Impacts of surface-applied lime on sheep production systems in south-western Victoria

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ABSTRACT

Lime was broadcast at 5 t/ha at two sites where perennial ryegrass-based pasture was grazed by Merino ewes. The soils at both sites had a similar pH prior to liming; however, soil exchangeable aluminium concentrations (Al) were 89 and 32 mg/kg respectively. For two years, higher stocking rates could be maintained after 5 t/ha lime was applied, compared to unlimed areas, at the site that had the higher Al. An extra 30 kg/ha of wool was produced over two years. Lime had little impact on sheep productivity at the other site. Results suggest that sheep productivity is a better means of assessing response to lime than pasture or soil changes. Reductions in Al, after broadcasting lime, were quicker and were found deeper in the soil than previous anecdotal reports suggested. The project has shown the potential for extra productivity when Al is reduced but critical levels of Al need to be defined for soils.

KEY WORDS

Botanical composition, ryegrass, wool, lamb, pasture growth

INTRODUCTION

The extent of soil acidity and rates of acidification are receiving interest in south-western Victoria (2). When soil pH_{Ca} is 4.8 or less aluminium concentrations rise in the soil solution and on exchange sites, frequently becoming toxic to pasture plants (9). There are, however, considerable gaps in our knowledge of potential productivity gains when lime is applied to overcome soil acidity. In the high rainfall zone, there is an increasing trend to use direct drilling when pasture resowing, therefore it is impracticable to incorporate lime into the soil, in contrast to other zones where cropping occurs. The rate of movement of lime down the soil profile needs evaluation. Furthermore, there are few reported studies of sheep production responses to applied lime on permanent pasture. This paper reports on grazing experiments that were conducted over five years at two sites in south-western Victoria. Soil, pasture and sheep parameters were monitored.

MATERIALS AND METHODS

Sites at Nareen and Branxholme were selected which had strongly acidic surface soils; pH_{Ca}, (0-10 cm) was $_{4.4}$ and 4.3, respectively (3). Exchangeable aluminium (0-10 cm) (Al), before lime application, was 89 and 32 mg/kg respectively. Both had duplex soils, ie. Dy3.2, with A horizons of very fine sandy clay loam (Nareen) or sandy loam (Branxholme) overlying medium clay (3). The proportion of perennial ryegrass in the swards was better that district average and the subterranean clover content was good.

Two rates of lime, 0 or 5 t/ha were broadcast onto the soil surface of each plot in autumn 1996, and were replicated twice in a randomised design. The degree of replication was limited by the financial resources available at the beginning of the project. Plots, of 2.2 or 3.6 ha for the Nareen and Branxholme sites respectively, were fertilised to achieve an Olsen P (0-10 cm) of at least 12 mg/kg in 1997.

In order to assess the effects of lime on soil acidity, composite soil cores (20) were collected from each plot in spring each year and split into four depths. Exchangeable aluminium was analysed (1:10, soil:1 M KCl solution, 30 min shaking) (2).

The plots were initially stocked with 2.5 year old August - September lambing Merino ewes joined to Merino rams. Allocation to the plots was based on liveweight and wool cut. Initially, all plots at a site were stocked at approximately the same rate, considered sustainable by the landholder. The aim was for all ewes at a site to have a similar annual liveweight pattern. Stocking rates were adjusted, no more than twice in a year, if the pasture availability at the end of winter or the end of the growing season, or sheep condition, was above or below key benchmarks.

Pasture growth and availability were measured at monthly intervals during the growing season (1), with three nests of three cages in each plot. Dry matter production from pasture was fitted using ASREML (4) to test for the effect of year and lime treatments interacted with a cubic spline of time and allowing for random plot effects.

Botanical composition was measured in August, September, October and November using the Botanal technique (5) at 10 points, spaced at 5 m intervals, along a fixed permanent transect. The statistical analysis was as used for dry matter production.

Samples of available pasture were collected from 50 points in each plot in mid October. These were sorted into green and dead. Green material was dried at 60^0C for 24 hours and analysed for digestibility and crude protein using NIR methods.

All ewes were weighed (unfasted) and fat scored in February, May, August (pre lambing) and December (lamb weaning). Lamb marking percentage was recorded and lambs weighed at weaning. Fleece plus belly wool weight was measured at shearing each year.

