Management of birdsfoot trefoil (*Lotus corniculatus* L.) pastures for productivity and persistence

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Abstract

The effects of contrasting grazing treatments on herbage and seed yield, and seedling recruitment of a birdsfoot trefoil (*Lotus corniculatus* L.) cv. Grasslands Goldie pasture were evaluated at AgResearch Lincoln on a Pallic soil (Wakanui silt loam) over the period October 1994 to March 1996. Defoliation every two weeks reduced plant density and herbage yield. Maximum seed yield was 651 kg/ha from pastures closed in November. It was concluded that intervals between defoliations should not be shorter than 4 weeks for the original plants to survive under grazing; this grazing interval is also consistent with maximum seedling recruitment following a November closing (422 seedlings/m^2). Thus there is managerial scope to enhance production and persistence by seasonal adjustments in the frequency of defoliation.

***Additional key words**: grazing interval, herbage yield, population dynamics, seed yield, seedling recruitment.*

Introduction

In many sites in Canterbury, New Zealand, particularly in less fertile soils, the traditional perennial ryegrass (*Lolium perenne* L.)/white clover (*Trifolium repens* L.) mixture is not persistent. In recent years problems of low pasture persistence have shown the relevance of the use of alternative species to improve pasture survival and productivity while optimizing animal production. Both legume and grass alternative species have been proposed to diversify the pasture base (MacFarlane, 1990; Fraser, 1994).

In New Zealand birdsfoot trefoil (*Lotus corniculatus* L.) has been recognized as a high-quality pasture species with potential for dryland areas with moderately-fertile soils, where acidity or impeded drainage limits the persistence of other legumes. Birdsfoot trefoil contains condensed tannins which prevent bloat in cattle, reduce the effects of intestinal nematodes upon productivity and protect plant proteins from degradation in the rumen, improving animal performance (Wang *et al.*, 1996). However, an incomplete understanding of the agronomy and grazing management requirements of birdsfoot trefoil has caused difficulties in obtaining satisfactory persistence.

Birdsfoot trefoil is a crown-forming legume without above-ground vegetative regeneration. Its persistence strategy is based on the survival of plants originally established and seasonal seedling recruitment (Grime *et al.*, 1988). To perennate, the reduction in lifespan of individual plants caused by disease, pests or inadequate management must be balanced by seedling recruitment. Therefore, in a pastoral situation, it is possible that its persistence can be improved by the development of a soil-seed bank and by promoting periodic stand regeneration from self-sown seed.

The only cultivar of birdsfoot trefoil currently available in this country, cv. Grasslands Goldie, has a semi-prostrate growth habit adapted for grazing (AgResearch, 1995). However, there is little information about the effect of grazing management on the population dynamics of birdsfoot-trefoil pastures in New Zealand.

The main objective of this paper is to summarize the information resulting from an experiment to develop a preliminary grazing management strategy aimed at improving the productivity and persistence of established birdsfoot trefoil pastures in the environment of the South Island East Coast.

Materials and Methods

The experiment was conducted at AgResearch Lincoln Farm, Lincoln (43° 38' S), New Zealand, on a Pallic soil (Wakanui silt loam; Udic Ustrochrept) (Hewitt, 1992) over the period November 1994-March

1996. The soil had a pH of 6.0 and Olsen P was 30. The trial was established on a stand of birdsfoot trefoil (*Lotus corniculatus* L.) cv. Grasslands Goldie sown in October 1992 in 15 cm row spacings at a seeding rate of 4 kg/ha. The trial was spray-irrigated when the topsoil dried to 50 % available soil water capacity; water (50 mm) was applied seven times during the experimental period. Four grazing interval treatments, 2, 4, 6 or 8 weeks, were replicated three times in a randomized complete block design. Blocks consisted of three individual plots of 10 x 20 m, with a total experimental area of 0.2 ha. Each plot was rotationally grazed by adult sheep to a 40 mm post-grazing stubble. Exclusion cages (0.6 x 0.9 m) were used to protect sampling areas from grazing, simulating spelling periods during flowering and seed development. Closing date treatments were applied in November 1994, December 1994 and January 1995. Seed yield and quality (germination (ISTA, 1993) and hard seed) in the protected cage sites was evaluated and the remaining seed was returned to the original sampling areas. The effect of the previously-defined grazing treatments on seedling recruitment and survival was evaluated by weekly seedling counts from each permanent quadrat site (data for the final count are presented). Pre- and post-grazing herbage mass was measured for each grazing treatment over the experimental period. Population density was measured in each plot every two months. Results were transformed and are presented on an area (ha or m^2) basis. All results were analysed using the SAS statistical analysis system (SAS Institute Inc., 1990).

Results and Discussion

Herbage yield and plant density

Total herbage yields of birdsfoot trefoil were highest in the 4- and 6-week interval treatments, intermediate in the 8-week treatment, and lowest in the 2-week grazing interval treatment (Table 1).

