Factors influencing the contribution of narrow-leaved plantain to North Island hill country pastures

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Abstract

We examined the contribution of narrow-leaved plantain (*Plantago lanceolata*) to pasture production and composition, as part of a larger experiment evaluating the role of biodiversity in North Island hill country pastures. Plantain was sown at rates between 0 and 13.5 kg/ha (equivalent) into small plots at two sites representative of North Island hill country pastures – Whatawhata and Ballantrae Research Centres. The sites encompassed variation in both slope and soil fertility. We measured the abundance and percent composition of plantain, and the total yield of the herbage growing on the plots in the spring and autumn of the year following establishment. The average abundance of plantain in both spring and autumn was greater on higher fertility plots but was not different between easy and steep slopes. Abundance was also related to sowing rate and the contribution of plantain to harvested DM yield was strongly related to abundance. There was some evidence that the percentage of plantain in spring pastures was positively related to total plot yield. Given that plantain occurs ubiquitously in most pastures, contributing 2–8% of pasture productivity, the data indicated a sowing rate of approximately 1 kg/ha was a minimum to significantly increase the abundance and contribution to productivity of this species.

Keywords: biodiversity, hill country, pasture, plaintain

Introduction

Compared to lowland, hill country pastures in the North Island are relatively species rich, both as a function of their origin from bush-burn mixtures, and in keeping with the variable nature of the hill country landscape at all spatial scales. In pasture development programmes, pastoralists have tended to focus on decreasing this richness by oversowing relatively few species – i.e., ryegrass, cocksfoot, white clover, subterranean clover. The intent of this approach was to create a more productive and nutritive forage supply with a desirable seasonal pattern of growth to match animal demand. Invariably these swards revert to a more complex mixture of grasses (e.g., browntop, sweet vernal), annual legumes (e.g., lotus spp., suckling clover) and miscellaneous herbs (e.g., chickweed, hawkbit).

In recent years, the value of complex pasture swards has become recognised, in terms of the stability (or persistence) of composition and production in marginal and variable environments, and the contribution to a 'balanced' animal diet (Daly *et al.* 1996). Complex swards also contribute toward increasing biodiversity in grasslands, the value of which is currently a hotly debated topic worldwide (Grime 1997). The benefits of complex swards are not limited to the pasture plant community alone – there is evidence that the soil faunal populations are also enhanced (Christie *et al.* 1974)

As a result of this conceptual shift, a number of species that pastoralists formerly thought of as weeds, have become recognised as having agronomic value. Narrow-leaved plantain (*Plantago lanceolata*, referred to from here as plantain) is one such plant – a ubiquitous species of pastures throughout New Zealand that is highly acceptable to animals (Stewart 1996). Some of the specific characteristics of plantain that have been identified as beneficial to animal performance (though not always demonstrated in the field (Fraser & Rowarth 1996)) include high tannin content, diuretic properties, high mineral content and anthelmintic effects (Stewart 1996). Two cultivars of plantain have been released in New Zealand – 'Grasslands Lancelot' and Ceres Tonic (Stewart 1996, Rumball *et al.* 1997). It has been generally recommended that the main role of plantain in pastures should be as a component of a mixed sward (Rumball *et al.* 1997).

In this paper we report on the performance of plantain as a component in a range of mixed species swards in North Island hill pastures, including both its establishment and contribution to total pasture production.

Methods

Plantain was oversown into two North Island hill country sites as part of a larger experiment aimed at examining the role of biodiversity within pasture swards. The two sites were the Whatawhata Research

Centre in the western Waikato district and the Ballantrae Hill Country Research Station in the southern Hawke's Bay district. At each site, the experimental plots (1 m^2) were located in four paddocks; two low (Olsen P <12) and two high (Olsen P >30) fertility paddocks, and two slope classes in each paddock: easy (0–10°) and steep (20–30°).

Plantain was sown with up to 10 other species (Table 1), at nine sowing rates (0 to 1.35 g/m^2) on 64 of the plots at each site. The total sowing rate of all species per plot was constant (1000 viable seeds per plot) resulting in the sowing rate of plantain being inversely related to the number of other species with which it was sown. However, the experiment was fully balanced with plantain being sown in every combination with every other species. Prior to the start of the trial, the original sward growing on the plots was harvested once in October 1997 and the pasture dissected into botanical components for analysis of species composition by dry weight.

Table 1 Other species included in the biodiversity experiment and sown with plantain.

Scientific name	Common name
Agrostis capillaris	browntop
Bromus hordeaceus	soft brome
Cynosurus cristatus	crested dogstail
Holcus lanatus	yorkshire fog
Hypochaeris radicata	catsear
Lolium perenne	ryegrass
Paspalum dilatatum	paspalum
Trifolium dubium	suckling clover
Trifolium repens	white clover
Trifolium subterraneum	sub clover

The plantain seed used was a mixture from three sources, i.e., resident plants at Ballantrae (23%, with a germination rate of 8%), resident plants at Whatawhata (66%, germination rate 25%) and 'Grasslands Lancelot' (11%, germination rate 45%). The plots were sprayed with Roundup™ to remove resident pasture, and were oversown in late autumn 1998. During the first year of establishment, grazing was excluded and the plots were hand-weeded to remove all species not originally sown.

