Pasture responses to lime over five years are limited and highly variable

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Abstract

Changes in soil chemical properties and responses in dry matter production resulting from the application of lime were investigated for five field sites on dairy pastures in southern Victoria. Treatments included surface applications of lime at rates of 0-20 t/ha in a single dressing. After 5 years, lime continued to have an effect on soil pH and exchangeable aluminium (Al) to 20 cm depth, with pH increases and Al decreases linearly associated with lime rates. Pasture responses were highly variable at all 5 sites. At 2 sites there were significant pasture responses of up to 33% at the highest rate of lime (P<0.001) in years 1 and 2, although these were not sustained, and responses diminished with time. When responses to lime are averaged over 5 years, the mean responses are much lower and are unlikely to be economic.

Keywords

Lime, soil pH, acidic soils, pasture response, dairy pastures.

Introduction

The application of lime to established perennial pastures is frequently recommended where soils are acidic, yet the benefits of such practices are not conclusive. Previous research on Victorian rainfed perennial pastures has been of a short-term nature with few responses observed, other than those attributable to a molybdenum (Mo) response. However, longer-term pasture production benefits to surface-applied lime have been demonstrated in Tasmania (4). Recommended target soil pH for pasture soils also varies, with workers in New Zealand suggesting that responses to surface-applied lime are likely to occur up to a pH_w of 5.8-6.1 for mineral soils (1).

The aim of this research was to establish the long-term effects of lime on pasture growth and composition for productive acid soils, and to determine the optimum lime application rate for these soils.

MATERIALS AND METHODS

Experimental sites were established in November 1994 on five dairy farms in southern Victoria, at Ellinbank, Nyora, Stony Creek, Wyelangta and Mepunga, encompassing a range of acidic soils (Table 1). The treatments applied included surface applications of lime at rates of 0, 2.5, 5, 10, 15 and 20 t/ha in a single dressing. A further treatment included the application of 2.5 t/ha of lime annually, providing a cumulative total of 12.5 t/ha over the five year experimental period. All treatments included annual split applications of phosphorus (P) and potassium (K). Mo fertiliser was applied at a rate of 0.05 kg/ha at establishment, and after three years. Field plots were 6 x 3 m, replicated 4 times and laid out in a randomised complete block design on established perennial ryegrass (*Lolium perenne?*L.) and white clover (*Trifolium repens?*L.) pastures. Field plots were under the normal grazing regime of the farm at all times other than when 'locked up' prior to assessment of pasture response.

Table 1. Initial soil characteristics (0-10cm) of field sites.

	Soil type	pH(H_2O)	Al (mg/kg)	Olsen P (mg/kg)
Ellinbank	Gradational red clay loam	5.2	128	11

Nyora	Duplex sandy clay loam	5.1	37	29
Stony Creek	Duplex fine sandy clay loam	5.1	31	52
Wyelangta	Gradational sandy clay loam	5.1	85	32
Mepunga	Duplex sandy loam	5.9	85	21

Plots were soil sampled annually in October by collecting 15 soil cores to a depth of 20 cm. Cores were sectioned into 5 cm increments, bulked, dried at 40?C and sieved (2 mm). Soil samples were tested for soil pH (H_2O and $CaCl_2$), extractable P (Olsen) and K (Skene), exchangeable aluminium (KCl) and extractable cations (Ca, Mg, Na, K). Pasture production was measured on a seasonal basis using a calibrated rising plate meter, at three key times per year, and botanical composition determined annually during early spring. Mixed herbage samples were also collected from each plot at this time for mineral analysis.

All data was statistically analysed using analysis of variance, with a blocking structure of depth within plot within block for soil results, and plot within block for dry matter, mineral analysis and botanical composition data (results not shown), focusing on the treatment contrasts of interest.

Results and Discussion

Changes to soil chemistry

Lime continued to have an effect on soil pH at all 5 sites, over the five year experimental period. Within the top 15 cm of soil, pH increased significantly ($P<0.001$), and was linearly associated with the amount of lime applied (Wyelangta results shown in Fig. 1). Despite the perception that lime moves slowly through the soil profile, within two years significant changes in pH had occurred to 20 cm at the higher rates at several sites. On average, soil pH in the surface 0-10 cm increased up to 0.1 pH unit per tonne of lime applied.