Summer (December to February) was the most productive season for the four grazing intervals, with 40-50 % of the annual yield produced over that period (Table 1). In the 2-week grazing interval treatment, herbage yield in the second growing season was significantly lower ($P<0.01$) than in the first growing season due to a decrease in plant density (Fig. 1) combined with a decrease in growth potential. Grazing every 2 weeks may have given inadequate herbage production to sustain continued growth and replenish reserves. This may have caused a permanent disruption in the photosynthetic capacity of birdsfoot trefoil plants. Since the accumulation of leaf area in birdsfoot trefoil is maximum 7-10 days after defoliation, it is likely that a regrowth period of 2 weeks was insufficient to satisfy the metabolic demand of plants during a period of high potential growth (Greub and Wedin, 1971).

Grazing interval did not influence birdsfoot trefoil density in the 2-week treatment until May 1995 (Fig. 1). A significant linear decline ($P<0.01$) in stand density was observed in that treatment at each subsequent count. A small but significant reduction (10 %) ($P<0.05$) in the birdsfoot trefoil population was observed between January 1995 and March 1996 in the 4-week grazing

Table 1. The effect of grazing interval on seasonal, total and annual herbage yield of birdsfoot trefoil (means ± s.e.m).

Grazing interval	Herbage yield (kg DM/ha) Spring '94	Summer '94-'95	Autumn '95	Winter '95	Spring '95	Summer '95-'96	Total yield	Mean annual yield
2 weeks	3055 ± 236	5132 ± 805	1874 ± 765 a	325 ± 123	1404 ± 345 A	1086 ± 321 A	12,877 ± 2343 A	7538 ± 1237 A
4 weeks	3422 ± 266	6225 ± 1234	3417 ± 345 b	390 ± 89	3890 ± 654 B	5103 ± 1234 B	22,447 ± 2876 B	13,126 ± 2134 B
6 weeks	3205 ± 312	5235 ± 1012	2997 ± 321 b	372 ± 101	3429 ± 765 B	4421 ± 1453 B	19,659 ± 1998 B	11,514 ± 1876 B
8 weeks	3199 ± 299	4676 ± 989	2359 ± 435 bc	339 ± 99	3154 ± 652 B	4024 ± 1488 B	17,751 ± 2278 B	10,224 ± 2367B
Significance	NS	NS	*	NS	**	**	**	**

*,** indicate significant at the 5 and 1% level of probability respectively. Within columns numbers without a common letter are significantly different at the 5% (small letters) or 1% (capital letters) level of probability (applies to all tables).

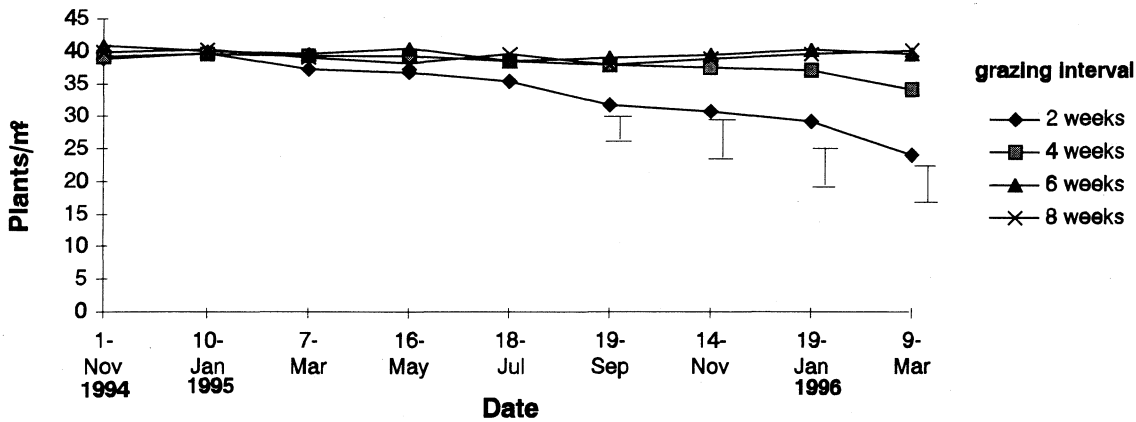

Figure 1. Changes in birdsfoot trefoil plant density under four grazing intervals over the period November 1994-March 1996. Error bars indicate l.s.d (0.05) between grazing interval treatments.

interval treatment. By the last sampling date plants in the 2-week treatment represented only 35 % of the original plant population. In the 4-week grazing interval treatment 87 % of the original plant population survived to the final sampling date.

Seed yield

Seed yield decreased with the delay in closing (Table 2), but the reduction was significant (P<0.01) only for the January closing; seed yield was 70 % that of the November closing.

The experimental seed yields were higher than average commercial seed yields for New Zealand (300 kg/ha; Hampton *et al.*, 1990) but they are low when compared with the potential seed yield of the species (1.2 t/ha; Lorenzetti, 1993).

Seed weight decreased as closing date was delayed (Table 2). These data compare with the results of Beuselinck and McGraw (1988) and indicate that the shorter maturation time which resulted from closing late in the flowering season shortened the period of pod filling, affecting seed weight.

