Pasture response to superphosphate application in topographically diverse landscapes of the Central Tablelands and Monaro regions of New South Wales

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Abstract

Phosphorus (P) as single superphosphate (9%P, 11%S) was applied annually at six rates ranging from 0-80 kg P/ha/yr for three years to north upper (NU), north lower (NL), south upper (SU) and south lower (SL) slope positions in three pasture paddocks *i.e.* 12 'locations', of the Central Tablelands (CT) and Monaro (M) region of NSW. The pastures used were based on native perennial grasses (*Microlaena stipoides* or *Austrostipa* spp. respectively for CT and M) or cocksfoot (*Dactylis glomerata*) (CT). A total herbage response to application of P was recorded at six out of 12 positions despite most locations having very low soil available P levels. Where an overall increase in production occurred it was linear and due to increased legume production at the native grass sites and to perennial grasses at the cocksfoot site. While responses were statistically significant, it may not be economically prudent to apply superphosphate to all responsive landscape positions. The results of this study indicate merit in adopting strategic fencing and differential fertiliser application strategies for improved economic outcome in topographically diverse landscape paddocks in NSW.

Keywords

variable landscape, phosphorus,

Introduction

Collectively the CT and M regions of NSW occupy an area of 50,000 km^2. Large scale cropping operations in these regions are precluded by topographic and climatic parameters. Livestock production (beef, meat sheep and Merino sheep) based on native perennial or introduced perennial grasses in combination with introduced legumes form the basis of income on most farms (Garden et al. 2000; Clements et al. 2003). Land prices relative to returns make expansion of existing farming operations via acquisition of more land difficult. Therefore farmers need to increase return per unit of land area to remain viable. Fertiliser can be used to increase pasture production and therefore carrying capacity. Use of fertiliser on pastures has declined historically initially due to the removal of the government-subsidised superphosphate bounty in the mid 1970's and more recently due to sharp increases in fertiliser prices (Mokany 2009). Traditionally, recommendations on how much fertiliser to apply have been based on the results of soil tests, with particular emphasis on the availability of soil P. The desired level of available P required to achieve a high level of pasture production has been described by various authors with refinements made over time to account for differences in parameters such as soil buffering capacity, pasture type and stocking rates (Gourley et al. 2007; Simpson et al. 2009). While the refinements in identifying critical soil P levels are valuable, it still assumes homogeneity in response potential over the target application site. Past New Zealand research in topographically variable landscapes has shown that pasture production and response to application of fertiliser differs significantly due to slope, aspect, botanical composition and microclimate (Radcliffe 1982) and considerable gains can be made in overall farm profitability by adopting a differential fertiliser application strategy (Barker et al. 1999). This area of research has largely been overlooked in Australia. Given fertiliser prices are predicted to remain high for the foreseeable future (Mokany 2009) it is critical the response potential of various areas of the landscape be defined so maximum production, financial and environmental benefit can be made from its use.

Materials and methods

Experimental locations were established on northern and southern aspects at upper and lower slope positions near Burraga (34°01'S, 149°33'E) on the CT of NSW in a native perennial grass-based pasture and a cocksfoot-based pasture and at Jimenbuen (36°43'S, 148°50'E) in the M region in a native perennial grass-based pasture (Table 1).

Table 1. Initial soil P (Colwell), critical soil P, P required to achieve critical soil P, phosphorus buffering index (PBI), exchangeable aluminium as a percentage of total CEC, elevation, slope and frequency of major pasture components for NU, NL, SU and SL locations at three variable landscape sites in NSW. Values within sites followed by the same letter are not significantly different (P=0.05).

