

Role of re-seeding and seedling recruitment for sustainable *Lotus corniculatus* based pastures in dry hill and high country

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Abstract

Birdsfoot trefoil (*Lotus corniculatus* L.) is a species with considerable potential for hill and high country of the South Island; however, difficulties in maintaining satisfactory stands due to problems with persistence have been reported. Plant recruitment through natural reseedling is considered a necessary tool for the maintenance and improvement of birdsfoot trefoil stands in the USA, but research which investigates the role of soil seedbanks, seedling recruitment and stand management for improving the persistence of birdsfoot trefoil in the drier hill and high country of the South Island of New Zealand is limited. Two field experiments in the dry hill and high country of Otago monitored changes in stand populations and seedling emergence of birdsfoot trefoil under differing grazing management. At Ardlui Station on the Coastal Otago Plateau, seedling emergence was greatest in autumn rather than spring after spelling over the flowering period. Despite considerable numbers of autumn seedlings (128 seedlings/m²), less than 1 seedling/m² survived to contribute to the stand after 12 months. Plant populations did, however, increase in 1991/92 following adequate rainfall in the previous autumn. Spring emerged seedlings did not survive through summer. At Omarama Station in the southern Mackenzie Basin, plant populations of birdsfoot trefoil continued to decline despite the presence of seedlings in spring and autumn. Results imply that natural reseedling cannot be relied upon to improve birdsfoot trefoil plant populations unless favourable climatic conditions prevail during spring or autumn.

Keywords: establishment, *Lotus corniculatus*, management, natural reseedling, persistence, seedling recruitment, soil seedbanks, survival

Introduction

Birdsfoot trefoil is a perennial forage legume widely used in North and South America and Europe (Seaney & Henson 1970). It is a deep tap-rooted, non bloating

and highly nutritive legume with potential for moderately fertile dry hill and high country in New Zealand, particularly where soil acidity limits the success of lucerne (Scott & Charlton 1983).

In areas of the USA where the perennial habit of birdsfoot trefoil is shortened by management (Van Keuren & Davis 1968), environment or disease (Miller *et al.* 1964), natural reseedling is a management tool used successfully to contribute to long-term persistence (Taylor *et al.* 1973). Chapman *et al.* (1990) identified some factors limiting the success of birdsfoot trefoil in the hill and high country of New Zealand and commented on the need for investigation of natural reseedling as a practice to increase plant numbers and ensure stand longevity.

The aim of this paper is to investigate natural reseedling of birdsfoot trefoil in the drier hill and high country of the southern South Island, and the role of grazing management on seedling recruitment and stand persistence.

Materials and methods

Ardlui

Sampling was carried out on Ardlui Station, on the Coastal Otago Plateau, within an experiment established following conventional cultivation in October 1987. The soil was a yellow-grey earth (pH 5.4) and 600 mm annual rainfall. Observations originate from two independent studies. The first used 20 permanent quadrats (0.25 m²) on 1750 m² plots of Dryland (an experimental selection developed in the South Island high country (Widdup *et al.* 1987)) and Granger (a North American cultivar with semi-erect growth habit) birdsfoot trefoil on each of 3 replicates to assess plant and seedling-populations in-October and May.

The second study investigated the role of grazing management on plant recruitment on the Dryland plots only using 2 grazing treatments. The grazing treatments consisted of (1) grazing throughout the flowering period, with normal grazing practices at other times and (2) summer spelling over the flowering period. Seedling counts were taken in October and May using 16 permanent quadrats (0.25 m²) per grazing treatment, and 2 seedlings per quadrat were marked using small rubber rings and survival assessed monthly.

Omarama

Sampling was carried out on Omarama Station, on the southern Mackenzie Basin, within an experiment established following direct drilling in September 1987 (Keoghan *et al.* 1989). The soil was a yellow-brown earth (pH 5.5) and the annual rainfall was 520 mm. Plant and seedling counts were taken in October and May using 10 permanent quadrats (0.25 m²) on 85.6 m² plots of Grasslands Goldie (a New Zealand-bred cultivar with semi-erect growth habit), **Dryland**, Granger and Empire (a North American cultivar with semi-prostrate habit) birdsfoot trefoil on each of 3 replicates.

Results

Ardlui

Seedlings emerging during autumn 1990 and spring 1991 (4-year stand) failed to increase numbers in following seasons (Table 1). However, plant numbers increased in spring 1992 from autumn seedlings in both **Dryland** and Granger birdsfoot trefoil.

Grazing treatments were imposed after autumn 1989 counts when the stand was 18 months old (Table 2). In the following spring, seedling numbers were low. The ungrazed treatment increased seedling numbers significantly ($P < 0.01$) in autumn 1990, with 128 and 3.2 seedlings/m² in the ungrazed and grazed treatments respectively. After 12 months, all seedlings in the grazed treatment had died and although seedlings in the ungrazed treatment survived, numbers were less than 1 seedling/m², with the greatest seedling mortality occurring in the first 3 months. Spring seedling mortality was greatest soon after emergence and after 12 months no seedlings survived in either grazing treatment (Table 2).

