

Productivity of *Lotus corniculatus* and *L. pedunculatus* cultivars with and without tall fescue under sheep grazing

K.H. WIDDUP¹, W. RUMBALL², M.P. ROLSTON¹ and B.J. ARCHIE¹

¹AgResearch, Canterbury Agriculture and Science Centre, P.O. Box 60, Lincoln

²AgResearch, Grasslands Research Centre, PB 11008, Palmerston North
keith.widdup@agresearch.co.nz

Abstract

The nutritional benefits of condensed tannin (CT) in forages such as *Lotus* are known but difficulties with establishment, herbage production and persistence in a pasture have hindered farmer uptake of this valuable legume. A sheep grazing experiment was established to investigate the effects of growing three *Lotus corniculatus* (Grasslands Goldie, G46 and Creeping) and two *L. pedunculatus* (Grasslands Maku and Grasslands Trojan) cultivars with or without Grasslands Advance tall fescue (*Schedonorus phoenix* syn. *Festuca arundinacea*) and with or without white clover (*Trifolium repens*) under infrequent (8-weekly) grazing. Without grass, the content of *L. corniculatus* and *L. pedunculatus* in the swards was 85% and 60% respectively by year 3. Adding white clover reduced the *Lotus* content in the swards by 20%. With tall fescue, the *L. corniculatus* cultivars increased from 6 to 34% between the summer of year 2 and year 3. In contrast, the *L. pedunculatus* cultivars remained at very low 1-2% levels in the summer of both years. Inclusion of white clover did not further reduce *Lotus* content in the tall fescue swards.

While there was no significant difference in content and yield between *L. corniculatus* cultivars, there was a consistent trend for Goldie to produce more herbage. Goldie had the potential to produce 2 t dry matter (DM)/ha/year in a mixed pasture with tall fescue under infrequent grazing. Creeping *L. corniculatus* contained higher CT levels than Goldie (3.5 cf. 1.1% of herbage DM respectively) and is thus potentially able to provide greater amounts of CT in a pasture. Trojan and Maku *L. pedunculatus* had similar plant density and herbage productivity. The experiment will be monitored further to determine the long-term persistence of these *Lotus* cultivars in a mixed pasture.

Keywords: condensed tannins, infrequent grazing, legume composition, *Lotus corniculatus*, *L. pedunculatus*, tall fescue, white clover

Introduction

The use of *Lotus* species such as *Lotus corniculatus* and *L. pedunculatus* as a quality forage for grazing animals has been promoted for some time. The benefits have been linked to the occurrence of condensed

tannins in the herbage which have resulted in improved liveweight gains, wool weight and ovulation rate in sheep (Douglas *et al.* 1995; Waghorn *et al.* 1998; Barry *et al.* 2003) and sometimes to a reduction in gastrointestinal worm numbers (Niezen *et al.* 1995). However, *Lotus* species are difficult to establish and manage in a grazed pasture and for that reason, *L. corniculatus* has been mainly promoted for use in drier regions in pure stands (Barry *et al.* 2003). In moist, high fertility situations where perennial ryegrass and white clover are present, *L. pedunculatus* is uncompetitive resulting in poor growth and persistence (Brock *et al.* 1978)

AgResearch Grasslands has recently produced a selection of *L. corniculatus* named Creeping, which develops large numbers of shoots with a prostrate growth habit designed to improve persistence with grasses in a grazed situation (W. Rumball unpublished). Creeping has also been selected for higher levels of condensed tannins in the herbage than are available in the current cultivars of this species. A new tetraploid *L. pedunculatus* cultivar named Trojan, selected for improved establishment vigour compared with Maku, has recently been released. This new plant material warrants closer examination under grazing in a pasture compared to current commercial material to determine whether improvements in establishment and persistence have occurred. Also, with the objective of developing a more compatible sward for *Lotus* species, the slower establishing tall fescue may be a better companion grass with *Lotus* in a pasture rather than the more competitive perennial ryegrass.