Site	Location	Initial P (mg/kg)	Critical P (mg/kg)[1]	P required for critical P (kg P/ha/yr)[2]	PBI	Al (%)	Elevation (m)	Slope (°)	Perennial grass frequency (%)	Sub clover frequency (%)	Other legume frequency (%)
Burraga native	NU	3.3[a]	30	32	55	15.2[b]	885	16	39[a]	17[a]	17[a]
	NL	7.5[ab]	27	80	29	9.7[a]	854	16	65[b]	20[a]	50[b]
	SU	11[bc]	30	132*	62	8.6[a]	885	13	65[b]	67[b]	64[b]
	SL	14[c]	27	124*	30	21.3[c]	847	8	65[b]	38[ab]	8[a]
	LSD (5%)	4.5				4.7			14	40	31
Burraga cocksfoot	NU	23[b]	27	19	32	14.3[a]	835	11	31[a]	66[b]	0[a]
	NL	28[c]	26	adequate	26	13.5[a]	820	11	28[a]	88[c]	0[a]
	SU	14[a]	26	54	28	24.3[c]	830	5	23[a]	62[b]	9[b]

	SL	23^{b}	27	19	33	20.2^{b}	815	13	45^{b}	29^{a}	15^{b}
	LSD (5%)	4.0				3.8			11	19	7
Jimenbuen	NU	15^{b}	30	53	60	3.8^{a}	883	9	45^{c}	1.0^{a}	16^{b}
	NL	15^{b}	30	53	61	9.7^{b}	863	2	40^{bc}	45^{b}	0^{a}
	SU	10^{a}	28	75	42	5.1^{a}	882	9	26^{a}	100^{c}	5^{a}
	SL	10^{a}	28	75	42	8.7^{b}	865	10	31^{ab}	100^{c}	0^{a}
	LSD (5%)	3.0				2.7			12	20	8

[1]Predicted critical Colwell P is based on the equation of Gourley et al. (2007) where Critical Colwell P = $19.6 + 1.1 \times PBI^{0.55}$

[2] Indicates the quantity of P that was required in this study to raise soil available P to critical level (soil response curves to application of P are available on request from the author). * indicates that P required to obtain critical P is outside the range of that applied in the study

Each location was fenced to exclude grazing. Six superphosphate (9% P, 11% S) treatments (0, 10, 20, 40, 60 and 80 kg P/ha) were applied to individual plots (4 m x 4 m), n=2 on 29 May 2001 and repeated 15 April 2002, 12 April 2003. Herbage production and botanical composition were assessed (t'Mannetje and Haydock (1963) on 15 (Burraga) or 14 (Jimenbuen) occasions over three years at 10 fixed points within each plot (quadrat = $0.1m^2$). Following each assessment, herbage was mown and removed. Total cumulative production and cumulative production of pasture components were calculated. The relationship between P-rate and herbage production was assessed using cubic smoothing splines fitted as linear mixed models (Verbyla et al. 1998) at the location level and significant differences (P=0.05) between phosphorus application rates determined . The underlying linear trend (slope) and curvature was identified. A covariance was fitted between intercept and slope at the replicate level.

Results

Responses in total cumulative production to application of P over the three years of the study were recorded at only 6 of the 12 locations (Fig. 1), despite most locations, particularly at the native grass based sites, being well below the critical level of P required for near maximum production (Table 1). Where an overall increase in production was recorded at the native perennial grass sites it was due to an increase in legume growth (Fig. 1). At the cocksfoot site, overall responses to P occurred due to an increase in perennial grass production. Native grass production was relatively stable at all locations (except the SU) at the Burraga native grass site with increasing rates of P, but at the Jimenbuen site, native perennial grass production declined at the south slope locations with increasing rates of P. Monitoring of soil available P over the duration of the study indicated that rates of 0-132 kg P/ha/yr for a period of three years would be required to reach critical soil P levels (Table 1).

Discussion

Results from this study indicate significant variation in response potential of discrete areas within variable landscapes. Differences in response cannot be fully explained by the soil chemical conditions that were measured. All locations at the native perennial sites were very deficient in soil P yet only four of the eight locations within these sites were responsive to applied P. Botanical composition also differed significantly across the sites and although some locations within sites had favourable legume content (e.g. the SL at the Burraga native site) and were also very deficient in soil P, there was still no response to applied P. These results indicate that factors other than P and botanical composition limited pasture production in those areas and may indicate that critical soil P levels in such landscapes require further refinements and/or greater consideration of other soil chemical factors in determining potential pasture response to P application. Only two of the four locations at the Burraga cocksfoot site where P had been applied regularly were responsive to P. Legume content of the pasture at that site was in the range considered favourable and soil available P was near adequate at three of the four locations indicating that near maximum production was probably being achieved.

