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This collection is currently under construction.

The XIX International Grassland Congress took place in São Pedro, São Paulo, Brazil from February 11 through February 21, 2001.

Proceedings published by Fundacao de Estudos Agrarios Luiz de Queiroz

ID # 04-10

PHOSPHORUS FERTILIZER REQUIREMENTS FOR TEMPERATE DAIRY PASTURES AND MILK PRODUCTION IN SOUTH EASTERN AUSTRALIA

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Abstract

Phosphorus (P) fertilizer is required to sustain productive pastures in Australia, yet optimum P fertility is poorly defined. A large farmlet study involving 10 herds was established in 1995 to determine the relationship between milk production and pasture response to four different P fertilizer rates, at three stocking rates. Pasture growth significantly increased with increasing P fertilizer rate. Cumulative milk production from pasture over 4 years, was significantly affected by P fertilizer, but responses diminished with increasing P rate. The results from this study will enable a better targeting of P fertility levels for profitable milk production from temperate dairy pastures and minimise the environmental impact of excess P fertilizer use.

Keywords: Pasture growth, farmlet study, stocking rates, Olsen P.

Introduction

Phosphorus fertilizer use is well-entrenched in pasture based dairy systems in Australia. Despite this, the direct link between P fertilizer and milk production is poorly defined and recommendations have been largely based on results from ungrazed pasture plots (Sparrow

1993). Over the past decade, increasing stocking rates and pasture utilisation, have been used to justify increases in P fertilizer recommendations. Recent studies highlighting the links between P fertilizer applications and losses from dairy pastures (Nash and Halliwell, 1999) make it essential that current and future P fertilizer practices are based on scientifically sound information.

Material and Methods

The study was located at Agriculture Victoria Ellinbank in West Gippsland Victoria (38^{o} 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 consisted of perennial ryegrass (Lolium perenne L)(>60%) in association with white clover (Trifolium repens L), annual grasses and broadleaf weeds.

Cows were initially allocated to herds in June 1995, and at the end of each lactation 3 heifers replaced cull cows. Each of the 4 lactation periods were between July and May, with cows staying in their respective paddocks during their dry period. At the beginning of each lactation, a projected milk production curve for each herd was calculated, based on a yield of 180 kg milk fat per cow and accounting for the calving pattern. Milk production from each herd was measured twice daily. Supplementary feed requirements was determined by assessing current milk production against the projected production curve. Conserved fodder, and brought in hay and barley, was fed when production fell below the projected curve.

Pasture mass (kg DM/ha) was determined weekly in all paddocks and growth rates (PGR kg DM/ha/day) calculated. Pastures were grazed from approx. 2200 to 1350 kg DM/ha. Pasture in excess of cow demand was conserved as silage and fed back to corresponding herds. Soils were sampled to 10 cm from all 130 paddocks in April of each year and P fertility measured using the Olsen P test (Olsen *et al.* 1954).

Results and Discussion

Phosphorus fertility and pasture production. The average initial Olsen P values of all farmlets in 1994 was 13 mg/kg. The addition of P fertilizer at 70 and 140 kg P/ha/year to the M3, H3, M4, H4 farmlets increased the P fertility over 4 years to 20 and 30 mg/kg, respectively. The farmlets receiving 35 kg P/ha/year (L2, M2) maintained their initial fertility and those receiving 0 kg P/ha (L1, M1) declined to 7 mg/kg (Table 1). The high P sorption capacity of the soil clearly impacted on the rate of change in P fertility. Even after 560 kg P/ha had been applied over 4 years (M4,H4), the Olsen P value had only changed from 13 to 30 mg/kg.

Increasing P fertilizer rates significantly ($P<0.05$) increased pasture growth rates (Table 1). At a uniform stocking rate of 3 cows/ha, the difference in pasture growth rates between the 0 and 140 kg P/ha/year farmlets increased from 8% in 1995-6 to 16% in 1998-9. Stocking rate had little effect on pasture growth rates or P fertility. The dry season in 1997-8 resulted in lower pasture growth rates across all farmlets (Table 1) but an increase in the relative growth rate difference between P fertilizer treatments. Work by Singh *et al.* (1999) on the same site during this dry period highlighted the improved performance of white clover when high P fertilizer rates were applied and this effect is likely to be influencing overall pasture performance.

Milk production. All herds had similar annual milk yields, producing around 74,000

L/herd/year. Milk production/ha was therefore related to stocking rate, with herds averaging 10,000, 15,000 and 19,000 L/ha, for the 3 stocking rates, respectively. When milk production from brought in supplements was accounted for, there was a significant effect of P fertilizer rate ($P<0.05$) on milk produced from pasture (L/ha) over the 4 years (Figure 1). However, the milk production response diminished with increasing P fertilizer additions. The response to P fertilizer was greatest between 0 and 35 kg P/ha and this effect increased each year. Milk production gains from increasing the P fertilizer rate from 35 to 70 or 140, (corresponding to Olsen P values of 13, 20 and 30 mg/kg respectively), were not significantly different ($P>0.05$), although a positive trend is apparent with increasing years.