This paper reports on the performance of five *Lotus* cultivars grown either in monoculture or in a pasture with tall fescue, with or without associated white clover under infrequent grazing with sheep.

Material and methods

Experimental design

The field experiment was sown into a cultivated seedbed on 12 October 2001 at the AgResearch Lincoln Farm in Canterbury (lat. 43° 38'S) on a Wakanui silt loam. The experimental design was a randomised split-split block with four replications. The main plots (2) measured 40 m x 5.4 m either with no-grass or Advance

tall fescue drilled at 15 kg/ha. The sub plots (5) measured 8 m x 5.4 m and consisted of three *L. corniculatus* cultivars: Goldie, G46 (a selection bred for the South Island high country), Creeping and two *L. pedunculatus* cultivars; Maku and Trojan. Seed of each *Lotus* cultivar was slurry inoculated with the appropriate *Rhizobium* and broadcast sown at 8 kg/ha. The sub-sub plots (2) measured 8m x 2.7m and were broadcast sown with or without Demand white clover at 1 kg/ha. All plots were chain harrowed to cover the seed. These combinations of *Lotus* in monoculture, with white clover and/or tall fescue, were designed to provide a range of levels of sward competition.

Management

During the November-January 2001 establishment period, flumetsulam (Preside at 65g/ha), diflufenican + promoxinil (Jaguar at 1 l/ha) and 2,4-DB (3 l/ha) were applied to control dicotyledon weeds. The experimental area was mechanically topped in December 2001 and received a fertiliser dressing with Cropmaster 15 (NPKS 15:10:10:8) applied at 200 kg/ha with a repeat dressing in April 2002. The first grazing occurred in February 2002, 18 weeks after sowing. Volunteer white clover in the no clover sub plots was controlled with ethofumesate (Nortron at 1.5 l/ha) in August 2002 and October 2003. Grass weeds in the no-grass plots were controlled with haloxyfop (Gallant at 1.5 l/ha) in August 2002 and with propyzamide (Kerb at 1.5l/ha) in July 2003. The experiment was irrigated with 50 mm of water in November and February of each year. The experiment was grazed infrequently with sheep (about every 8 weeks) in September, November, January, March and June of each year. The tall fescue plots were topped in October and December each year to remove reproductive stem material and encourage vegetative growth.

Measurements

The plant population was measured from two 0.25 m² quadrats per plot in April 2002. Herbage assessments started in November 2002 when the botanical composition (percentage of grass, *Lotus*, clover and weeds) of each plot was visually assessed before each grazing. In November (spring) and March (autumn) of year 2 and year 3, dry matter (DM) yield and botanical composition were determined from two 0.25 m² quadrats cut from all plots. Samples were oven dried with forced-air at 80°C. All data were analysed using the Genstat 7 statistical package and where interactions were non-significant, only the main effects were presented. Treatment means were separated using least significant difference at a 5% probability level (LSD_{0.05}).

Table 1 The effects of grass, *Lotus* and grass x clover treatments on the number of *Lotus* plants/m² at 25 weeks from sowing.

	<i>Lotus</i> (plants/m ²)
Grass (G)	
No-grass	41
Tall fescue	19
LSD _G (5%)	4
<i>Lotus</i> (L)	
Goldie	38
Creeping	44
G46	29
Maku	17
Trojan	23
LSD _L (5%)	9
Grass x Clover (C)	
No-grass	No clover 45
No-grass	White clover 38
Tall Fescue	No clover 18
Tall Fescue	White clover 20
LSD _{G x C} (5%)	4

Results

Six months after sowing, the *Lotus* plant population in the no-grass treatments had twice the density of those in the tall fescue treatments (Table 1). There was a significant difference between species with *L. corniculatus* (except G46) establishing more plants than the *L. pedunculatus* cultivars. There was no significant difference between the *L. pedunculatus* cultivars Trojan and Maku. White clover significantly reduced the *Lotus* plant numbers in the no-grass plots but did not further reduce *Lotus* plant numbers in the tall fescue plots.