Analysis of variance (ANOVA) in Genstat 5.41 was used to test lime treatment effects, with year as a factor for wool and lamb data. ANOVA was also used to compare ewe weights for periods between stocking rate changes.

RESULTS AND DISCUSSION

Lime application appeared to reduce Al at Nareen in 1996 (Fig. 1). This trend appeared to extend down to the 10-20 cm zone in 1998 so Al was near 40 mg/kg or less throughout the profile. Overall concentrations of Al were less at Branxholme but lime appeared to have a similar effect down the soil profile over time, reducing Al concentrations to less than 30 mg/kg in 1999 (Fig. 2). Considerable change in Al occurred in the 10-20 cm zone between 1998 and 1999 at Branxholme. Some other changes in soil chemistry at these sites have recently been reported (3,7).

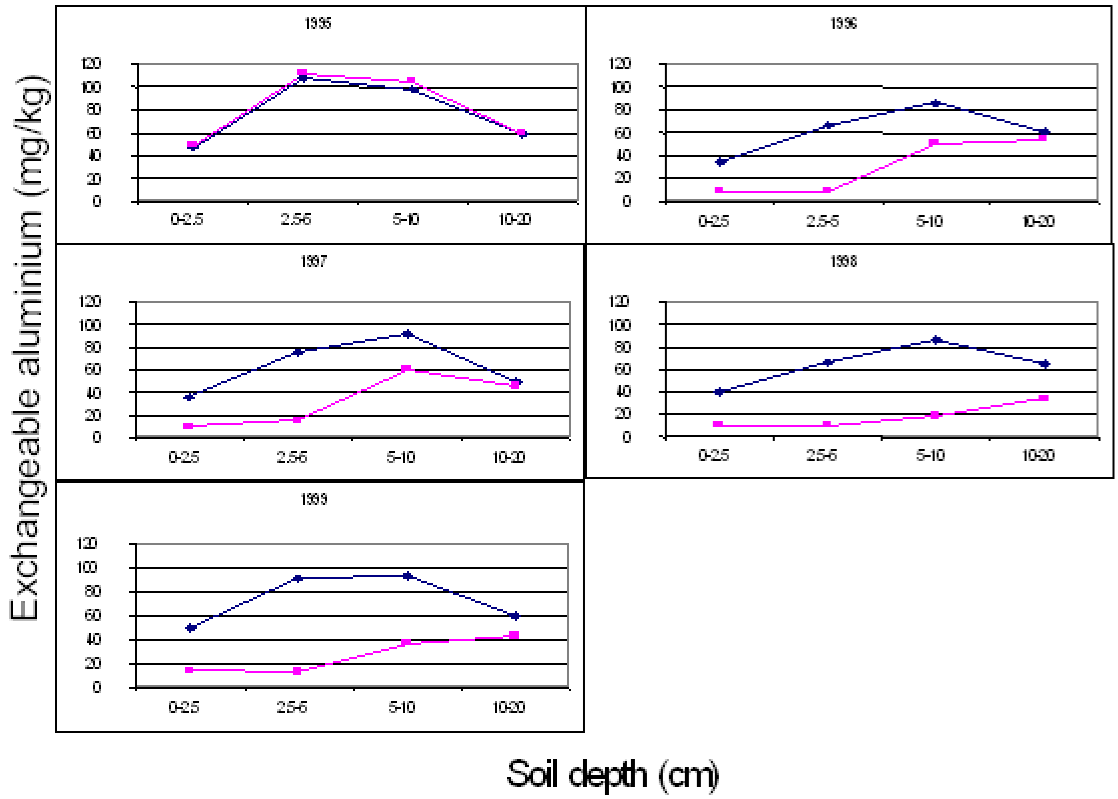

Figure 1. Changes in exchangeable aluminium over five years at Nareen. ◆control, ■lime 5 t/ha.

Differences between the control and the lime treatment were small and inconsistent when nutritive values of pasture were compared at both sites (Table 1).

Table 1. Nutritive values of pasture herbage samples collected from Nareen and Branxholme.

(Dead plant material removed from samples).