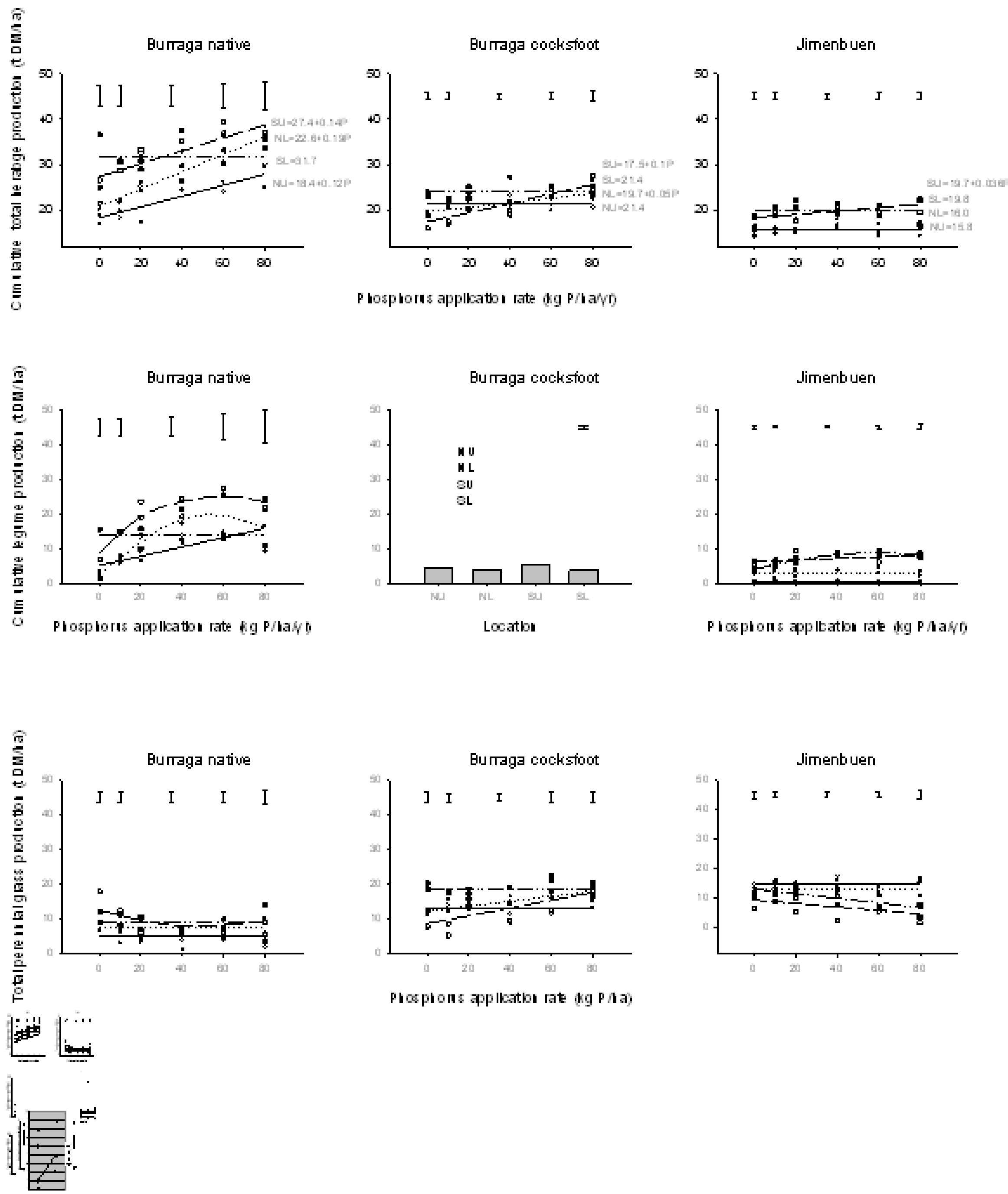

Figure 1. Total cumulative pasture production, total cumulative legume and total cumulative perennial grass production (t DM/ha) over three years at various rates of P addition at NU, NL, SU and SL landscape locations in three variable landscape sites in NSW. Where only vertical bars are shown in the figure, there was no relationship between P-application and herbage production at any location within a site and therefore only the average for the respective location is shown.

While there were P-responsive locations at all sites, magnitude of the response to P application, the time of year the increase in production is achieved and the ability to capture the increased production as animal product need to be considered. At the native perennial grass-based sites, additional production generated through P addition occurred in spring and the increase in production ranged from 36 kg DM/kg

P applied (Jimenbuen) to 120-190 kg DM/kg P applied (Burraga) over the three years of the study or 12-63 kg DM/kg P applied/yr. At the commonly used farmer application rate of 10 kg P/ha/yr this would equate to an increase in production of 120-630 kg DM/ha/yr. In recent years superphosphate, the most commonly used form of P used on pastures, has exceed $500/t (Mokany 2009). At this price the extra increase in pasture production at 10 kg P/ha has cost $99 - $520/t. Grazing livestock show strong preferential grazing behaviour based on microclimate, aspect and elevation differences (Hilder 1964; Whalley et al. 1978), therefore capturing increases in production in these landscapes under current fencing arrangements would be difficult. Additionally, Kaiser et al. (2003) estimated utilisation of spring growth in pastures in Australia was only around 30%. If this level of usage is factored in, then the real cost of extra pasture produced at an application rate of 10 kg P/ha becomes $330-$1733/t. Certainly at the higher cost end, the worth of applying P where response is small should be questioned and farmers and advisors in