CHANGING PROPORTIONS OF LEGUMES AND GRASSES DURING DEVELOPMENT OF OVERSOWN PASTURES IN OTAGO TUSSOCK GRASSLANDS

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ABSTRACT

Oversowing trials have been conducted on acid tussock grassland soils in Otago. Observations in 3 mowing-trials were made on the grass and legume components of total pasture production. The sites were located at three altitudes (500, 750, 1,050 m) and included a range of fertiliser and lime treatments applied to 'Grasslands Maku' (*Lotus pedunculatus*), Maitland (*Lotus corniculatus*), and 'Grasslands Huia' and 'Grasslands Tahora' white clovers (*Trifolium repens*). An examination was made of the effects of legume, altitude and fertility on sward development. Swards were initially legume dominant and we concentrate on the increasing grass component during sward development over 4 years.

At the lowest site the grass component of all swards was about 30 % in year 1. This component in lotus swards showed little change until year 4. In clover swards the grass component increased rapidly and remained high throughout the trial.

With increased altitude the swards took longer to develop, and at the highest site the grass component increased rapidly and remained high throughout the trial. The swards also took longer to develop at increased altitude and at the highest site the grass component of lotus swards generally remained low throughout the trial. With the clover cultivars the grass component increased more slowly than at lower altitudes.

Because the grass was generally an increasing component of all swards with time, the actual weight of grass production also tended to increase with time and sward development.

All legumes showed highly significant responses to superphosphate, but there was little relationship between rate of superphosphate applied and the percent of grass in the sward, which was influenced by lime rate, and especially, by altitude.

INTRODUCTION

The productivity of New Zealand hill and high country, much of which is unsuitable for cultivation, has been dramatically increased through the aerial application of fertiliser, and oversowing legumes (Pantall, 1988).

Following the introduction of legumes tussock grassland usually changes quite quickly from being dominated by low fertility tolerant grasses to being dominated by legumes. Subsequently, as soil fertility improves due to fertiliser application and nitrogen fixation by legumes, the resident and sown grasses respond and become an increasing component of the sward (Hall, 1987).

In this study we report observations on the development of the grass component of swards associated with four different legumes (2 lotus species and 2 white clover cultivars), and we discuss how this development is influenced by altitude, fertiliser, and lime application.

EXPERIMENTAL

Three experimental sites were established on Upland Yellow Brown Earth soils (Treviot set) at 500, 750 and 1,050 m on the Lammerlaw and Lammermoor ranges in spring 1983. Sites had no known previous fertiliser history and were chosen to have similar soil chemical properties and gently sloping north easterly aspect (Table 1). Vegetation was dominated by snow tussock (*Chinochloa rigida*) but included *Festuca novae zelandiae*, *Poa colensoi*, *Anthoxanthum odoratum*, *Agrostis capillaris* and *Holcus lanatus* as well as some

Table 1: Location, soil and vegetative characteristics of trial sites.

Property	Site 1	Site 2	Site 3
Site characteristics			
Location	Ailsa Craig	Castle Dent	Waipori
Map reference (NZMS.1)	S153 582003	S162 435838	S162 582678
Soil pH	4.52	4.55	4.66
Olsen-P (ug/ml)	5.9	2.8	6.9
Sulphate-S (ug/g)	6.2	6.7	12.5
Growing Season (days with mean temp > 5°C)	175	231	245
Altitude (m)	1,050	750	500
Intertussock resident grasses (Percent by point analysis)			
Anthoxanthum odoratum	19	8	13
Agrostis Capillaris	1	52	36
Holcus lanatus	0	0	10

other herbaceous plants. Sites were trimmed to about 150 mm and cut herbage removed prior to oversowing.

Treatments were applied to 2 m x 4 m plots, replicated three times, and included the following legume cultivars: Maitland lotus (*Lotus corniculatus*), 'Grasslands Maku' lotus (*Lotus pedunculatus*), and 'Grasslands Tahora' and 'Grasslands Huia' white clovers (*Trifolium repens*): no grasses were oversown.

Legume seeding rates supplied approximately 750 viable seeds/m², equivalent to 6 kg/ha Maku lotus. All legumes were inoculated at 5 times the recommended rate (Lowther, 1977) and all, except Maku lotus, were lime pelleted (Lowther, 1976). These were oversown and treated with a modified factorial arrangement of lime (up to 4 t/ha) and superphosphate treatments (0, 250 and 500 kg/ha initially followed by 0, 125 and 250 kg/ha annually) described by Floate *et al.* (1988). On account of this, lime and superphosphate data were analysed separately.

Pasture production was measured using a cut and remove technique with a subsample being taken to determine total and grass dry matter (DM) yields. In the last two years this technique was modified: in these years, estimation of the second and subsequent harvest yields was made using a pasture capacitance probe (Crosbie *et al.*, 1987), and herbage was removed.