The first year (October 2001-September 2002) was considered the establishment year, with herbage measurements taken in Year 2 and Year 3. The spring and autumn *Lotus* and total herbage yields of swards with and without tall fescue are shown in Table 2. While there were no summer yield assessments, the data provides some indication of the potential *Lotus* and total herbage yield. In the no-grass treatments, the *L. corniculatus* cultivars produced three times the *Lotus* herbage yield compared with *L. pedunculatus* cultivars in Year 2 and twice the yield in Year 3. The total herbage yields were also significantly greater in the *L. corniculatus* than the *L. pedunculatus* swards except in the autumn of Year 3. The *L. corniculatus* cultivars had similar herbage yields except that Goldie was superior to Creeping in the autumn of both years. Herbage yields of Trojan and Maku did not differ significantly.

In the tall fescue swards, the relative differences between *Lotus* cultivars were similar to the no-grass treatment. The *Lotus* yields of Goldie were similar to the

Table 2 The seasonal *Lotus* and total herbage yield (kg DM/ha) of the swards with *L. corniculatus* and *L. pedunculatus* cultivars growing without grass or with tall fescue over Year 2 and Year 3.

	<i>Lotus</i> herbage yield (kg DM/ha)				Total herbage yield (kg DM/ha)			
	Year 2		Year 3		Year 2		Year 3	
	Spr 02	Aut 03	Spr 03	Aut 04	Spr 02	Aut 03	Spr 03	Aut 04
No-grass								
Goldie	2620	2780	4380	3150	3250	3300	5180	3340
Creeping	2390	1970	3890	2300	3220	2620	4970	2970
G46	2030	3040	4090	2630	2890	3310	4990	2940
Maku	830	435	1810	1910	2250	1210	3310	3020
Trojan	1230	850	2460	1780	2340	1850	4060	2900
LSD (5%)	715	520	1080	865	570	400	800	NS
Tall fescue								
Goldie	210	665	900	765	2490	1730	4580	2760
Creeping	210	310	640	440	2430	1430	4510	2160
G46	100	360	500	575	2490	1590	4160	2320
Maku	15	25	240	70	2290	1040	4420	2260
Trojan	40	5	230	20	2620	1100	4600	2020
LSD (5%)	145	345	460	410	NS	390	NS	500

NS non-significantly different

other *L. corniculatus* cultivars but consistently better than the *L. pedunculatus* cultivars. All *Lotus* cultivars showed a marked improvement in yield between Year 2 and Year 3. Total sward yields from the *Lotus* cultivars were similar in the spring of both years but Goldie-based swards had greater autumn yields. Goldie showed the potential to produce 2 t/ha of *Lotus* herbage in the tall fescue sward during Year 3, whereas Trojan produced less than 0.5 t/ha by the third year (Table 2).

The % *Lotus* from plots with and without tall fescue is shown in Figure 1. During the spring/summer/autumn period, the *L. corniculatus* cultivars maintained 80-90% content in the no-grass plots compared with 40-60% content for the *L. pedunculatus* cultivars, with the remainder being weeds and white clover. In the tall fescue plots, the *L. corniculatus* cultivars made up 6% of the herbage in the spring of Year 2 but increased to 34% by the summer of Year 3 (Figure 1). *L. pedunculatus* cultivars in the tall fescue plots produced less than 1% of the herbage in Year 2 and remained at a low 2% level by the summer of Year 3.

In *L. corniculatus*, Goldie, Creeping and G46 produced similar amounts of herbage (Figure 2, Table 2) except for Creeping with significantly lower autumn production than Goldie in each year. The *L. pedunculatus* cultivars were significantly poorer than the *L. corniculatus* cultivars throughout the year except in the winter, with no significant difference between Maku and Trojan (Figure 2).

White clover had a greater competitive effect on *Lotus* in the no-grass treatment by reducing the *Lotus* content by 15-20% throughout the season, compared to the tall fescue treatment where *Lotus* content was unaffected by

the presence of clover (Figure 3).