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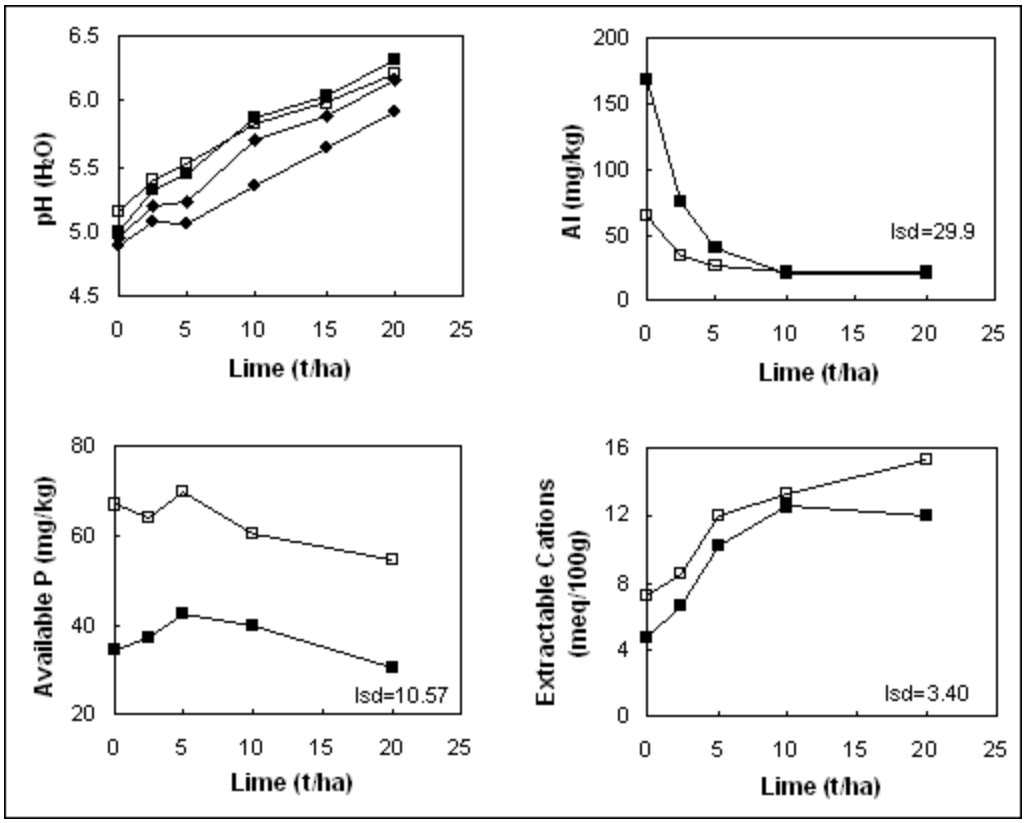

Figure 1. Effect of lime on soil pH(H_2O), exchangeable Al (KCl), available P (Olsen) and extractable cations at Wyelangta in October 1999, five years after application. Depths shown are 0-5 cm (□), 5-10 cm (■), 10-15 cm (◆) and 15-20 cm (●).

Lime either increased, decreased or had no effect on extractable P and K. This may be due to either a change in nutrient availability and/or dilution effect caused by increased plant growth. Exchangeable Al concentrations were significantly reduced at the 20 cm depth ($P<0.001$) within two years at the higher rates (Wyelangta results shown in Fig. 1). Cation exchange capacity significantly increased ($P<0.001$), although this increase was generally explained by an increase in extractable Ca.

Effects on pasture

Pasture production gains were highly variable at all 5 sites. At Ellinbank and Wyelangta, there were significant pasture responses of up to 33% at the highest rate of lime ($P<0.001$) in years 1 and 2, although these were not sustained, and responses diminished with time (Wyelangta results shown in Fig. 2). When responses to lime are averaged over 5 years, the mean responses are much lower and are unlikely to be economic (Table 2). At Nyora, Stony Creek and Mepunga, there has been either no response to lime applications, or significant depressions in pasture production ($P<0.05$). Yield increases from lime applications were not due to an increase in the availability of Mo associated with the increase in soil pH. No additional benefits in pasture response to the application of lime on an annual basis were measured.

