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RESPONSES TO NITROGEN FERTILIZER IN DAIRY PASTURES WITH DIFFERING PHOSPHORUS FERTILITY IN SOUTH EASTERN AUSTRALIA

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Abstract

The application of nitrogen (N) fertilizer to temperate pastures is an increasingly popular management tool for boosting pasture production on dairy farms in Australia. However, limited information is available about N fertilizer responses that can be obtained from pastures with varying levels of phosphorus (P) fertility. A field experiment examining the initial and residual response of pasture growth to urea was carried out within a large dairy farmlet study, in October 1998. The four P fertility treatments (Olsen P values) ranged from 9 to 32 mg/kg. Dry matter yields increased with increasing N rates in all treatments, at both harvests. Only pastures with Olsen P values of < 12 mg/kg had a significantly lower response to N fertilizer.

Keywords: Farmlet study, Olsen P, pasture growth, urea

Introduction

Strategic applications of N fertilizer on pastures are now used by most dairy farmers in Australia as an effective way of overcoming short-term seasonal feed deficits, especially when legume derived N is limiting pasture growth (Eckard and Franks 1998). A number of pot and field studies have demonstrated an interaction between the response to N fertilizer and P fertility of the pasture soil (Grant *et al.* 1981; Mouat and Nes 1983; Davison *et al.* 1997; Cayley *et al.* 1998). These results have supported a common perception that high soil P fertility is required to achieve optimum N responses, and led to an increase in P fertilizer use on many dairy farms. However, responses to N fertilizer, obtained from pastures at various levels of soil P status have not been well defined, particularly across the range found between most dairy farms in Australia.

Material and Methods

The study was located at Agriculture Victoria Ellinbank in West Gippsland Victoria (38o 15’ S; 145 o 93’E; mean annual rainfall of 1100 mm). The farmlet study involved 10 dairy herds of 15 cows, in an incomplete factorial design, with 3 stocking rates of 2 (L), 3 (M) and 4 (H) cows/ha, and 4 phosphorus fertilizer rates of 0 (1), 35 (2), 70 (3), and 140 (4) kg P/ha/year. Two of the treatment combinations, M2 and M4, were replicated twice. Each farmlet contained 13 paddocks of uniform area, with total areas of 7.5, 5 or 3.9 ha, corresponding to the 3 different stocking rates. Basal applications of 44 kg sulphur/ha/year and 30-60 kg potassium/ha/year were applied to all pastures with P fertilizer in autumn and spring. The soil type was a well-drained red clay loam (ferrasol).

The permanent pasture within all farmlets consisted of perennial ryegrass (*Lolium perenne*) (>60%) in association with white clover (*Trifolium repens*), annual grasses and broadleaf weeds. Urea was applied to 2 x 10 m plots within 3 paddocks in all of the 10 farmlets in late winter, at rates of 0, 20, 40, 80 and 160 kg N/ha, in a randomised block design. Prior to N fertilizer application, 150, soil cores (10 cm) were collected from each experimental area to determine extractable P values (Olsen et al. 1954) and total N (Leco N analyser). Mixed pasture samples were also analysed for P and N content using x-ray fluorescence spectroscopy. Pasture yields and compositions were examined after 28 days and again after a further 21 days. Nitrogen rates were log transformed to fit a linear model to the response relationship, and the slope determined. All data were subjected to a one-way analysis of variance.

Results and Discussion

There was a significant effect (P<0.05) of P fertilizer rate on soil P levels (ranging from 9 to 32 mg/kg) and pasture P content (ranging from 0.38 to 0.54%), but not soil or pasture N levels, prior to the N fertilizer application (Table 1). There was also a significant effect of stocking rate (P<0.05) on P% in pasture between the L2 and M2 farmlets.

Pasture DM yields increased with N fertilizer in all farmlets, and at both harvests, but responses diminished with increasing N fertilizer rates (Figure 1). The exception to this was a small decrease in dry matter yield from 80 to 160 kg N/ha within the L2 farmlet (35 kg P/ha/year and 2 cows/ha), at harvest one. In general, the treatments with the higher soil P levels produced the most pasture (Figure 1). There was a significant effect of P fertility on response to N fertilizer, as shown by the significant difference (P<0.05) between the slopes of the relationships between log N fertilizer applied and pasture DM (Table 1). The slopes were similar across all but the lowest soil P levels (< 12 mg/kg), indicating no difference in response to N above an Olsen P of 12 mg/kg. There was no significant effect (P>0.05) of stocking rate. Dry matter yield responses in harvest 2 were substantially lower across all treatments, with no significant (P>0.05) effect of P fertilizer rates or stocking rates (data not shown).