such a situation need to consider whether there is more merit in subdividing variable landscape paddocks to achieve better utilisation of existing pasture growth. Such an approach would then allow fertiliser application to be strategically targeted to areas capable of achieving higher increases in production per unit of fertiliser applied.

References

Barker JD, Sheppard DG, Mackay AD and Dymock N (1999). Hill country farm investment options - cocksfoot pasture vs. superphosphate fertiliser. Proceedings of the New Zealand Grassland Association 61, 17-21

Clements B, Ayres, L et al. (2003). The Graziers Guide to Pasture. NSW Agriculture, Orange.

Garden DL, Dowling PM, Eddy DA and Nicol HI (2000). A survey of farms on the Central, Southern and Monaro Tablelands of New South Wales. Australian Journal of Experimental Agriculture 40, 1081-88

Gourley C, Melland A, Waller R et al. (2007). Making Better Fertiliser Decisions for Grazed Pastures in Australia. Department of Primary Industries, Victoria.

Hilder, EJ (1964). The distribution of plant nutrients by sheep at pasture. Proceedings of the Society of Animal Production 5, 241-8

Kaiser A, Piltz J, Burns H and Griffiths N (2003). Successful Silage. Dairy Research and Development Corporation and NSW Agriculture, Orange.

Mokany, K (2009). Assessing fertiliser options as prices increase. Australian Wool Innovation Ltd

Simpson R, Graham P, Davies L, Zurcher E (2009). Five Easy Steps to Ensure you are Making Money from Superphosphate. CSIRO and Department of Primary Industries NSW.

t'Mannetje, L and Haydock, KP (1963). The dry-weight rank method for the botanical analysis of pastures. Journal of the British Grassland Society 18, 268-275

Whalley RDB, Robinson G and Taylor J (1978). General effects of management and grazing by livestock on rangelands of the northern tablelands of NSW. Australian Rangeland Journal 1, 174-90.

Verbyla A, Cullis B, Kenward M and Welham S (1999). The analysis of designed experiments and longitudinal data by using smoothing splines. Applied Statistics 48, 269-311.