that lime application increased N uptake by from 9 to 11 kg/ha between the second and third harvests. Chemical analysis of the leaves of ryegrass for N and S (Table 2) suggests a role for lime in enhancing uptake of N and S at harvest 2.

Table 2. Concentration of N and S in ryegrass leaves on two harvests.

	Tissue N and S (% DM) (±s.e., 0.05)					
	+ Lime			- Lime		
Harvest	N	S	N/S	N	S	N/S
2	3.06±0.10	0.36±0.03	8.5	2.75±0.14	0.26±0.02	10.6
3	3.55±0.20	0.33±0.15	10.1	3.52±0.22	0.23±0.10	14.7

Discussion

In two experiments similar responses of N and S uptake to lime were observed over a wide range of fertiliser treatments and soil moisture conditions. Both experiments show the effect of soil pH on uptake of soil nitrogen and sulfur by grasses while the effect of aluminium toxicity can be discounted from the observed responses. In experiment 1 aluminium can be ruled out due to the extreme tolerance of Saia oats in the presence of moderate levels of aluminium (5). Additionally, significant responses in N and S uptake for lime rates greater than 4 t/ha were obtained where there was nil exchangeable aluminium. In experiment 2 the unlimed soil had a very low level of exchangeable aluminium.

Critical concentrations for N and S relevant to experiment 1 are 3.0% and 0.14% respectively. For experiment 2, N is deficient at less than 4.0% while S is critical below 0.27 (7). In experiment 1, the levels of S are more than adequate in all treatments. Nitrogen however is deficient in all treatments except 16 t/ha at the second harvest. The response to lime in this experiment was most likely a response to increased availability of soil nitrogen. In experiment 2, at the second harvest, the unlimed treatments had deficient N and marginal S concentrations and both were improved by liming. At the third harvest liming did not improve the N status while liming did increase the S concentration. These results indicate that improved nutrient cycling of N and S contribute substantially to responses from liming these acid soils.

Acknowledgments

This research was funded by DMM-Lime Pty Ltd and by the Dairy Research and Development Corporation.

References

1. Adams, T.McM. and Adams, S.N. 1983. J. Agric. Sci., Camb. 101, 553-558. Awad, A.S. and Edwards, D.G. 1977. Plant and Soil 48, 169-183.

2. Barrow, N.J. 1965. Aust. J. Anim. Hus. Exp. Agric. 5, 442-449.

3. Coventry, D.R., Morrison, G.R., Reeves, T.G., Hirth, J.R. and Fung, K.K.H. 1987. Aust. J. Exp. Agric. 27, 687-694.

4. Cregan, P.D., Scott, B.J. and Cumming, R.W. 1984. Agfact P1.4.1, Dept Agric. NSW, Agdex 534.5.

5. Nyborg, M. and Hoyt, P.B. 1978. Can. J. Soil. Sci. 58, 331-338.

6. Reuter, D.J. and Robinson, J.B. 1986. Plant Analysis: An Interpretational Manual. (Inkata Press: Melbourne).

7. White, J.G. 1959. NZ J. Agric. Res. 2, 255-258.

8. Williams, C.H. 1967. Plant and Soil 26, 206-223.