The abundance of plantain in all of the plots on which it was sown was assessed by visual scores in November 1999 and February 2000. We used an arbitrary scale that discriminated between plots with low plantain abundance (Table 2). We also measured total plot yield and botanical composition by weight from herbage harvested over an 8-week period in October/November 1999 and a 10-week period in March/April 2000. All species were identified and separated in the botanical dissections.

Table 2 Visual scoring criteria for the abundance scores of plantain.

Score	Criteria
0	No plantain plants present in a 1 m^2 plot
1	One plantain plant present in the plot
2	Several plantain plants present in the plot
3	Many plantain plants present in the plot
4	Plantain abundant across the plot
5	Plot dominated by plantain

The effects of site, slope and fertility on abundance and yield were analysed using SAS in a factorial design. Mean abundance scores and yields were calculated for each sowing rate treatment. The relationships between plantain composition and abundance, and between plot yield and plantain composition were examined using linear regression.

Results

Data from the harvest of the resident vegetation on the plots at Whatawhata prior to the commencement of the study (spring 1997) indicated an average contribution of plantain to yield of 6%. This figure varied between 2 and 8% in individual plots across the site. Overall, sowing plantain increased the average contribution of plantain to yield. In November 1999, mean contribution to yield was ~1.5% where plantain was not sown (assessed from volunteer establishment in the other plots in the biodiversity trial), and over all plots where it was sown, its mean contribution to yield was 18.9%. By April 2000, the respective figures were 5.8% where plantain was not sown and 14.7% where plantain was sown.

The establishment of plantain populations in the plots, as measured by visual abundance scores in November 1999, was strongly related to sowing rate (Figure 1). Scores ranged from 2 (a few plants per plot) at the lowest sowing rate (1.7 kg/ha equivalent) to 5 (plot dominated by plantain) at the highest sowing rate (13.5 kg/ha equivalent). There appeared to be a steeper decline in abundance scores at sowing rates below 2.2 kg/ha. When abundance was measured again in April 2000, those plots that had higher abundance scores in November appeared to show a greater decrease in abundance of plantain relative to the previously lower-scoring plots.

There were no significant differences between the average abundance scores on easy vs. steep plots for either date (data not shown). However, there were significant main effect differences in average scores between sites (Ballantrae vs. Whatawhata) and fertility treatments (Table 3). Scores tended to be higher at Whatawhata, and high fertility plots had greater

Figure 1 Abundance of plantain in spring 1999 (solid circles) and autumn 2000 (open squares) in response to sowing rate (bars represent standard error of the mean).

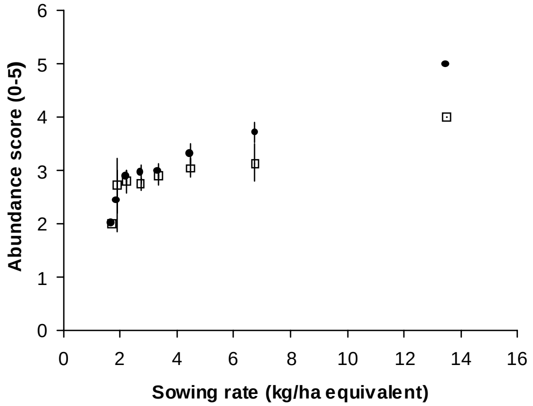


Table 3 Average abundance score and% contribution to yield of plantain in response to soil fertility (sown plots only).

Plot fertility	November abundance (score 0–5)	April abundance (score 0–5)	November contribution (%)	April contribution (%)
High	3.3	3.1	26.2	22.1
Low	2.7	2.6	11.7	7.4
P-value	<0.001	<0.01	<0.001	<0.001

abundance than low fertility plots in both November and April.

The contribution of plantain to plot DM yield was also related to soil fertility but not to site or slope (Table 3). Mean contribution to yield was significantly greater on the high fertility paddocks than the low fertility paddocks in both November 1999 and April 2000. There was no significant difference in mean contribution to yield between Ballantrae and Whatawhata, or between easy and steep slopes, in either season.

The contribution of plantain to plot yield was also strongly related to abundance in both spring 1999 and autumn 2000, both regression relationships having a significant (P<0.01) positive slope. In November, the mean contribution to spring yield for each abundance score was greatest at 44% of yield on the plots that had the highest abundance score (Figure 2). In April, the plots scoring 4 and 5 on the abundance scale had a relatively lower contribution to autumn yield (~19%) than similarly high scoring plots had to spring yield.

