

PERFORMANCE OF *LOTUS CORNICULATUS* CULTIVARS AND LINES IN AN ALTITUDINAL SEQUENCE ON THE EAST OTAGO PLATEAU

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ABSTRACT

The performances of 35 *Lotus corniculatus* cultivars and lines of diverse type and origin were evaluated on acid and infertile soils of the East Otago Plateau. Trials were at three sites representing an altitudinal sequence of increasing severity of climate, but with similar soil and aspect.

At the lowest site, material from mild temperate Mediterranean and cool temperate climates performed best for annual, spring and autumn herbage production. With increasing severity of climate the performance of cultivars and lines from Canada and Russia (Continental) improved relative to those from milder climates. Material from South America performed poorly relative to other cultivars and lines at all sites.

Superior plants from highly ranked cultivars and lines for annual dry matter production from all three sites have been isolated and polycrossed to produce an experimental "Otago Plateau" cultivar. Genotypes from cultivars and lines of continental and cool temperate origin dominated the experimental cultivar.

Lotus corniculatus showed greater early spring and autumn growth relative to *L. penunculatus*. Autumn herbage of all cultivars and lines of both lotus species was highly vulnerable to severe frosting damage, whereas red clover cultivars and lines showed a high level of tolerance at this time.

Additional Key Words: Birdsfoot trefoil, lotus, evaluation, selection, herbage production, spring yield, autumn yield, frost damage.

INTRODUCTION

Lotus corniculatus L. (birdsfoot trefoil) is a perennial species used extensively in North and South America and Europe. Although introduced during the early 1900s (Levy, 1918), it has only recently been advocated for use in New Zealand (Charlton *et al.*, 1978; Scott and Charlton, 1983).

It has shown considerable potential as an alternative and complementary forage legume to lucerne and conventional clovers in the dry hill and high country regions of New Zealand (Charlton *et al.*, 1978; Scott, 1985; Scott and Charlton, 1983; Widdup *et al.*, 1987). However little work has been done to assess its performance on moist, acid and infertile soils of the high country, although Lowther *et al.* (1987), concluded that lack of sufficient tolerance to soil acidity is likely to limit the use of *L. corniculatus* on the more acid tussock grassland soils in the absence of lime.

A co-operative programme between DSIR plant breeders and MAF agronomists to develop a cultivar adapted to the South Island tussock country was initiated in 1983 (Widdup *et al.*, 1987).

This paper outlines the performance of 35 *L. corniculatus* cultivars and lines on acid and infertile soils in an altitudinal sequence on the East Otago Plateau.

Some aspects of *Lotus pedunculatus* Cav., Huia white clover (*Trifolium repens* L.) and red clover (*Trifolium pratense* L.) performance in this trial is included to place *L. corniculatus* performance into better perspective.

MATERIALS AND METHODS

Three sites were chosen in undeveloped tussock grassland dominated by snow grass (*Chionochloa rigida*) at Waipori, Castle Dent and Ailsa Craig, each with similar soil and aspect (Table 1).

The 35 *L. corniculatus* lines formed part of a trial of 169 lines of a wide range of legume species, arranged in

TABLE 1: Soil and climate features from a range of sites on the East Otago Plateau.

	Waipori	Castle Dent	Ailsa Craig
Altitude (m)	450	750	1050
Soil			
Type	YBE	YBE	YBE
pH	4.7	4.6	4.6
Olsen P ($\mu\text{g/ml}$)	7	3	6
SO ⁴ -S ($\mu\text{g/g}$)	13	7	6
Climate (December 1987-April 1988) ¹			
Mean air temp ($^{\circ}\text{C}$)	9.7	-	7.7
Mean soil temp ($^{\circ}\text{C}$)	11.0	10.4	9.7
Hours temp > 0 $^{\circ}\text{C}$	25	153	206
Days of frost	9	28	34
Rainfall (mm)	590.5	-	492.5

¹Invermay Research Centre Radio Telemetry System

rows in each of four replicates, in a 13 x 13 lattice design to reduce intra-replicate variation. Seedlings were established in the glasshouse, inoculated with the recommended strain of *Rhizobium* and transplanted into the sites during spring/early summer 1983/84, in 8 plant rows, 30 cm between plants, 2 m between rows, following mowing, clearing and removal of resident vegetation with glyphosate along a narrow planting strip.

Each site received basal lime (1.0 tonne/ha) and molybdate superphosphate (250 kg/ha, (9% P and 11% S)) in the first year and maintenance superphosphate (125 kg/ha) annually.

