Factors affecting pasture growth in a topographically diverse native perennial grass pasture on the Central Tablelands of New South Wales

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Abstract

Thirty-six sampling locations in a variable landscape paddock on the Central Tablelands of NSW were established to determine the effect of soil chemical, soil physical and botanical composition factors on pasture production. Combinations of these factors were found to be good predictors of potential pasture production. Subterranean clover frequency and the ability of soil to hold moisture were predictors of pasture production in both years. Subterranean clover frequency was in turn affected by soil physical characteristics and at a second tier level by soil available phosphorus (P) in year 1 and soil aluminium in year 2. The results of this research indicate that researchers, advisors and producers need to consider more than just soil available P levels in assessing productive potential of pasture paddocks and their likely response to fertiliser application. Subdivision of variable landscape paddocks on an aspect/position on slope basis appears warranted based on the findings of this study. Subdivision would allow for enhanced management of grazing and better targeting of fertiliser to nutrient responsive areas of the landscape.

Keywords

variable landscape, aspect

Introduction

Topography of the medium to higher rainfall tableland areas of NSW is inherently variable. Livestock-based production enterprises (beef cattle and sheep) form the basis of on-farm income in these areas (Clements et al. 2003). Improving farm productivity and profitability requires an increase in production as high property prices preclude increasing production through acquisition of more land. Increasing productivity requires an increase in pasture growth in order to increase livestock production. This has traditionally been achieved via applying fertiliser (usually in the form of superphosphate 9% P, 11% S) to pasture (Henzell 2007). Soil tests, particularly soil available P, are commonly used to determine whether pasture paddocks require fertiliser application (Gourley et al. 2007). This does not consider variability in soil conditions (chemical and physical), botanical composition and microclimate in topographically diverse landscapes. In New Zealand, significant research in diverse landscapes has found pasture production and response to application of fertiliser vary significantly with aspect, slope, soil conditions and botanical composition (Gillingham 1980; Radcliffe 1982). This area of research has been overlooked in Australia. The aim of this study was to identify factors affecting pasture production in a topographically diverse pasture paddock in the tablelands of NSW and assess the capability different areas of the landscape to respond to fertiliser application.

Materials and Methods

The site was located 14 km south of Burraga (34^{o}01'S, 149^{o}33'E) on the Central Tablelands of NSW. The dominant perennial grass was *Microlaena stipoides*. Subterranean clover (*Trifolium subterraneum*) cvv. Mt Barker and Woogenellup had been introduced to the site in the 1960's and the naturalised annual clovers *T. cernuum*, *T. dubium* and *T. arvense* were common (referred to as 'naturalised clovers'). The site was 30 ha. It was predominately oriented north and south with a gully line dividing the aspects (15 ha each). Within each aspect were various aspect-slope sub categories (Table 1). P as single superphosphate had been applied at 10 kg/ha every third year in the 10 years prior to commencement of the study.

Thirty-six sampling locations were selected across the paddock in a grid pattern. At each sampling location soil (0-10 cm) was collected and analysed for pH_{Ca}, available P (Colwell), available K (Colwell), organic carbon (Walkley-Black) and cation exchange capacity (CEC). Potential rooting as defined by penetrometer resistance to 3 MPa (Cass 2001) was measured at field capacity. Soil physical characteristics, field capacity (Fergus and Stirk 1961), coarse particle fraction (percentage of particles >2 mm) were determined at 0-10 cm, 10-30 cm, 30-50 cm and 50-80 cm. Four plots each measuring 2 m x 2 m were established at each sampling location. Fertiliser as single superphosphate was applied at the equivalent of nil or 20 kg P/ha replicated twice on 1 May 2002. This was repeated on 1 May 2003 with adjacent plots so that the previous year's fertiliser application did not confound the second year study. Botanical frequency of all pasture components was assessed in each plot using a 1m x 1m quadrat divided into a 10 cm x 10 cm grid. Frequency was recorded as the number of grid squares in which a plant base could be found. The paddock was grazed until 22 August 2002 and 27 August 2003. Livestock were then excluded from the paddock to determine spring herbage production. Hackney (2009) in a previous study at this site identified that all response to fertiliser and more than 70% of annual production occurred in spring. Spring herbage production was assessed using a quadrat 50 cm x 50 cm cut to ground level in the middle of each plot. Owing to very dry seasonal conditions, herbage production was measured on October 10 2002 and 23 November 2003. Annual rainfall was 639 mm and 722 mm in 2002 and 2003 respectively compared to a 20 year average of 829 mm. Spring rainfall was 76 mm and 237 mm in 2002 and 2003 respectively compared to a 20 year average of 240 mm. To investigate the relative importance of soil chemical, soil physical and botanical composition features on herbage production, a regression tree was fitted using least squares in Systat 12. Minimum split and split proportions were set at 0.05.