Site	1997				1998				1999			
	Crude protein (%)		Digestible dry matter (%)		Crude protein (%)		Digestible dry matter (%)		Crude protein (%)		Digestible dry matter (%)	
	Control	Lime	Control	Lime	Control	Lime	Control	Lime	Control	Lime	Control	Lime
Nareen	22.3	22.0	78.9	77.2	26.5	28.0	75.6	76.8	23.0	24.6	76.5	74.1
Branxholme	24.8	23.4	78.4	78.2	26.7	25.5	79.5	78.5	21.3	21.6	78.3	77.6

At both sites, there was no significant difference in annual pasture DM production from the two treatments. However, in an adjacent small plot experiment at Nareen (located in one of the control plots) there were significant DM increases for three years after broadcasting lime at 2.5 t/ha (8). No significant differences between treatments were detected in the botanical composition.

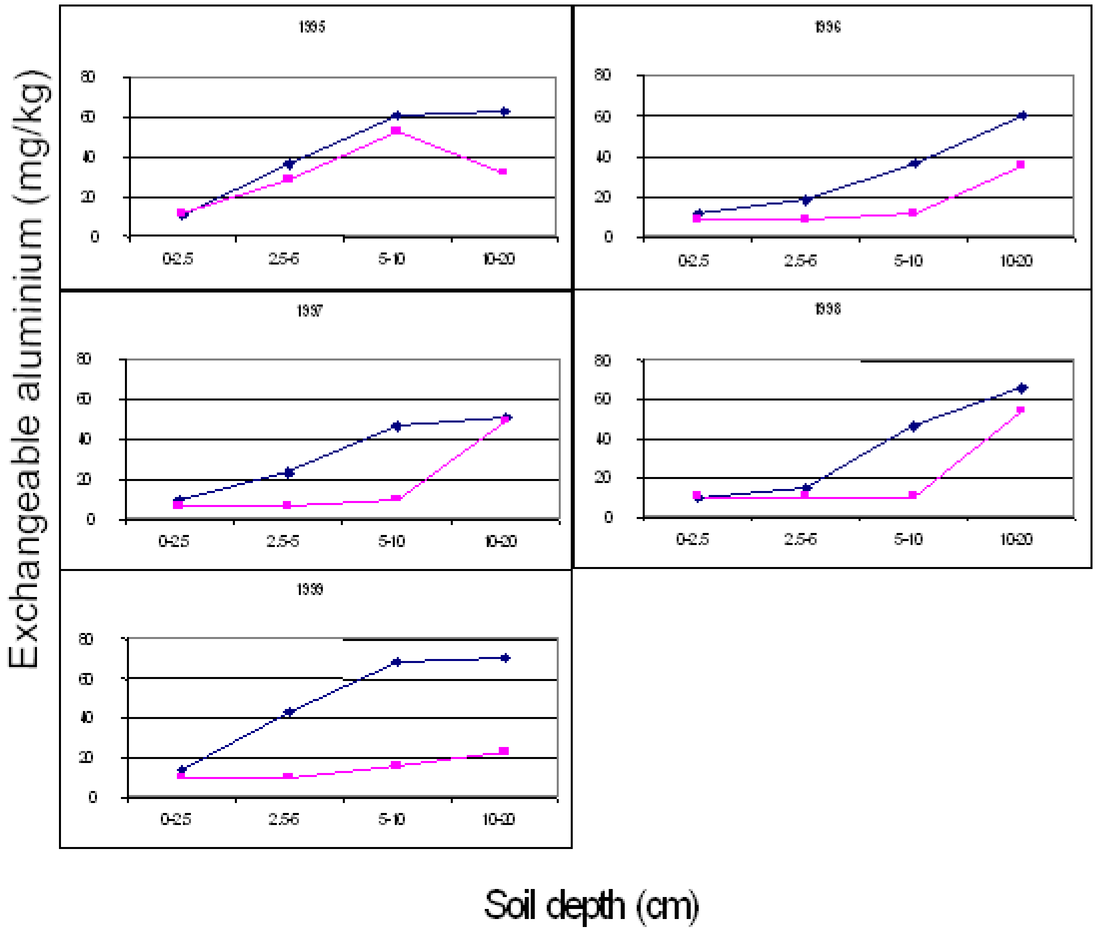

Figure 2. Changes in exchangeable aluminium over five years at Branxholme. ◆control, ■lime 5 t/ha.

Changes in stocking rates are shown in Table 2. In 1997, on each of the seven occasions when pasture growth was measured at Nareen, there was higher DM production on the lime treatment than on the control plots. Although these differences were not statistically significant, the stocking rate on the lime treatment was increased in early 1998 because of the extra feed production. Ewe liveweights were also significantly (P<0.05) higher during 1996 and 1997 on the limed plots at Nareen. There were no differences between treatments in ewe liveweights during 1998, 1999 or early 2000. Equal increases in stocking rate for both treatments at Nareen were undertaken at the beginning of 2000. There were never any differences between treatments in ewe liveweights at Branxholme.