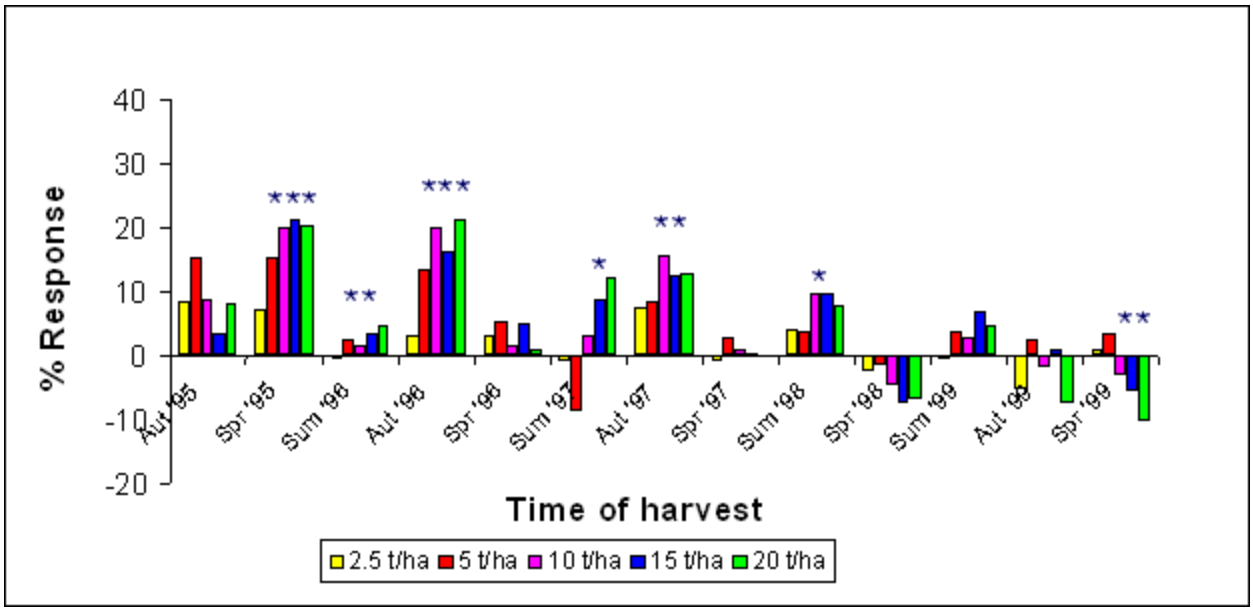

Figure 2. Pasture dry matter response to lime application at Wyelangta (1995-1999).

*** *P* < 0.05, ** *P* < 0.01, *** *P* < 0.001.**

Table 2. Mean pasture response (%) to different lime applications between 1995-1999.

		Initial pH_w	Lime rate (t/ha)				
Site	**Soil type**	**(0-10 cm)**	**2.5**	**5**	**10**	**15**	**20**
Ellinbank	Gradational red clay loam	5.2	3	4	6	7	9
Nyora	Duplex sandy clay loam	5.1	-3	-2	-4	1	1
Stony Creek	Duplex fine sandy clay loam	5.1	-1	0	-1	0	3
Wyelangta	Gradational sandy clay loam	5.1	2	5	6	7	7
Mepunga	Duplex sandy loam	5.9	1	-5	-10	-8	-4

In every year after application, high rates of lime continued to have a significant effect on the pasture mineral composition. In general, increases in calcium content were linear (*P*<0.001) and manganese and zinc were frequently depressed (*P*<0.001). However, the mineral values recorded still fell within the broad ranges required for optimal plant growth and dairy cattle requirements (3,2). There has been no measurable treatment effect on botanical composition.

Seasonality of pasture response to lime has been previously recorded, with the largest relative responses occurring in summer and/or autumn and the smallest responses, or depressions, occurring in spring (5). However, responses were variable at Ellinbank and Wyelangta, the two sites most responsive to lime

applications. While significant depressions often occurred at later spring measurements, highly significant positive responses occurred in the first spring (Wyelangta results shown in Fig. 2.). It is suggested that this may be due to a flush of nitrogen mineralisation, with increased biological activity, although this was not measured.

Implications for lime recommendations

Response to lime application is commonly due to a number of factors including decreasing Al or Mn toxicity, improved clover nodulation and increased availability of Ca, Mo and P. While lime is frequently recommended for the acid soils investigated in this study, it is proposed that these soil conditions were not consistently limiting pasture production. Nutrients such as Ca, Mo and P were in sufficient supply, and exchangeable Al, whilst high, may be below critical values for perennial ryegrass and white clover. The largest pasture responses to lime occurred at the higher application rates, estimated to cost upwards of $1000/ha. Such high rates are unlikely to be economic, given the magnitude and variability of responses that occurred.

It is important however, for land managers to monitor their soils on an ongoing basis, and ensure that farm practices such as the use of high rates of nitrogen fertiliser is not leading to the acidification of the soil. In such circumstances, the application of lime would be warranted to prevent soil acidification.

Conclusion

Lime applied to dairy pastures will increase soil pH, but not necessarily result in a sustained and economic increase in pasture yields. These results confirm the necessity to further examine the mechanisms through which lime may increase pasture production.

Acknowledgments

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References

1. Edmeades, D.C., Pringle, R.M., Shannon, P.W. and Mansell, G.P. 1984. *N.Z. J. Agric. Res.* **27**, 371-382.

2. Jacobs, J.L. and Rigby, S.E. 1999. Minerals in Dairy Pastures in Victoria*. (Department of Natural Resources and Environment:* Warrnambool, Victoria).

3. Pinkerton, A., Smith, F.W., and Lewis, D.C. 1997. In: Plant Analysis: an interpretation manual. 2nd Ed. (Ed. D.J. Reuter and J.B. Robinson) (*CSIRO Publishing:* Collingwood, Victoria). pp. 285-346.

4. Rowe, B.A. 1982 *Aust. J. of Exp. Agric. and Anim.Hus.* **22**, 100-105.

5. Shannon, P.W., Pringle, R.M., Mansell, G.P., and Edmeades, D.C. 1984. *N.Z. J. Agric. Res.* **27**, 357-361.