Discussion

In monoculture, the *L. corniculatus* cultivars established an adequate plant density whereas the *L. pedunculatus* cultivars had poor establishment compared with other studies (Bologna *et al.* 1996; Brock *et al.* 1978). Low plant numbers may have resulted from the use of herbicides six weeks after sowing to control dicotyledon weeds. These herbicides checked the development of the young *Lotus* seedlings and caused some seedling mortality. However, under the infrequent grazing management of this experiment, the *Lotus* content and herbage yields of the *L. corniculatus* cultivars steadily increased such that the potential *Lotus* yield in the third year was equivalent to 10-12 t/ha (including an estimate for summer production). In contrast, the *L. pedunculatus* cultivars had fewer plants and suffered from white clover and weed competition, resulting in low *Lotus* content and herbage yields half those of the *L. corniculatus* cultivars.

In the tall fescue swards, both *Lotus* species had low plant density but this had a greater detrimental impact on herbage yields from *L. pedunculatus* than *L. corniculatus* cultivars. Earlier research has shown the poor competitive ability of *L. pedunculatus* in a mixed sward with white clover and ryegrass under high fertility conditions (Brock *et al.* 1978; Sheath 1981). In this study, the associated slower establishing and less competitive tall fescue together with infrequent grazing management still failed to improve the *Lotus* content of the *L. pedunculatus* based swards.

The performance of *L. corniculatus* in association

Figure 1 The % *Lotus* herbage of the *L. corniculatus* cultivars growing either without grass (—●—) or with tall fescue (---○---) and *L. pedunculatus* cultivars growing without grass (—■—) or with tall fescue (---□---). The bars indicate LSD ($P < 0.05$).

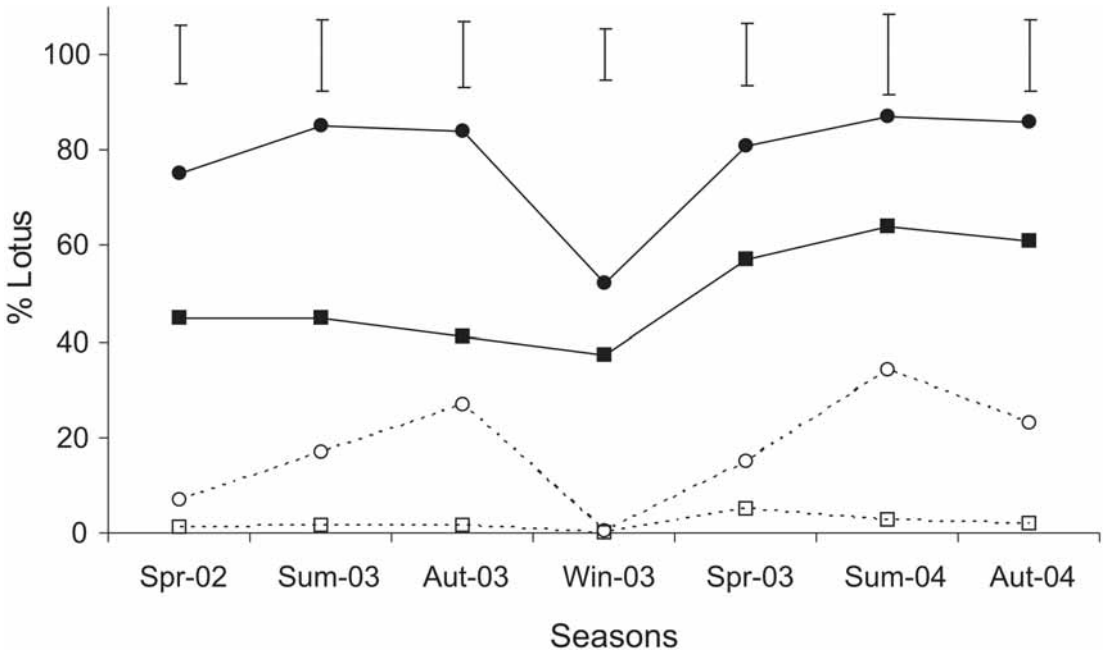


Figure 2 The % *Lotus* herbage of the *L. corniculatus* cultivars, Goldie (—■—), G46 (—●—) and Creeping (—▲—) and the *L. pedunculatus* cultivars, Maku (---○---) and Trojan (---□---) averaged over the no-grass and tall fescue treatments. The bars indicate LSD ($P < 0.05$).