There was no significant effect of the sowing of plantain on total plot yield. In spring 1999, the average yields of plots with and without sown plantain were 1965 and 1969 kgDM/ha, respectively. In autumn 2000, the average yields of plots with and without sown plantain were 706 kgDM/ha and 683 kgDM/ha, respectively. However, where plantain was sown, there was a significant (P<0.01) positive regression relationship between total plot yield and the contribution of plantain to plot yield in November 1999 (Figure 3). For a 10 percentage point increase in plantain content of the pasture, plot yield increased by ~200 kgDM/ha equivalent. In April, the same analysis of plot yield vs. plantain content revealed no significant relationship.

Figure 2 Contribution of plantain to plot yield in spring 1999 (solid circles) and autumn 2000 (open squares) based on prior abundance scores (bars represent standard error of the mean).

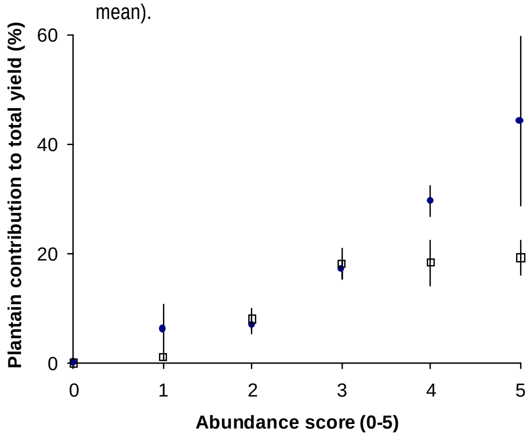
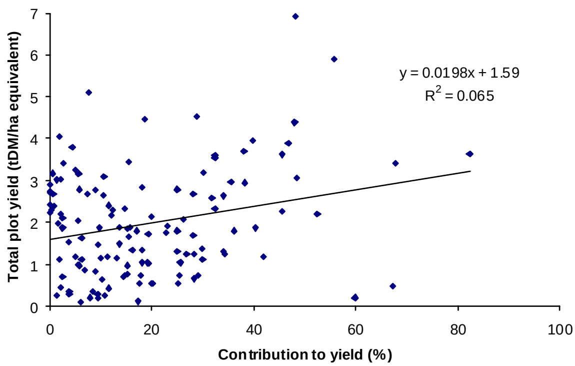


Figure 3 Relationship between total plot yield and plantain contribution to yield in spring 1999. The fitted regression is significant at P<0.01.



Discussion

The establishment of plantain by oversowing into hill country pastures using conventional methods (Macfarlane & Bonish 1986) was successfully achieved in this experiment. The average abundance score of plantain in all the plots in which it was sown was 3.0, second only to browntop (3.4) of all the 11 species oversown in the larger biodiversity experiment. This level of abundance represented an increase in the abundance of plantain compared with resident pasture. Given that plantain in resident pastures typically had a contribution to yield of 2–8%, attaining an abundance score of 1 or 2 would be insufficient to alter this level of contribution, as it would result in a contribution to yield of approximately 6% (Figure 2). Thus, achieving an abundance score of 3 appears to be a minimum to significantly increase the contribution to yield of plantain. Based on Figure 1, this would require a sowing rate of at least 2.7 kg/ha. However, in view of our relatively low seed germination rates (average 23%), more appropriate guidelines would be 1.4 kg/ha of 45% germ seed or 0.8 kg/ha of 80% germ seed.

There is good evidence from this study that plantain establishes better and contributes more to yield on higher fertility sites. In the context of this experiment, higher fertility meant Olsen P values of >30. Given the nature of hill country slope and fertility relationships, it might therefore be expected that plantain would do similarly well on easy vs. steep slopes, but the data do not support this.

The difference in average abundance scores in November between the two sites (Ballantrae and Whatawhata) was probably a result of differing interpretations of the scoring scale by different operators. Discussions on this matter between November and April appear to have resolved this, since no similar effect was evident in the April data.

There was some indication that the content of plantain within a pasture sward had an impact on overall DM yield, in that greater yields were measured where plantain made up a greater proportion of those yields. Since this result was noted with relatively prostrate, small-leafed and low yielding germplasm, it may be even more marked with a more erect and larger-leafed selection/cultivar.

However overall, there was no difference in pasture DM yield where plantain was sown vs. where it was not sown. This suggests that plantain simply substituted for other equally productive species in the sward. The question of the relationship between sowing rate of plantain and the DM yield of pasture could not be answered by this experiment owing to the confounded nature of the design. An experiment specifically designed to evaluate this question would be more conclusive. Our study indicates that there is room to reconsider what constitutes ideal pasture composition in hill country, and that plantain would be a suitable component of a complex pasture mix.

Conclusions

Plantain was successfully oversown in hill country and its establishment was among the best of the 11 pasture species used in the wider experiment. A sowing rate of ~1 kg/ha of high germination rate seed in a mixture would increase the contribution to pasture yield over that of resident swards where plantain is common. The establishment of plantain was better and contribution to pasture mass greater in higher fertility paddocks. Further work is needed to examine the effect of sowing rate on total dry matter yield of pastures containing plantain.

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