Seed quality components (Table 2) were similar for November and December closing treatments and generally statistically superior to those from the January closing treatment. All closing treatments produced high levels of hard seed; seed viability was considerably lower in the January closing treatment than in the earlier closing treatments. These trends in seed yield and seed quality components corroborate results presented by Anderson (1955), Albrechtsen *et al.*, (1966) and Stephenson (1984) who also reported that early-set pods produced higher seed yields of higher quality than late-set pods.

Table 2. The effect of closing date on seed yield and quality components (mean ± s.e.m).

Closing date	Seed yield (g/m^2)	1000 seed weigh (mg)	Seed viability (%)	Seed germination (%)	Hardseed (%)
November	65.1 ± 0.9 A	1.528 ± 0.007 A	86 ± 7 A	22 ± 4 a	64 ± 4 a
December	60.5 ± 0.9 A	1.471 ± 0.007 AB	90 ± 7 A	17 ± 1 ab	73 ± 4 a
January	45.8 ± 1.2 B	1.385 ± 0.030 B	68 ± 8 B	12 ± 4 b	56 ± 6 b
Significance	**	**	**	*	*

These data have been presented and discussed in full in the Journal of Applied Seed Production 14: 47-52.

Seedling recruitment

The seasonal pattern of seedling recruitment and survival was similar under the different grazing intervals. In each case, most seedlings appeared during a major period of germination and emergence in late autumn and early winter (May-June), reaching 600 seedlings/m^2 in the 8-week grazing treatment, 800 seedlings/m^2 in the 2- and 6-week grazing interval treatments, and 1200 seedlings/m^2 in the 4-week grazing interval treatment. A secondary seedling-emergence period was observed in late winter/spring when a small (100-200 seedlings/m^2) increase in the total density of seedlings was observed from August. A similar seasonal pattern of regeneration was reported by Fraser *et al.* (1994).

There were significant differences among grazing interval treatments in the density of established seedlings in March 1996 (P<0.01) (Table 3). Seedling numbers were highest in the 4-week grazing interval treatment while the 2-week grazing interval treatment gave the lowest seedling density. Seedling survival was poor in the 2-week grazing interval due to grazing by sheep; in the 8-week grazing interval and, to a lesser extent, the 6-week grazing interval, seedling recruitment and survival was poor due to shading by existing herbage.

Table 3. Density of established seedlings of birdsfoot trefoil in March 1996 (mean ± s.e.m).

Grazing interval	Final establishment (seedlings/m^{-2})
2 weeks	3.7 ± 1.1 A
4 weeks	32.7 ± 2.7 B
6 weeks	27.6 ± 3.1 B
8 weeks	18.5 ± 1.1 C
Significance	**

The low density of established seedlings at the final count in March 1996 reflects the high mortality risks associated with the regeneration of pastures by natural reseeding (Chapman and Anderson, 1987; Jones and Bunch, 1988; Fraser *et al.*, 1994). Germination and seedling emergence were not the limiting processes but high seedling losses that began immediately after emergence, and continued throughout the experimental period, did restrict final establishment.

The number of seedlings finally established in the 4-, 6- and 8-week grazing interval treatments were adequate to replace plant losses from the established population. In the 2-week grazing interval treatment, however, seedling establishment (4 seedlings/m^2) was not sufficient to balance total plant losses over the experimental period (14 plants/m^2).

Conclusions

The results of this experiment highlight the potential of birdsfoot trefoil as an alternative pasture species for the South Island East Coast. Birdsfoot trefoil cv. Grasslands Goldie showed morphological adaptation to grazing, it produced high herbage yields and the role of natural reseeding as a mechanism to improve its plant population dynamics was confirmed for this environment. The seasonal pattern of herbage production of birdsfoot trefoil makes it an attractive option for grazing during summer when the quality of other species is low in this region.

Grazing management had a major influence on the population dynamics of birdsfoot trefoil; grazing intervals of longer than 4 weeks promoted the survival and productivity of established plants, allowed sufficient seedling recruitment to replace eventual losses and reduced weed invasion.

Under the conditions of this experiment birdsfoot trefoil seed yields were higher than the average in the three closing dates evaluated. This suggests that the potential for birdsfoot trefoil seed production in this region is high. Further research is required to develop a general strategy to maximize seed yield. The main seedling recruitment period was autumn; a significant proportion of the seedlings that had become established early in autumn survived throughout the following winter and summer. Grazing management during autumn also affected spring recovery. Therefore, autumn appears to be a critical period for the long-term persistence of birdsfoot trefoil and careful grazing management is required in that season.

The management guidelines suggested should promote the persistence and productivity of birdsfoot trefoil pastures in the lowlands of the South Island East Coast. This may result in an increase in the adoption and use of birdsfoot trefoil as an alternative pasture species. However, the data were obtained over only two growing seasons and further research is needed to verify the results and to refine some of the management principles proposed.

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