Table 1. Regions, number of sampling areas, elevation and average soil available P for each region on a north and south facing slope in a variable landscape pasture on the central tablelands of NSW.

Aspect	Region of paddock	Total locations	Elevation range (m)	Available P (mg/kg)	Available S (mg/kg)	pH (0-10 cm)	K (mg/kg)	OC (%)	CEC (cmol+/kg)	Clover freq[1]	Herbage increase [2] (kg DM/ha)
North	N-facing upper to mid slope (NU)	4	900-920	15.1a	6.2	4.2a	99	1.6a	2.6a	5.6b	57
	NW-facing upper to mid slope	5	890-920	18.0bc		4.3ab			2.6a	4.0a	74

	(NW)										
	N-facing mid to lower slope (NN)	5	870-900	12.3a		4.5b			2.6a	5.2ab	566*
	NE-facing mid to lower slope (NE)	5	860-880	16.4abc		4.4abc			2.6a	5.9b	688*
South	S to SE-facing upper to mid slope (SU)	6	900-920	16.8bc	5.5	4.3ab	88	1.9b	2.5a	6.3bc	250
	SW-facing mid slope (SW)	3	880-910	15.4ab		4.4abc			2.9a	5.0ab	223
	S-facing mid to lower slope (SS)	5	870-900	19.9c		4.6c			3.7b	7.7c	322
	SE-facing lower slope (SE)	3	860-885	17.2bc		4.3ab			2.7a	5.5b	255
LSD				4.45	1.1	0.20			0.70		

(5%)

[1] Clover frequency shown is the square root of clover frequency (%). [2] Increase in herbage production with addition of P as compared to the nil treatment. * indicates these were significant increases above the nil P treatment. Where only a mean value is given for north and south slopes there was only a significant different between aspects with no interaction of region by aspect.

Results

Application of P (and S) in superphosphate increased pasture production significantly only in the NN and NE regions (Table 1). The effect of all parameters on pasture production with and without fertiliser was modelled using regression trees and the factors affecting production did not vary. The results shown here include all sampling areas with and without fertiliser addition where all soil chemical, soil physical and botanical composition measurements were made. In 2002, 85% of the observed variation in spring production was explained by differences in subterranean clover frequency, naturalised clover frequency, coarse particle fraction of the 0-10 cm soil layer and total species number (Figure 1). Areas with high subterranean clover frequency and high coarse particle fraction were most productive sites (four of the five areas in this group were found on the southern aspect). Where subterranean clover and naturalised clover frequency were low, overall production was lowest. Of the 11 sampling areas in this category, ten were found on the northern aspect with the majority from the NW region. In 2003, use of all parameters explained 79% of the variation in pasture growth (Figure 2). Again, areas with low subterranean clover frequency produced the least amount of herbage with five of the six sampling areas in this category found on the north aspect. Where subterranean clover frequency was very high (>75%) pasture production was greatest with all areas in this category being found on the south aspect. Where subterranean clover frequency was greater than 28% but less than 75% field capacity those areas with high field capacity at 30-50 cm and low coarse particle fraction were most productive of the remaining areas with five of the seven sampling areas in this group being located at mid to lower slope positions. In neither year was soil available P identified as being a factor influencing spring production.