A number of previous field studies have also found greater pasture DM yield responses to N fertilizer at higher P status. Davison *et al*. (1997) found an N x P interaction on Green Panic based pasture (*Panicum maximum* cv. Gatton) but this only occurred after 5 years, when the P fertility of the two P treatments had separated markedly. Work in sheep pastures by Cayley *et al.* (1998) found that N responses increased with increasing P fertility, but the composition of these pastures were substantially different between their different treatments. Grant *et al.* (1981) reported significant N x P interactions in ryegrass monoculture, but not for browntop (*Agrostis tenuis*) in hill country in New Zealand. Our study supports these results, indicating that responses to N fertilizer in dairy pastures were limited when P fertility was low (Olsen P values < 12 mg/kg), but not where P fertility was moderate or high (between 12 – 32 mg/kg).

The results from this study have indicated that DM yield response of dairy pastures to N fertilizer may be restricted by low soil P fertility. Since the P fertility levels found on most dairy farms in south eastern Australia are generally above 12 mg/kg, these results do not support the need for higher soil P status, and therefore high P fertilizer inputs, to maximise the response to N fertilizer.

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Table 1 - Treatment combinations of stocking rate and P fertilizer rate in the farmlet study and nitrogen and phosphorus levels of the soil and pasture prior to urea application and response to nitrogen fertilizer, in October 1998.

Farmlet	**P application rate (kg P/ha)**	**Stocking rate (cows/ha)**	**Soil**		**Pasture**		**Slope[1]**
			Olsen P (mg/kg)	**Total N % (w/w)**	**Total P % (w/w)**	**Total N % (w/w)**	**(kg DM/ha)/ log (kg N/ha)**
L1	0	2	9	0.68	0.38	3.8	116.3
M1	0	3	9	0.64	0.39	4.1	96.1
L2	35	2	12	0.65	0.42	3.4	193.3
M2[2]	35	3	13	0.67	0.47	4.2	159.8
M3	70	3	16	0.75	0.52	4.3	152.6
H3	70	4	19	0.69	0.50	4.3	142.9
M4[2]	140	3	30	0.70	0.53	4.1	166.3
H4	140	4	32	0.67	0.54	3.9	168.5
	l.s.d.(P=0.05)[3]		4.14	0.15	0.05	0.5	88.2
	Phosphorus rate		S[4]	NS	S	NS	S
	Stocking rate		NS	NS	S	NS	NS

[1] Slopes of the relationship between DM yield and log transformed N fertilizer rates within each farmlet in harvest one
[2] Results are means of replicate farmlets
[3] Least significant difference
[4] S and NS are significant ($P<0.05$) and non significant ($P>0.05$) differences, respectively

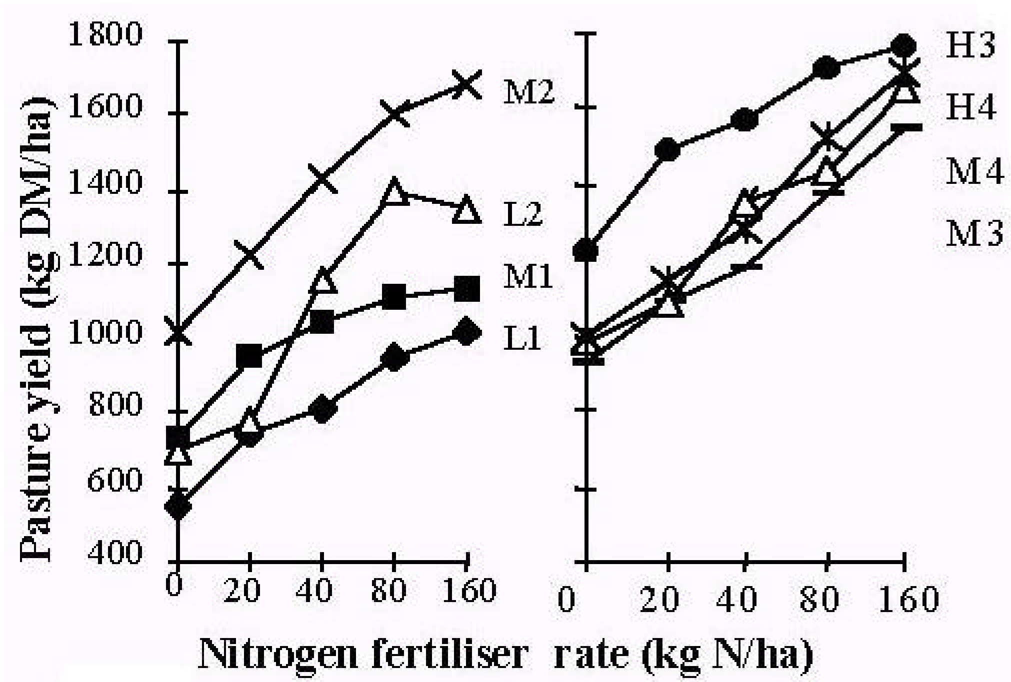

Figure 1 - Effect of N fertilizer applications on pasture DM yield (kg DM/ha) in October 1998, when applied to dairy pastures with varying stocking rates of 2 (L), 3 (M) and 4 (H) cows/ha and P fertilizer rates of 0 (1), 35 (2), 70 (3) and 140 (4) kg P/ha/year.