Data for each site were analysed by analysis of variance, with year nested within plots, assuming temporal correlation was negligible. An among site analysis was also conducted.

Following oversowing in spring 1983 there was little growth of the sown legumes except at the lowest altitude (Site 3). We therefore present only the complete data sets for 1984-85 (year 1), 1985-86 (year 2), 1986-87 (year 3) and 1987-88 (year 4).

RESULTS

At the lowest altitude the proportion of volunteer grass in all swards was about 30 % in year 1. In years 2 and 3 the proportion of grass in the Maitland and Maku swards remained low but in year 4 increased to about 60 % (Fig 1). Grass in clover swards increased rapidly in year 2 and exceeded 80 % throughout the remainder of the trial.

At the intermediate altitude the grass component of all swards was about 40 % in year 1. This is higher ($P < 0.01$) than at the lowest site, reflecting the smaller legume component and slower legume establishment at this site. The grass component of both lotus swards was lowest in year 2 when lotus was dominant. Subsequently, the proportion of grass in the lotus swards increased steadily to about 60 % in year 4. With both clover cultivars, the grass component increased steadily from year 1, reaching about 80 % in years 3 and 4.

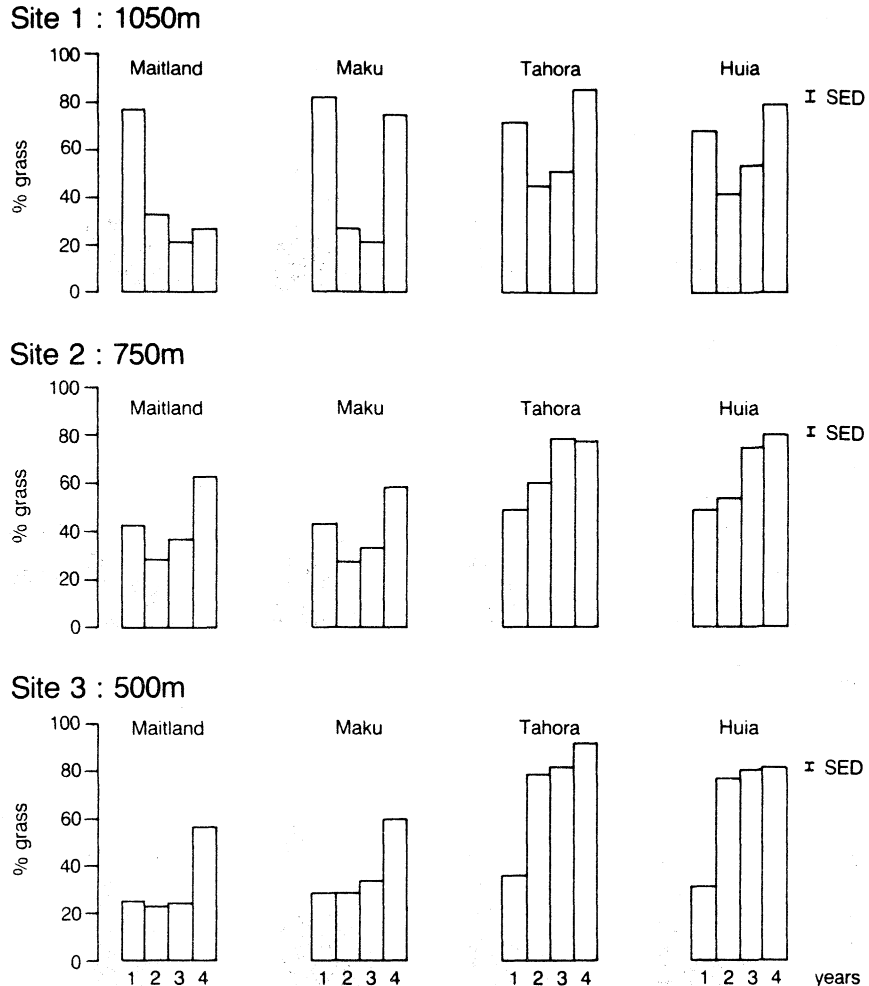

Figure 1. **Changes in the grass component of four oversown legume swards over a five year period.**

At the highest altitude the proportion of grass in all swards was very high (70 - 90 %) in year 1 due to the slow establishment of the legumes. In subsequent years the grass component of both the lotus swards was small, except for Maku in year 4 when it was exceptionally high. The proportion of grass in clover swards dropped to about 50 % in year 2 when the clover was dominant and subsequently increased, reaching 80 % in year 4.

Sward development was thus markedly influenced by altitude: Grass approached 80 % of total production as all clover swards developed, and this was reached in year 2 at 500 m, in year 3 at 750 m, but not until year 4 at 1,050 m. With the lotus swards the grass component only reached 60 % of total production at the two lower sites in year 4. At the highest site and after year 1, the grass component was generally less than 30 % of total production.