Omarama

Following good initial establishment during the first season (Allan *et al.* 1991), there was a large decline in birdsfoot trefoil plant numbers by autumn 1989 (Table 3). The decline in plant numbers continued despite the regeneration of seedlings in both spring 1990 and autumn

Table 1 Establishment of **Dryland** and Granger birdsfoot trefoil on Ardlui Station, Central Otago Plateau under sheep grazing (numbers/m²).

Treatment	Autumn 1990		Spring 1991		Autumn 1991		Spring 1992	
	Plant	Seedling	Plant	Seedling	Plant	Seedling	Plant	Seedling
Dryland	27.9	19.1	27.4	32.7	27.6	13.6	31.8	0
Granger	21.2	12.0	21.0	45.1	22.1	16.8	29.4	0
SED	2.75	6.38	3.06	17.34	2.24	3.04	3.16	•

Table 2 Seedling emergence and survival of **Dryland** birdsfoot trefoil on Ardlui Station, Coastal Otago Plateau with and without sheep grazing (numbers/m²).

Treatment	Autumn 1989		Spring 1990		Autumn 1990		Spring 1991	
	Emerging	Surviving	Emerging	Surviving	Emerging	Surviving	Emerging	Surviving
	After 3 months	After 12 months	After 3 months	After 12 months	After 6 months	After 12 months	After 1 month	After 12 months
Grazed	8.36	0	0.88	0	3.2	0.31	0	0
Ungrazed	11.76	0.07	0.79	0.08	126.0	9.98	0.67	0.13
SED	3.168	•	0.550	•	15.60	•	•	•

Table 3 Plant and seedling numbers of Grasslands Goldie, **Dryland**, Granger and Empire birdsfoot trefoil on Omarama Station, southern Mackenzie Basin, under sheep grazing (numbers/m²).

Treatment	Spring 1987 ¹		Autumn 1989		Spring 1990		Autumn 1990		Spring 1991		Autumn 1991		Spring 1993	
	Plant	Seedling	Plant	Seedling	Plant	Seedling	Plant	Seedling	Plant	Seedling	Plant	Seedling	Plant	Seedling
Grasslands Goldie	6.9	6.07	7.94	6.80	1.07	6.27	1.07	4.40	3.33	2.67	0.80	2.53	0	
Dryland	102	4.00	0.67	5.33	4.27	4.40	0.93	4.93	2.80	3.87	0	3.47	0	
Granger	3.4	1.07	0.80	1.07	2.13	0.93	0	0.80	1.07	0.53	0	0.67	0	
Empire	6.0	0.27	0	0.53	0	0	0	0	0.80	0	0	0	0	
SED	7.0	1.446	2.151	1.435	1.699	1.195	0.681	1.164	1.239	0.999	0.282	0.896	•	

¹From Allan *et al.* 1991.

1990. Plant numbers were greater with the New Zealand-bred cultivars than with the North American cultivars.

Discussion

These results highlight concerns about the feasibility of natural reseeding for the persistence of birdsfoot trefoil stands in the drier hill and high country of the South Island. For successful natural reseeding, consideration must be given to ecological factors.

Van Keuren & Davis (1968) concluded that inappropriate grazing management can lead to a decline in birdsfoot trefoil numbers and grazing through the flowering period will diminish seed production. At Ardlui, summer spelling over the flowering period resulted in a large increase in autumn seedling emergence, whereas grazing throughout the flowering period resulted in poor seedling emergence. A summer spelling during the flowering period is critical if plant recruitment by natural reseeding is deemed necessary.

It was not unexpected that spring seedlings failed to persist at either site as soil moisture deficits from November to April are common (Douglas *et al.* 1988). The establishment and survival of autumn seedlings appears better owing to more favourable moisture conditions, although at Ardlui mortality at an early stage was high, with few seedlings contributing to the stand after 12 months, under dry conditions. Frost heave in autumn following hard grazing reduces the protective effect of vegetative cover for developing seedlings and is likely to result in fewer established seedlings.

At Ardlui an above-average rainfall in autumn 1991 (36% above normal expected rainfall for April) resulted in early germination and increased parent plant cover ensuring adequate seedling growth for survival over the following summer. This result implies that natural reseeding cannot be relied upon to improve birdsfoot trefoil plant populations without favourable climatic conditions through the spring or autumn period.

Rhizobium capable of infection is essential for seedling recruitment of birdsfoot trefoil. Lowther & Patrick (1993) demonstrated the importance of rhizobium movement in the soil for establishing new seedlings, and that maximum rates of spread of root nodule bacteria of <0.25 and 4.0 m per year laterally and downslope respectively should be expected and although these sites were summer dry environments, root-nodule bacteria movement could be expected during the period of favourable soil moisture in the autumn to spring period.

Although there were some differences in seedling emergence between cultivars and lines, none had superior natural reseeding in these dry hill and high country regions.

Summary

Problems with birdsfoot trefoil stand performance and persistence in the drier hill and high country of the South Island can be addressed by natural reseeding, provided stand management promotes seed production and climatic conditions are favourable for seedling survival. Further research is required for techniques to improve seedling survival and plant recruitment for persistence stands of birdsfoot trefoil in the drier hill and high country of New Zealand.

ACKNOWLEDGEMENTS

The authors wish to thank Marye McGregor for technical assistance and farmers Sam Inder and Dick Wardell for providing experimental sites.

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