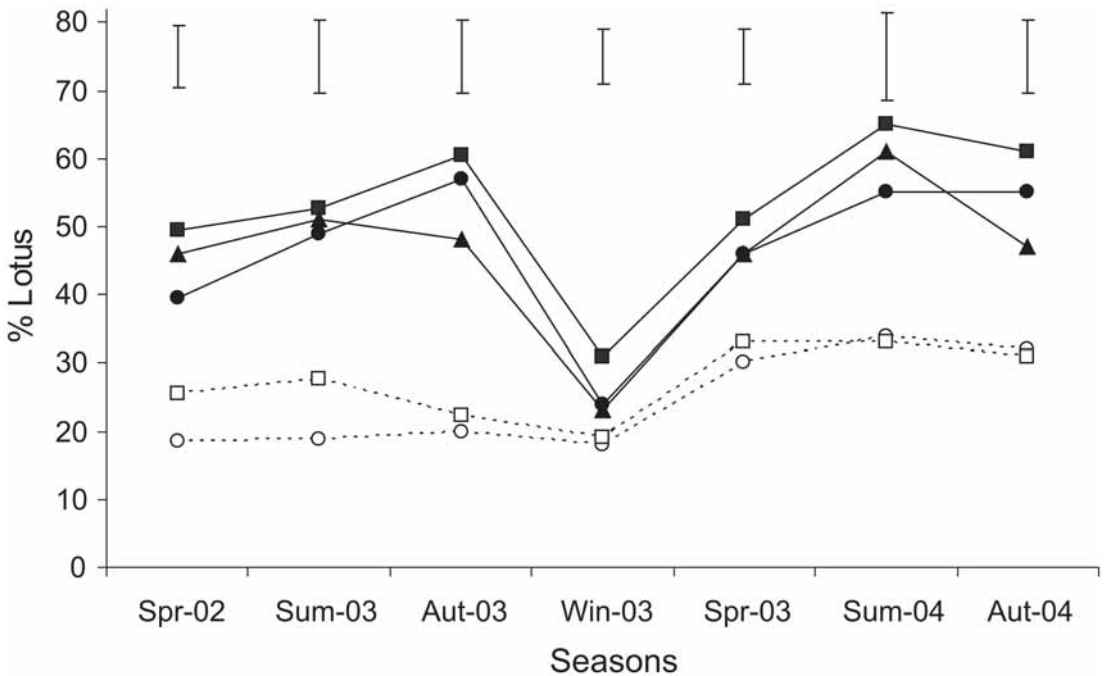
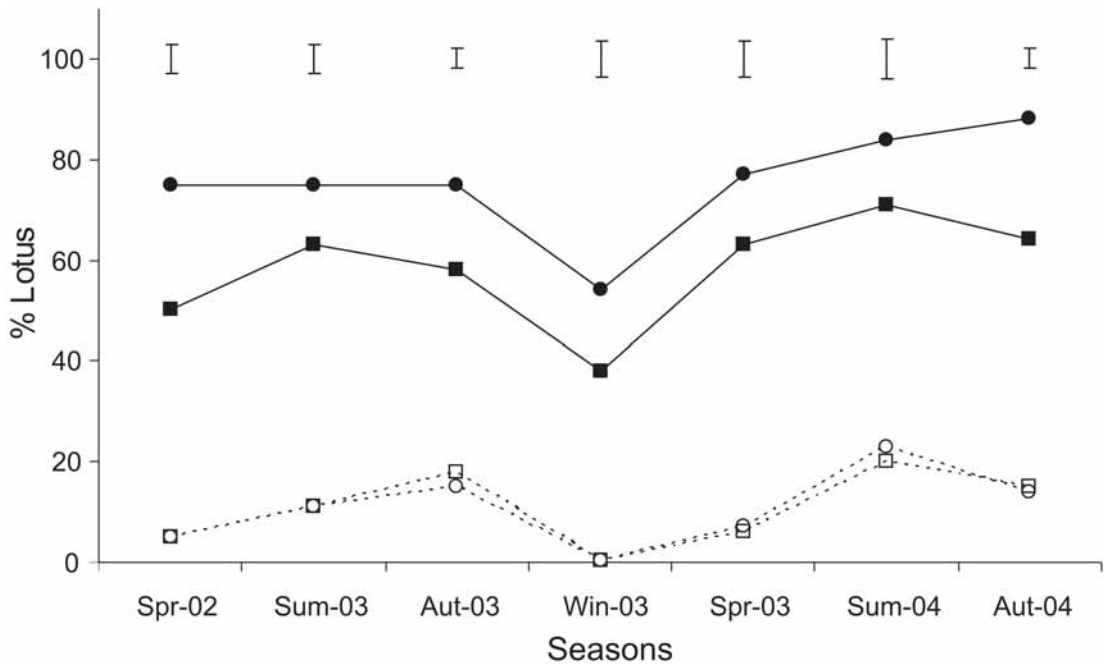