Discussion

The results of the regression tree analysis identified botanical composition and soil physical properties as being the main factors affecting pasture production in the topographically diverse pasture paddock used in this study. Subterranean clover frequency was the first tier indicator of pasture production in both years and this is not surprising given that Australian soils are generally very low in soil N and pasture legumes are the major providers of N and therefore the main drivers of the pasture production system (Donald 1964). Pasture legumes, however, require adequate nutrition (particularly provision of P and S) in order to grow to their full potential and provide N for non-leguminous pasture components. Soil available P is still widely used in Australia as an indicator of whether response to applied P is likely. Gourley et al. (2007) has revised the suggested levels of soil available P required to achieve 95% of maximum production to take into account the phosphorus buffering index (PBI) of the soil. In the same paddock used in the current study, the PBI ranged from 29-62 which is in the low range. The critical P required to achieve 95% of maximum production was calculated as being 27-30 mg/kg. All soils in the study reported in the current paper were well below this threshold and therefore response to P application would be expected. Based on the findings of Gourley et al. (2007), available S was marginal while available K was also deficient. That only two of the eight regions in this study were responsive to application of P and S indicates that factors other than availability of these nutrients limited pasture production. While K was below desirable levels, it was not identified as a key factor determining productivity. Further analyses were undertaken to determine the factors affecting subterranean clover frequency (results available from author). Soil available P was found to be a second tier factor affecting subterranean clover frequency in only the drier of the two study years with soil depth being the main factor affecting subterranean clover frequency in that year. In the second year of the study, where rainfall was 87% of the long-term average, soil depth and available aluminium levels were the main factors affecting subterranean clover frequency with frequency higher on deeper soils with low aluminium.

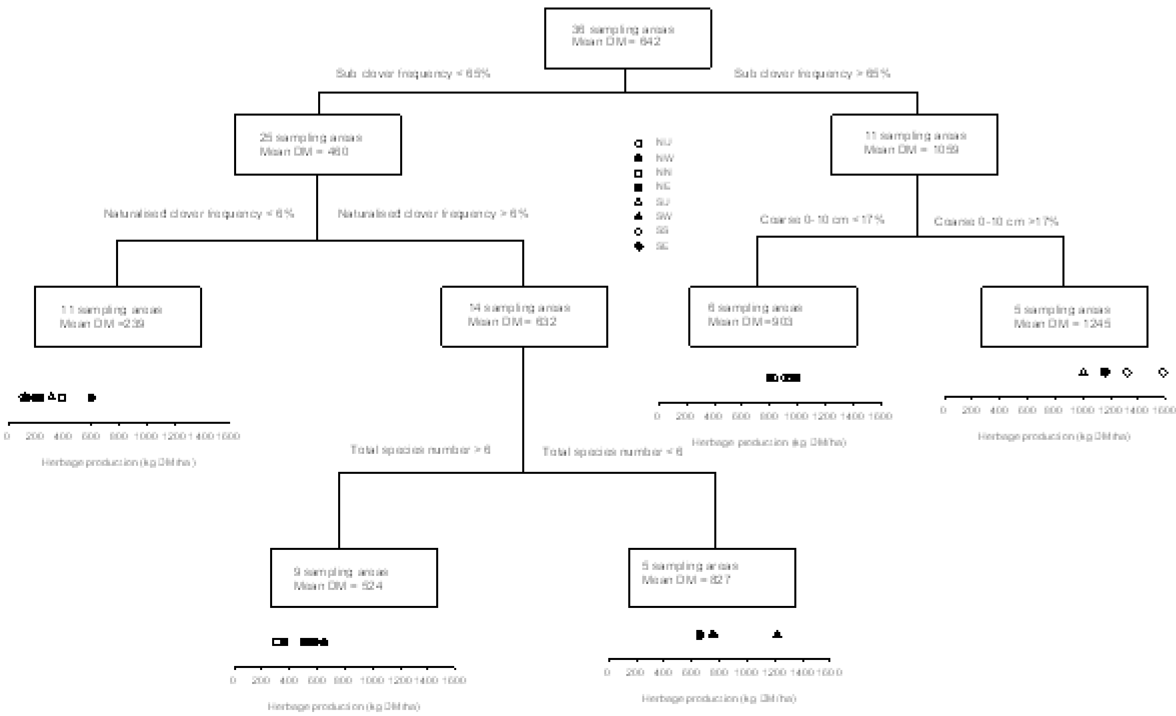

Figure 1. Spring herbage production estimated by soil chemical, soil physical and botanical composition characteristics for 36 sampling areas in eight regions of a native perennial grass-based pasture at Burraga NSW in 2002.