Table 2. Changes in stocking rates (ewes/ha) at Nareen and Branxholme.

Site	Date	Control	Lime
Nareen	1 May 1996	10.8	10.2

	6 May 1998	10.1	12.5
	22 Mar 2000	11.8	14.1
Branxholme	1 May 1996	10.6	11.0
	1 Dec 1997	11.0	11.5
	21 Jan 1999	12.3	13.5

There was significantly (P<0.05) more wool production per hectare from the lime treatment at Nareen in 1999 and 2000 (Table 3). This difference amounted to 30 kg/ha of greasy wool over two years. There was no difference in wool production in the two earlier years when there was less difference in stocking rate. Lime application did not lead to significant differences in wool production at Branxholme.

There were no significant differences in lamb production per hectare at either site (Table 3). Although a lambing-ewe production system has been recognised as sensitive to management practice, lamb survival *per se* can also be influenced by weather conditions and mothering ability of individual ewes. In this experiment, there was large variability within treatments, between replicates and between years so treatment effects could not be demonstrated conclusively.

Table 3. Wool (kg/ha) and lamb production (kg/ha) at Nareen and Branxholme sites.

Site	Year	Wool			Lamb		
		Control	Lime	l.s.d. (P=0.05)	Control	Lime	l.s.d.(P=0.05)
	1996	-	-		135	121	ns
Nareen	1997	45.4	43.9	ns	244	220	ns
	1998	44.0	43.8	ns	240	313	ns
	1999	39.4	50.4	7.6	204	218	ns
	2000	49.3	68.7	7.6	-	-	
Branxholme	1996	51.7	54.6	ns	155	190	ns
	1997	49.3	53.3	ns	219	174	ns
	1998	56.4	56.7	ns	126	120	ns

1999	53.3	56.1	ns	92	106	ns
2000	64.4	69.7	ns	-	-	

ns, not significant (*P*>0.05)

In New Zealand, it has been concluded, that where both animal and pasture measurements were made, animal performance offered the best and most consistent indication of lime response because sheep are able to integrate the multiple effects of lime over time (6).

CONCLUSION

The effects of broadcast lime on Al were quicker than anticipated and were found within the 10-20 cm zone. The potential for broadcast lime to increase animal productivity can vary from site to site and in this case was associated with differences in initial soil Al concentrations rather than pH. Producers need to be aware that Al is a better predictor of potential response to lime rather than pH. Definition of critical Al for the soil types in south-western Victoria is required before accurate predictions of lime response can be made.

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REFERENCES

1. Cayley, J.W.D. and Bird, P.R. 1996. Techniques for measuring pastures. (*Agriculture Victoria*). 51p.

2. Crawford D.M., Baker T.G. and Maheswaran, J. 1994. *Australian Journal of Soil Research* **32**, 105-115.

3. Crawford, D.M., Quigley, P.E., Schroder, P.M. and Brown A.J. 2000. *Proceedings Soil 2000 Conference*. Lincoln NZ. (In press).

4. Gilmour, A.R., Thompson, R., Cullis, B.R. and Welham, S. J. 1997. 'ASREML.' (*NSW Agriculture: Orange, NSW*).

5. Jones, R.M. and Hargreaves, J.N.G. 1979. *Grass and Forage Science* **34**, 181-9.

6. O'Connor, M.B. and Edmeades, D.C. 1984. In: Lime in New Zealand Agriculture. (Eds. B.L.J. Jackson and D.C. Edmeades) (*Ruakura Soil and Plant Research Station*) pp. 17-19.

7. Quigley, P., Cameron, F. and Schroder, P. 1998. *Proceedings 39th Annual Conference of the Grassland Society of Victoria*. p.144.

8. Quigley, P.E., Schroder, P.M. and Cameron, F.J. 2001. *Proceedings 10th Australian Agronomy Conference*, Hobart. (In press).

9. Slattery, W.J., Conyers, M.K. and Aitken, R.L. 1999. In: Soil Analysis an Interpretation Manual. (Eds. K.I. Peverill, L.A. Sparrow and D.J. Reuter) (*CSIRO Publishing Melbourne*). pp. 103-128.