Changes in plant frequency within a grazed pasture under ten different fertiliser regimes

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The natural grasslands of the north-west slopes of New South Wales consist mainly of summer-growing frost-susceptible perennial grasses which provide adequate quality herbage during summer but only poor quality residues during winter. Pasture legumes, especially subterranean clover (*Trifolium subterraneum*), can be introduced successfully into these pastures (FitzGerald 1994) thereby improving feed quality in winter, but their persistence is dependant on suitable management and adequate fertilisation.

Fertiliser is the most costly component of a pasture improvement programme, particularly because the requirement is on-going. Difficult economic circumstances may induce producers to consider interrupting or ceasing a fertiliser program. Such decisions need to be taken with full knowledge of the implications for pasture and animal productivity in the short and medium term, and the effects on the long term persistence of desirable pasture components which may have to be resown if lost from the pasture.

Soil tests for nutrient levels in pasture soils are considered useful in the determination of pasture needs in relation to productivity. However, many useful species which are responsive to high soil nutrient levels may persist on soils with low nutrient status, albeit with low productivity. Soil tests may not be a useful guide to the long term persistence of these species.

In this experiment, the objective was to determine the fate of component species of a pasture under various rates and frequencies of application of superphosphate. An established subterranean clover/native grass pasture with a 15 year history of fertiliser application was subjected to various fertiliser regimes. Changes in soil phosphate and the survival of the various component species were observed over a six year period.

Methods

The experiment was conducted from 1985 to 1991 near Gum Flat (150^{0}55'E, 29^{0}48'S; altitude 660m), 10 km south of Inverell NSW. The soil was a sandy grey podsolic of granite origin with pH 4.5 (1:5 $CaCl_2$) and initial soil phosphate of 12.9 ppm (Bray No.1). Average annual rainfall is 750mm of which 62% falls from October to March inclusive. The pasture consisted of native and naturalised grasses and forbs, predominantly redgrass (*Bothriochloa macra*), paramatta grass (*Sporobolus elongatus*), spear grass (*Stipa scabra*), couch (*Cynodon dactylon*), vulpia (*Vulpia* spp.), sorrel (*Rumex acctosella*), flatweed or catsear (*Hypochaeris radicata*) and a substantial stand of subterranean clover *cv* Seaton Park which had been sown in 1974. It had been top dressed annually since sowing with 125 kg/ha single superphosphate. Grazing of the pasture was by sheep and cattle as part of the normal farm management which included occasional periods of rest.

Single superphosphate was broadcast over experimental plots at 4 rates (nil, 100, 200 and 400 kg/ha) and 4 frequencies of application (annually, biennially, triennially and nil) commencing in June 1985. Treatments were fully randomised with 3 replications. They were applied by a 3-point linkage super spreader mounted on a tractor and calibrated to deliver 100 kg/ha down the centre of the plots

Table 1. Phosphorous (μg/g - Bray No 1) measured annually over 7 years under fertiliser applied at 4 rates (kg/ha) and at 4 frequencies on a granite soil near Inverell, adjusted for covariate

		Year						
Rate	Frequency	1985	1986	1987	1988	1989	1990	1991
Nil		12.9	2.0	8.2	8.1	6.0	1.5	4.1
100	Annual	12.9	14.8	41.6	22.8	28.2	13.9	24.4
	Biennial	12.2	3.5	10.2	8.3	15.0	7.0	7.9
	Triennial	11.7	7.8	20.6	11.9	14.2	12.2	17.1
200	An nual	12.5	19.8	34.9	34.7	41.1	31.3	26.4
	Biennial	12.3	6.7	17.6	16.5	29.5	5.1	15.9
	Triennial	11.4	7.9	13.4	12.6	14.2	8.2	20.2
400	Annual	11.7	27.6	92.9	85.5	72.5	22.9	66.5
	Biennial	11.9	6.4	26.3	25.6	34.0	11.3	26.2
	Triennial	12.2	5.3	14.6	20.0	13.4	6.9	25.3

Least significant difference between means (P<0.05) 11.5

Table 2. Effect of frequency of application of superphosphate (mean of 3 rates) on botanical frequency (%) of components of a grazed subterranean clover/natural grass pasture over 7 years

	Frequency of application:				
	Annual	Biennial	Triennial	Nil	lsd[1]
Sub clover	105	88	86	87	6.4
Redgrass	47	41	35	42	ns[2]
Speargrass	28	33	4	29	14
Couch	25	32	33	38	ns
Sorrel	35	41	43	50	ns
Vulpia	2	18	12	31	11.3
Flatweed	0	14	13	20	7.3

[1] Least significant difference (P<0.05); [2] ns = No significant difference

which were 30m in length and marked by a single peg at each end. The 200 and 400 kg/ha rates of application were achieved by travelling the plot twice or 4 times. In 1990, in addition to the sixth year treatments, fertiliser was applied at 100 kg/ha across the northern end of all plots. Subsequent yield and density of subterranean clover seedlings was recorded, in order to observe recovery of plants from resumption of fertiliser application.