As swards developed over 4 years, not only did the proportion of grass in the swards increase but the total amount of grass produced also generally increased at all sites (Fig. 2). The maximum DM production at 500, 750 and 1,050 m was 3.8 t/ha, 1.8 t/ha and 1.6 t/ha respectively. At the lowest altitude large lotus yields were accompanied by small grass yields especially in the first 3 years. Clover yields, on the other hand, rapidly diminished and by year 2 were accompanied by

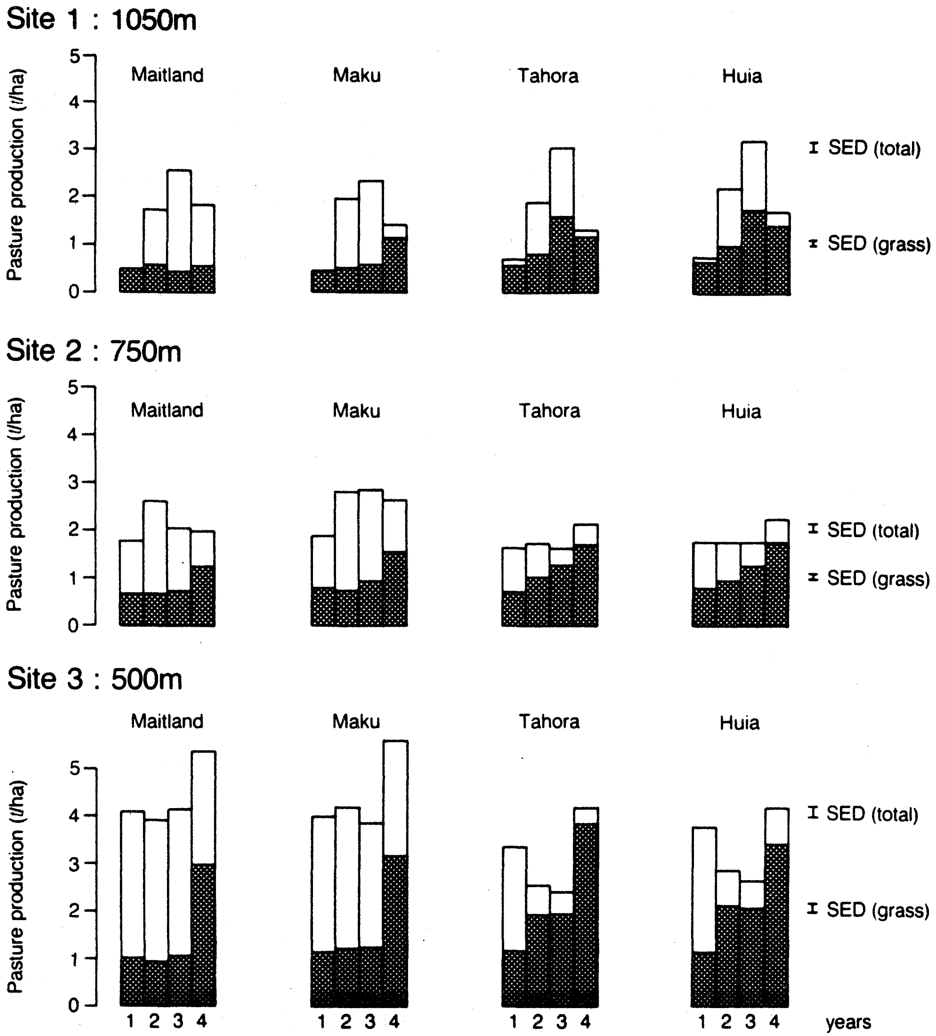

Figure 2. Changes in total pasture and grass DM yield of four oversown legume swards over a four year period.

increased grass yields. At higher altitudes this general pattern was repeated, but both grass and total sward production declined markedly with increased altitude.

Where no superphosphate was applied the proportion of grass was high at all sites (Table 2) because legume growth was poor (McIntosh *et al.*, 1984; Floate *et al.*, 1985). Legume growth responded to superphosphate application, and the grass percent in the sward was correspondingly reduced. There was, however, no significant difference in the grass percent in the sward which was attributable to amount of superphosphate applied. Although grass percent was influenced by time and by altitude, there was no interaction with the amount of superphosphate applied.

In all swards the proportion of grass declined significantly with increased rates of lime at all sites (Table 3). This can be attributed to the improved performance of all legumes.

There were no significant differences among sites in their response to lime, but there were changes in the

Table 2: The effect of superphosphate on the percent of grass in oversown legume swards at 3 tussock grassland sites in Otago.

Altitude(m)	0	250	500	SED
1,050	73	54	57	1.7
750	81	57	54	1.2
500	72	51	50	1.1

Table 3: Effect of lime on the percent of grass in oversown legume swards at 3 tussock grassland sites in Otago.