These results are in contrast to reports from previous New Zealand farmlet studies which suggested increasing P rates up to 100 kg P/ha/year and Olsen P values in excess of 50 mg/kg, were economically justified (Thomson *et al.*, 1993). However, these conclusions were based on the last year of the 3 year study, and when differences between soil sampling depth, lactation lengths, and the inclusion of all years data are accounted for, the results appear similar.

Given the financial costs and environmental implications of applying excess P fertilizer rates, it is important that dairy farmers optimise the P fertility of their farms. The results from this study have quantified the benefits of P fertilizer on milk production and will enable farmers and advisers to target soil P fertility for optimum milk production.

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Table 1 - Average Olsen P soil test values (OP, mg/kg) and pasture growth rates (PRG, kg DM/ha/day) across all paddocks in each farmlet between 1995 and 1999.

Farmlet and treatment	**1995-6**		**1996-7**		**1997-8**		**1998-9**	
	OP[1]	**PGR**	**OP**	**PG**	**OP**	**PG**	**OP**	**PG**
L1 (2 cows; 0 kg P/ha/year)	6	25	10	17	9	23	7	23
L2 (2 cows; 35 kg P/ha/year)	8	28	14	19	12	28	13	25
M1 (3 cows; 0 kg P/ha/year)	7	25	12	18	10	23	8	25
M2 (3 cows; 35 kg P/ha/year) [3]	9	26	13	20	11	25	14	27
M3 (3 cows; 70 kg P/ha/year)	10	27	15	22	16	28	20	27
M4 (3 cows; 140 kg P/ha/year) [3]	12	27	24	22	24	28	30	29
H3 (4 cows; 70 kg P/ha/year)	10	26	18	22	17	28	20	29
H4 (4 cows; 140 kg P/ha/year)	13	27	23	23	25	27	29	30

1. Average for all 13 paddocks in each farmlet measured in April of each year

2. Pasture growth rates determined weekly in ungrazed paddocks in each farmlet

3. Results are means of replicate farmlets

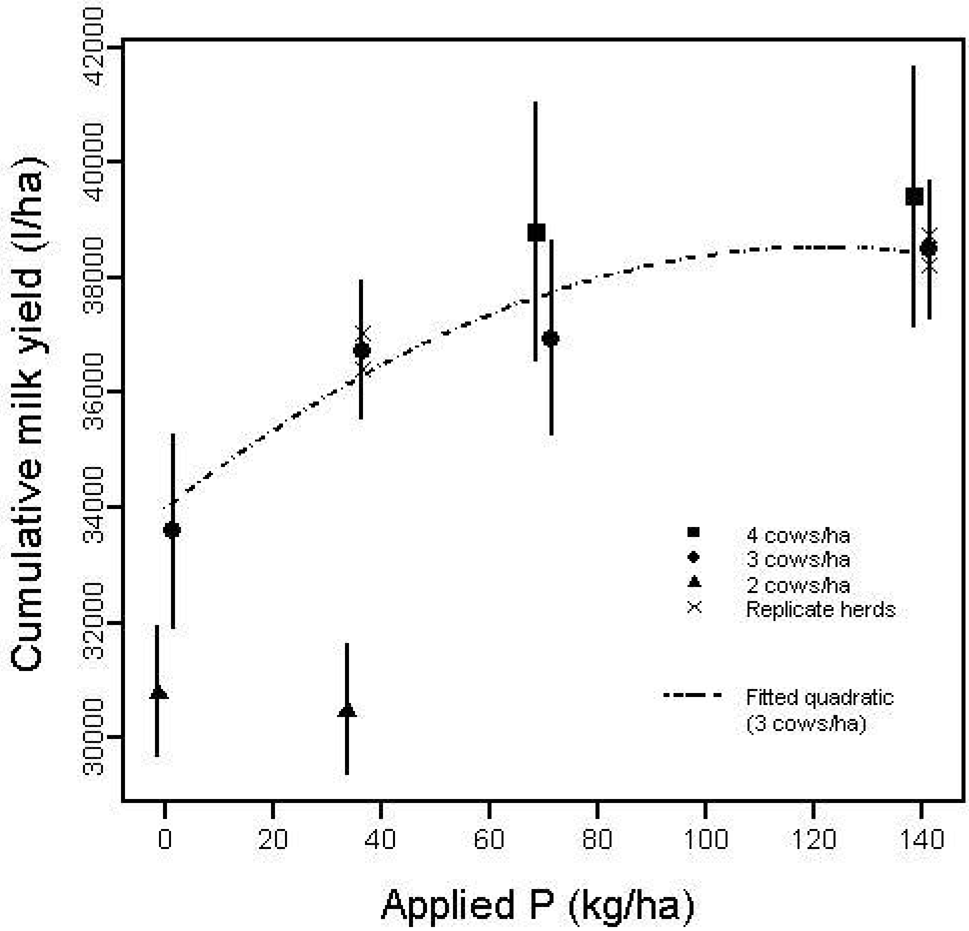

Figure 1 - The cumulative effect of P fertilizer application and stocking rate on milk production between 1995 and 1999. Error bars are 95% least significant intervals (LSIs) for comparing treatment means. LSIs are defined such that intervals overlap when differences are not significant.