Herbage yield (kg DM/ha) determined from a 30 cm wide cut along the full 2.4 m length of each row was recorded from each site. The number of harvests varied with site and season from three at Waipori, two at Castle Dent, one in the first full season at Ailsa Craig and two in the second season.

Rows were visually scored for spring vigour (0 low to 5 highest) and frosting damage (0 negligible to 3 severe) at all sites.

The 35 cultivars and lines were classified into 5 origin/climate groups (Table 2).

TABLE 2: Five origin/climate groups of the 35 cultivars and lines on the East Otago Plateau.

Groups	
A	South American (Brazil, Uruguay).
B	Mediterranean/mild temperate (Portugal, Yugoslavia, Italy, France, Israel, South and West USA, Northern New Zealand).
C	Maritime Europe/cool temperate (Denmark, Czechoslovakia, Germany, Poland, Hungary, Netherlands, Southern New Zealand).
D	Continental temperate (Canada, North and Central USA, Russia, Lithuania).
E	Middle East (Iran, Turkey).

RESULTS AND DISCUSSION

Figure 1 and Table 2, Table 3, Table 4, Table 5, and Table 6 partition the lines into the five groups based on the climate/origin of each line. Although the mean herbage production, spring vigour and summer frosting damage of each group is presented, there is considerable cultivar and line variation within groups. The performance of the highest lines for mean annual herbage production indicates the extent of this variation.

Cultivars and lines from Group C and D regions dominated the top rankings for herbage production averaged over three sites and three seasons (Table 3).

The top ranked line overall S1843 (Denmark), performed well at all three sites. However like most Group C material, performance relative to Group D material declined with increasing severity of climate; whereas S1843 ranked number 1 at Waipori, its rankings at Castle Dent and Ailsa Craig were 10 and 11 respectively.

TABLE 3: Mean annual yield (kg DM/ha) of 3 sites over 3 seasons, of *Lotus corniculatus* on the East Otago Plateau (1984-1987).

Rank	Cultivar or line	Yield	Origin	Group
1	S1843	3770	Denmark	C
2	S2103	3660	Canada	D
3	S1859	3490	Netherlands	C
4	S1468 Leo	3340	Canada	D
5	S2110	3300	Canada	D
6	S2105	3280	Canada	D
7	S1070 Taborsky	3260	Czechoslovakia	C
8	S1717	3230	Italy	B
9	S1437 Moskovskij 287	3220	Russia	D
10	S1803	3150	Yugoslavia	B
11 =	S1687	3130	Russia	D
11 =	S1522 Lot	3130	Poland	C
11 =	S1846	3130	Poland	C
14	S1796	3010	Iran	E
15	S1755	3000	France	B
16	S1505 Tana	2960	United States	B
17	S1532 Maitland	2950	Canada	D
18	S1821	2940	Israel	B
19	S1039	2840	Portugal	B
20	S2085	2780	New Zealand	C
21 =	S1438 Gelsvis	2720	Lithuania	D
21 =	S1646 Franco	2720	Italy	B
23	S2101	2660	Canada	D
24	S1629 Odenwalden	2610	Germany	C
25	S2078 G32	2530	New Zealand	B
26	S1788	2400	Uruguay	A
27	S1835	2380	Germany	C
28	S2102	2110	Canada	D
29	S2000 Saskatoon	2030	Canada	D
30	S1812	2000	Hungary	C
31	S1741	1760	Turkey	E
32	S1620 Mandan	1650	United States	D
33	S1870	1610	Chile	A
34	S1652 San Gabriel	1000	Brazil	A
35	S1517	910	Brazil	A
SED		400		

Group	Yield
A	1480
B	2920
C	2950
D	2840
E	2380
SED	232

Species	Overall Mean	Waipori (450)	Castle Dent (750)	Ailsa Craig (1050)
<i>L. corniculatus</i> (35)	2700	3670	2730	1720
<i>L. pedunculatus</i> (55)	2450	2750	2620	1990
LSD (1%)	190	330	NS	230