Lime rate (t/ha)	Altitude (m)		
	1,050	750	500
0	65	70	59
0.5	56	57	53
1.0	51	54	49
2.0	47	49	46
4.0	46	47	45
SED	2.9	1.9	1.6

effects of lime on the percent grass with time (Table 4). The main effect of lime persisted throughout the trial but there was a small and significant diminution of the difference among treatments, as the percent of grass in the higher lime treatments increased over the four year period.

DISCUSSION

Pasture development aims to produce swards which are both productive, and of high quality for grazing stock. The latter is generally associated with the legume content of the swards but high levels of production especially with white clover cannot usually be maintained without developing a satisfactory grass component.

In more moist tussock grassland areas volunteer grasses such as browntop and sweet vernal can be a significant component of the unimproved sward. These grasses respond to increased fertility but can make difficult the introduction of higher producing grasses (Hall & Scott, 1985). However, these workers have shown that under some conditions the volunteer grasses can produce as much feed during late spring and summer as areas oversown with new grasses.

Table 4: Changes in effects of lime on percent grass in oversown legumes over four years.

Lime rate (t/ha)	Year			
	1	2	3	4
0.0	63	57	57	77
0.5	46	46	52	73
1.0	44	44	47	68
2.0	42	38	42	65
4.0	40	35	42	64
SED				2.0

In this study we examined some of the factors affecting the rate of development of volunteer grasses in swards originally oversown with a single legume. Sward development was greatly influenced by legume choice. Swards based on Huia and Tahora white clover developed more quickly and grasses consistently made a greater contribution to total pasture production in association with both these clovers than with either Maitland or Maku lotus. The better development of grasses in association with clovers may be dependent upon nitrogen fixation and transfer. Nordmeyer & Davis (1977) compared Huia white clover with uncertified *Lotus pedunculatus* in the Kaweka range and showed that in the first year white clover grew better than lotus but lotus improved in the second and third years. In spite of more soil nitrogen in the lotus plots (but more could have been removed in higher production in earlier years from the clover plots) there was more associated grass growth in the clover plots. These workers stated that even amongst lotus lines (Maku vs G4712) there were differences in the amounts of associated grass which were related to the N concentration of the legume component. They speculated that high levels of maintenance superphosphate could depress the content and ultimately the N-fixing function of lotus through grass competition, whereas high levels of superphosphate would be necessary to maintain or increase the N fixed by clover as grass competition increases with improved supplies of mineralised N.

Our work has extended that of Nordmeyer & Davis (1977) to lower altitudes, and to include the effects of superphosphate and lime on sward development. Altitude has a marked effect on both total pasture production and on legume production (Enright & Floate, 1988) so that the supply of nitrogen available for transfer to grass is also likely to be dependent upon the same environmental factors (Grant & Lambert, 1979), and hence closely related to altitude. This probably accounts for the faster development of the grass component of swards associated with the clovers which we have shown to reach approximately 80 % of total pasture production by years 2, 3 and 4 at altitudes of 500, 750 and 1,050 m respectively. Unlike the findings of Nordmeyer & Davis (1977) for high altitude, eroded subsoils in the Kaweka range, our results do not show any marked relationship between sward development and rate of superphosphate applied. Although there was a highly significant legume response to superphosphate, this was not related to any change in the grass component of the sward. There was however a significant increase in legume performance with increasing rate of lime application, which was associated with lower proportions of grass in these swards. This contrasts with the initial flush of grass growth observed when the highest rate of lime was applied in 1983, and which was attributed to mineralisation of soil-N. It would be expected that the better performance of legumes, stimulated by lime, would eventually lead to improved performance of associated grasses as the additional fixed N is transferred. We have observed a small but significant changing influence of lime on the percentage of grass with time. We interpret this as a consequence of better legume growth in the higher lime treatments, in the early years, followed by an increase in the grass component of these swards in the later years. Thus, the expected result has been observed, but the magnitude of the effect was small, probably because of the complete removal of all nitrogen in the herbage from these plots which were managed on a cut and remove basis, and the less efficient transfer of N from clover to grass in the absence of grazing animals.

Finally, it must be pointed out that for these reasons the results obtained here relate strictly only to the experimental conditions employed. It is probable that the general principles would still apply under a more intensive grazing regime, where the processes could happen more rapidly with improved N-transfer. The work reported here is more relevant to low-intensity grazing where N-transfer by stock is generally lower but its potential effects can be observed in areas of above-average nutrient return.

ACKNOWLEDGEMENTS

The authors with to express thanks to staff in the Invermay Herbage Laboratory for herbage dissection, to Kathy Woodrow for field assistance, and to Dr Roger Littlejohn for statistical advice and analysis.

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