An interesting outcome of these analyses was that very highly productive areas tended to be located on south aspects and/or mid to lower slope north aspects. Differentiation of pasture production capability on an aspect basis are in agreement with past New Zealand studies where individual site characteristics, predominately soil moisture, botanical composition, microclimate conditions and north or south locations, influenced production (e.g. Gillingham 1980, Radcliffe 1982). Hackney (2009) found considerable differences in microclimate conditions between north and south slopes at the site used in this study. An important parameter differing between aspects was availability of soil moisture. Soil moisture conditions were more stable, particularly in autumn when annual legumes were germinating and again in mid to late spring when pastures were growing at their highest rate. The availability of greater moisture confers greater productive capacity on the south slope especially in a dry season.

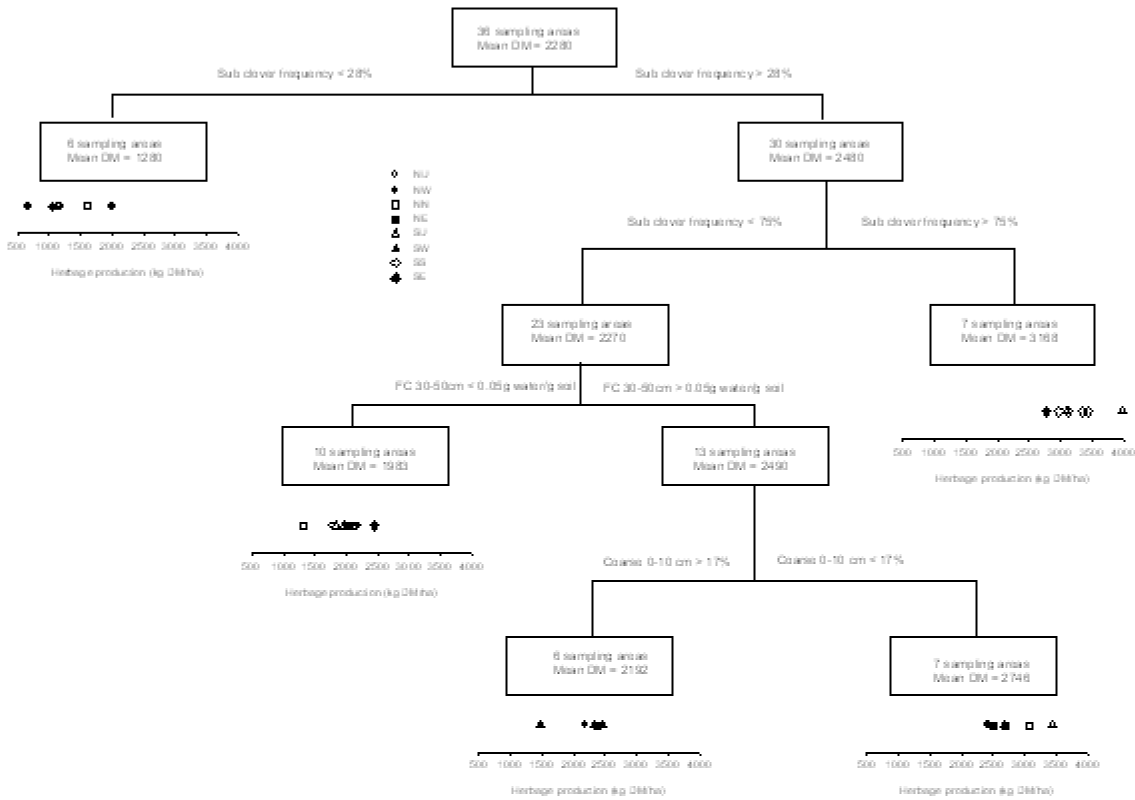

Figure 2. Spring herbage production estimated by soil chemical, soil physical and botanical composition characteristics for 36 sampling areas located in eight regions of a native perennial grass-based pasture at Burraga NSW in 2003.

Overall the results of this study have highlighted the need for consideration of more than just soil available P in assessing the productive capacity of variable landscapes. Certainly farmers and advisors need to consider more closely the composition, particularly the legume content of pastures and the ability of soils to hold sufficient moisture for sustained periods of pasture growth. Further, given the differentiation of productive capacity based on aspect and/or slope position, greater consideration of subdivision of paddocks to better manage pasture growth should be considered. Splitting of paddocks on an aspect and/or slope position basis would allow more targeted use of fertiliser and its allocation to responsive localities within landscapes.

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