Figure 3 The % *Lotus* herbage in the sward of 5 *Lotus* cultivars growing without grass but either with white clover (—■—) or without white clover (—●—), and growing with tall fescue either with white clover (---□---) or without white clover (---○---). The bars indicate LSD ($P < 0.05$).



with grass has been much better than *L. pedunculatus*. New Zealand researchers have promoted the use of *L. corniculatus* in pure stands to achieve high legume yields and better persistence and have discouraged its use in mixed pastures (Barry *et al.* 2003; Ramirez-Restrepo *et al.* 2003; Waghorn *et al.* 1998). However in this study, the *L. corniculatus* cultivars developed 20 and 34% *Lotus* content in the tall fescue swards by the second and third summers respectively. The combination of infrequent grazing, occasional topping in spring and early summer and the association with less competitive tall fescue, has collectively enabled *L. corniculatus* to produce and persist well in a mixed pasture situation.

A major objective of the experiment was to determine whether the new *Lotus* cultivars were more competitive and persistent in a pasture situation than the old cultivars. To date, Goldie, G46 and Creeping have produced similar herbage yield, but the denser low-growing habit of Creeping may improve its persistence in a grass sward over time. In addition, the seasonal growth pattern of Creeping being concentrated in spring-summer with less late autumn-winter growth than Goldie, may assist with its long-term productivity and persistence. G46, which was bred for the South Island high country also has a spring-summer growth pattern. Continued monitoring of this experiment will answer some of the persistence related issues.

These results suggest that neither of the *L. pedunculatus* cultivars is adapted for use in a lowland mixed pasture situation, possibly affected by the poor establishment, competition from the tall fescue and by the unsuitability of the 'dryland' environment.

The *Lotus* herbage in a mixed sward is valuable to grazing animals for the improved nutritional value that is associated with legume herbage containing condensed tannin (CT). In three measurements from a field experiment at Palmerston North through the summer of 2002-2003, Creeping produced 4.89%, 2.19% and 3.36% CT of the herbage DM, whereas Goldie produced 0.89%, 0.68% and 1.62% respectively (Geoff Lane pers. comm.). Therefore, the Creeping selection has a higher potential for providing CT in the mixed pasture than Goldie. However, at this stage Goldie has produced greater herbage DM than Creeping and G46. If Creeping does improve its productivity relative to Goldie over time, then Creeping could provide greater levels of CT in a pasture.

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