Soil samples were taken annually prior to fertiliser application in June using 5 cores to a depth of 10cms within a fixed area of approximately 0.25 sq m situated exactly 15 m from the peg at the northern end of each plot. Species plant frequency was determined annually in June by counting the presence or absence of species in 50 squares within a quadrat 1m x 2m situated at a point exactly 10m from the peg at the southern end. In this way, samples and observations were taken from positions which remained fixed throughout the experiment. In spring 1989, 1990, 1991 and 1992 (after treatments had ceased), herbage yield was assessed by placing exclosures on the plots, 2 per plot, and harvesting all plant material within a 1m x 1m quadrat from inside the exclosure when sufficient harvestable material had grown. Samples were dried and weighed.

Data were analysed with GENSTAT (analysis of variance) using data collected prior to commencement as a covariate. Data was transformed to stabilise the variance where appropriate.

Results

Soil P without fertiliser (Nil) remained relatively constant for the duration of the experiment (Table 1). The soil P levels generally increased with increasing rates of fertiliser when applied annually. At less frequent applications, soil P varied in response to intermittent applications without show-ing any positive upward trend except with biennial applications at high rates (400 kg/ha). Variation in soil P appeared to be independent of the application schedule.

Botanical composition of the pasture was affected much more by frequency of application than by rate of application and generally the effects were consistent over time. Frequency of subterranean clover was greater under annual application than under other application frequencies, while weedy species (vulpia and flatweed) had lowest frequencies from annual applications (Table 2). There was some interaction between rate and frequency for sorrel and spear grass. Both species were suppressed by high rates of fertiliser unless that fertiliser was applied infrequently (Table 3). Likewise, flatweed frequency declined from 19% in the absence of fertiliser to 12% at 100 kg/ha and only 5% at 400 kg/ha (lsd 7.6).

Difficulties with sampling for yield including dry climatic conditions contributed to a failure to detect differences in yield between fertiliser regimes. Likewise no yield response was observed at the conclusion after addition of fertiliser across the

Table 3. Effect of frequency and rate of application of superphosphate on botanical frequency (%) of sorrel and spear grass over 7 years.

Species	Rate (kg/ha)	Frequency of application(%)			
		Annual	Biennial	Triennial	Nil
Sorrel	Nil				50
	100	40	24	37	
	200	5	67	40	
	400	21	32	51	
Spear grass	Nil				29
	100	19	21	54	
	200	37	44	33	
	400	29	34	45	

[1] Least significant difference between means for sorrel, 15.7, and spear grass, 15.1.

northern end of all treatments. Mean density of subterranean clover seedlings at the conclusion (measured in June 1992) was $206/m^2$ and $176/m^2$ across treatments with and without added fertiliser respectively, but this apparent trend in stand recovery was not significant.

Conclusions

There are a number of procedures available to land managers for the manipulation of botanical composition of plant communities. Considerable effort in recent years has been directed at the use of grazing management strategies for this purpose, *e.g.* MRC Temperate Pasture Sustainability Key Program, but the results presented here show the importance of fertiliser strategies for influencing pasture composition as well. The impact of each approach may be greatly enhanced if used in conjunction with other approaches rather than in isolation.

The pastures in this study were part of a commercial paddock and received no special treatment. Commercial grazing entailed occasional rests, and alternation between sheep and cattle. The possibility of interaction between fertiliser strategy and animal type may need further investigation. In the meantime it seems clear that fertiliser programmes are an important adjunct to other management tools for control of pasture composition, and that, consistent with current recommendations (Cregan *et al.* 1989), on granite soil, high quality (non-weedy) pastures are best sustained by frequent (annual) rather than infrequent applications of fertiliser. Crocker (1992) also observed a reduction in legume contribution from cessation of annual applications of fertiliser.

The emphasis in preparation of the experimental protocol was on botanical changes rather than yield. Consequently, yield data which was collected involved procedures and timing which would only detect very large yield differences, and such differences were not observed. Their absence can be attributed in part to the observation reported that when populations of some species declined, they were replaced by others, apparently compensating in terms of yield if not in terms of feed quality. This compensation was not reported by Crocker (1992) but his trials were conducted on old cropping soils sown to introduced species and were ungrazed.

Provision of soil P is necessary for establishment (Cregan *et al.* 1989) and maintenance (Crocker 1992) of pasture legumes. Soil P levels at commencement in this experiment were adequate (12.9 ppm) but declined in the Nil treatment to 1.5-4.1 ppm after 7 years. It is noteworthy that, despite this low P level, the well-established stand of subterranean clover did not decline to the extent that it would require resowing.

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