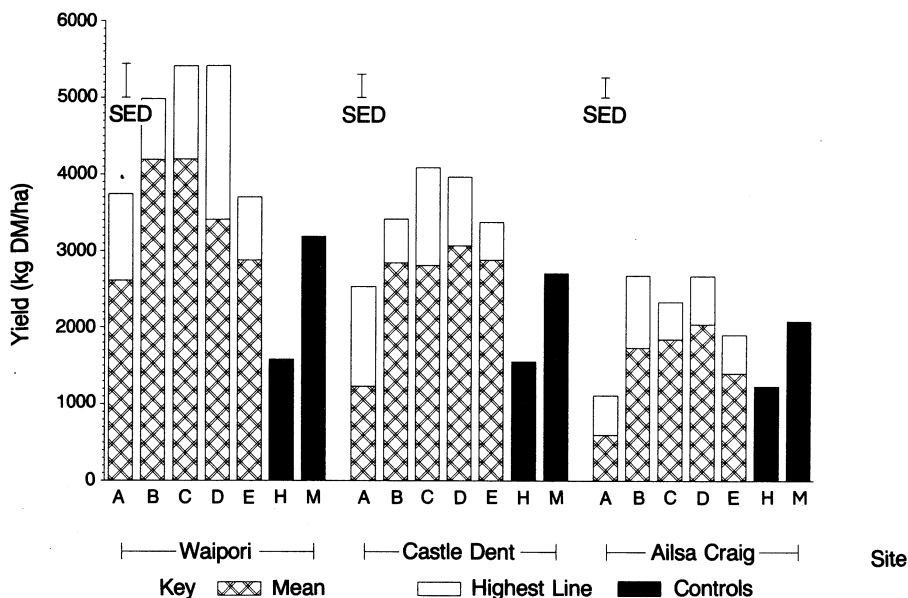


Figure 1: Mean seasonal herbage production of *Lotus corniculatus* introductions at three sites in the East Otago Plateau, 1984-87.

Groups: A. South American; B. Mediterranean/mild temperate; C. Maritime Europe/cool temperate; D. Continental temperate; E. Middle East.

Controls: H Huia white clover; M Maku *Lotus pedunculatus*

The performance of the approved cultivar Tana (United States), typified the performance of Group B cultivars and lines as a whole, i.e. its ranking declined from 6 at Waipori to 30 out of 35 at Ailsa Craig. The decline in most Group B material with increasing severity of climate relative to Group D was more accentuated than that for Group C, reflecting the milder climate of origin of the Group B material. Material from both Group B and C had good spring and autumn production (Table 4 and Table 5).

Top ranking Group D cultivars and lines Leo and the Leo-derived S2103, typified Group D material as a whole, their performance relative to Group B and C cultivars and lines improving markedly from the lowest site to the middle and highest. Leo for example ranked 20 at Waipori and 3 and 4 at Castle Dent and Ailsa Craig respectively.

Leo and Guelph material derived from Leo (S2101, S2102, S2013, S2105 and S2110) concentrated their production mainly over late spring and summer. They showed relatively slow growth in early spring and became dormant early in autumn indicating a high inherent capacity to develop resistance to freezing with the onset of shorter days. Herbage growth becomes increasingly replaced by build up of crown and root reserves in such continental type material.

The Group A (South American) lines, performed poorly and were never placed in the top 3 ranked groups (Figure 1). With increasing severity of climate there was a

TABLE 4: Autumn herbage yields (kg DM/ha) at Waipori in 1985 and 1986.

Groups	1985		1986	
A	1120		230	
B	1030		340	
C	860		260	
D	450		70	
E	610		150	
SED	144		55	
Cultivars and lines				
S1843	1370	(2)	400	(4)
S2103	410	(29)	80	(25)
S1859	850	(16)	230	(15)
S1468 (Leo)	280	(31)	0	(31=)
SED	286		113	
Groups				
Species	1985		1986	
<i>L. corniculatus</i> (35)	770		200	
<i>L. pedunculatus</i> (55)	530		130	
<i>T. pratense</i> (10)	1710		730	
SED	69		31	

Values in parenthesis refer to rankings within species (1 = best; 35 = poorest)

TABLE 5: Spring vigour (0-5), spring yield (kg DM/ha) and summer frosting damage (0-3) of *Lotus corniculatus* introductions.

Groups	Spring ¹ Vigour	Spring ² Yield	Frosting ³ Damage
A	2.1	790	1.2
B	3.1	1740	1.1
C	2.8	1720	1.1
D	2.3	1320	1.0
E	2.0	1030	1.0
SED	0.18	197	0.04
Cultivars and Lines			
S1843	3.2 (6)	2150 (3)	1.1 (24=)
S2103	2.6 (19)	1940 (8)	1.0 (7)
S1859	2.9 (14)	1630 (14)	1.0 (11)
S1468 (Leo)	2.4 (22=)	1510 (19)	1.0 (6)
SED	0.25	346	0.09
Species			
<i>L. corniculatus</i> (35)	2.6	1440	1.1
<i>L. pedunculatus</i> (55)	1.2	1370	1.5
<i>T. pratense</i> (10)	3.7	2250	1.1
SED	0.07	93	0.04

¹Mean of three recordings at Waipori over three seasons. (0 = low, 5 = highest).

²Mean of three harvests at Waipori over three seasons (1984-87).

³Mean of four frosts at Castle Dent over two seasons. Values in parenthesis refer to rankings relative to all lotus accessions (1 = best; 35 = poorest).

marked reduction in the group's performance. The performance of San Gabriel (Brazil) typified that of Group A. Although having good autumn yield (Table 4), poor spring production, susceptibility to summer frosting damage and overall poor production, led to cultivars and lines from this group not being considered for selection in the "Otago Plateau" experimental cultivar (Table 6).

Group E (Middle East) cultivars and lines performed poorly at the lowest and highest sites. Only at Castle Dent was the Group E performance comparable with B, C and

TABLE 6: The percentage of lines from which elite plants have been selected.

Groups	Waipori	Castle Dent	Ailsa Craig	Otago Plateau (overall)	Tara Hills (overall)
A	— (—)	— (—)	— (—)	— (—)	16 (16)
B	41 (44)	8 (3)	13 (19)	30.5 (27)	53 (56)
C	29 (37)	42 (55)	25 (43)	30.5 (43)	21 (20)
D	24 (15)	50 (42)	62 (38)	35 (28)	5 (4)
E	6 (4)	— (—)	— (—)	4 (2)	5 (4)

Values in parenthesis refer to genotype percentage.

D. Due to the mediocre performance of Group E lines only two Group E genotypes were included in the polycross.

SPECIES

Lotus corniculatus markedly out yielded *L. pedunculatus* at the lowest site. Yields between the two species at Castle Dent were similar and *L. pedunculatus* produced slightly more than *L. corniculatus* at the highest site (Figure 1).

Spring vigour recorded in early-mid October showed that *L. corniculatus* growth was earlier than *L. pedunculatus* but there was no significant difference between *L. corniculatus* and *L. pedunculatus* for spring production measured in late November. Both lotus species were significantly poorer than red clover for spring vigour and spring production. *L. corniculatus* out-produced *L. pedunculatus* during the autumn period.

There was no significant difference between *L. corniculatus* and red clover for summer frosting damage, although both were superior to *L. pedunculatus*. Both species were highly vulnerable to severe herbage losses from late autumn frosting. This was clearly shown in the data for autumn yields in 1986; herbage was greatly reduced in both lotus species. By contrast, red clover showed high frost tolerance at this time (Table 4).

The potential of *L. corniculatus* on moist, acid and infertile tussock grassland has also been shown in a sister trial (Floate *et al.*, 1989). In the sister trial, sward performance of the approved *L. corniculatus* cultivar Maitland, compared favourably with Maku lotus and Huia and Tahora white clover when a small quantity (1 tonne/ha) of lime was applied and yet Maitland was ranked only 17 for annual yields in this trial.

Lotus corniculatus Breeding Program

The co-operative effect between DSIR and MAF to produce a *L. corniculatus* cultivar or cultivars adapted to the South Island tussock country has produced two experimental cultivars to be used in establishment/management studies and on-farm trials (Widdup *et al.*, 1987).

The "Otago Plateau" cultivar has been based on elite genotypes from each site on the East Otago Plateau. Consequently, the cultivar has a high proportion of genotypes from Group C (43%) and Groups B (27%) and D (28%). By contrast elite genotypes selected from a trial at Tara Hills for a dryland experimental cultivar (Widdup *et al.*, 1987) were mainly derived from Group B (56%) (Table 6).

Included in the "Otago Plateau" experimental cultivar 58% of the genotypes were selected from the top 10 ranked cultivars and lines for mean herbage production.

On the completion of polycross isolations in 1987/88, seed from individual plants will be progeny tested at sites throughout the South Island tussock country. Simultaneously, bulked seed from the polycross, will be tested for agronomic potential in acid/infertile tussock country. These proposals include co-operation between contributors from different organisations and farmers to

ensure that the final bred cultivar has been widely tested and is accompanied by a package of technical information.

CONCLUSIONS

Material from cool temperate and Continental type regions dominated the top rankings for herbage production averaged over three sites. Among the 35 *L. corniculatus* cultivars and lines S1843 from Denmark was the top ranked line for herbage production and also had good spring vigour and autumn production.

The outstanding performance of top ranked *L. corniculatus* cultivars and lines relative to Maku lotus and Huia white clover indicates *L. corniculatus* to be an option for acid, infertile tussock grassland.

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