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BREEDING *Lotus corniculatus* FOR SOUTH ISLAND TUSSOCK COUNTRY

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Abstract

Lotus corniculatus introductions and cultivars from Europe, the Mediterranean and North and South America *were* evaluated for herbage production and morphological characteristics at six sites In the South Island tussock country. The sites constitute a sequence of increasing altitude, soil acidity, infertility, rainfall and cold temperatures.

In the dry intermontane basins of Central Otago and the McKenzie Country, material from Portugal, Yugoslavia, Italy and France performed best, with high yields, a wide seasonal spread of production and desirable growth habit. In contrast, on the cold and infertile soils of upland Otago, material from Holland, Sweden, Canada and Russia proved superior by concentrating growth into summer. South American material had some cool season activity, but an erect growth habit and susceptibility to frosting reduced the suitability of this material. The relative merits *of Lotus corniculatus* compared with red, white and alsike clover, lucerne and Lotus *pedunculatus* are discussed.

Superior plants have been isolated and will be polycrossed to produce lines for progeny testing. Experimental cultivars will be produced by bulking these superior lines for establishment/management studies and on-farm trials. A co-operative effort between research organisations and farmers is envisaged.

Keywords: Introductions, adaptation, selection, breeding programme.

INTRODUCTION

Lotus corniculatus is used extensively in North and South America and Europe but has only recently been advocated for use in New Zealand (Charlton *et al.* 1978, Scott and Charlton 1983). It has potential as a forage legume in the dry hill and high country regions of New Zealand. Lucerne has been tried on the high country yellow-brown earths of the McKenzie Basin but failed to persist. High soluble aluminium levels in these soils limit the rooting depth of lucerne, resulting in stands invaded by weeds and lacking drought tolerance (Douglas 1986). *Trifolium* species, although tolerant of aluminium, fail to persist under dry conditions (Scott 1985). *L. corniculatus* combines the aluminium and drought tolerance to become a more reliable option in these less-fertile dry regions (Scott and Charlton 1983).

In 1983, a programme was initiated to develop a cultivar of *Lotus corniculatus* adapted to the South Island tussock country. A co-operative programme between DSIR plant breeders and MAF agronomists enabled extensive testing of a wide range of genetic material at diverse sites in the South Island tussock country.

MATERIALS AND METHODS

The initial evaluation screened up to 170 *L. corniculatus* introductions at each of 6 sites ranging from the warm, dry, fertile Alexandra site to the cold, wet, infertile Ailsa Craig site (Table 1). The controls were 'Grasslands Huia' white clover *(Trifolium repens* L.), 'Grasslands Pawera' red clover (T. *pratense* L.), commercial alsike clover (*T. hybridum* L.), 'WL 318' lucerne *(Medicago sativa* L.) and 'Grasslands Maku' lotus (*L. pedunculatus* L.). A rectangular lattice design with four replicates was used.

Seedlings were established in root trainer pots in the glasshouse then transplanted into the sites between September and December 1983. All plants were

Table 1: Soil and climate features from a range of sites in the South Island tussock country.

	Alexandra	Tara Hills	Tekapo	Waipori	Castle Dent	Ailsa Craig
Altitude(m)	270	490	660	500	750	1040
Soil						
Type	BGE	YGE/BGE	YBE	YBE	YBE	YBE
pH	6.1	5.7	5.4	4.7	4.7	4.6
Olsen P	15	20	11	5	5	5
SO_4S	3	3	5	9	8	6
Climate'						
Rainfall (mm)	350	530	600	1200	1100	1000
Mean Air Temp. (°C)	10.5	9.1	9.0	6.2	7.2	6.2
No. of Introductions	170	90	170	35	35	35

'New Zealand Meteorological Service 1973.

inoculated with recommended strains of *Rhizobium*. The resident vegetation was removed in narrow strips with glyphosate prior to planting. Each line was represented by one 8 or lo-plant row per replicate with plants spaced at 30 cm.

The trials at Alexandra, Tekapo and Tara Hills were fertilised with 200 kg/ha molybdic superphosphate (7%P, 27%S) in the first year and 100 kg/ha superphosphate in the third year. The trials on the upland Otago sites received 250 kg/ha molybdic superphosphate and 1 t lime/ha initially followed by 125 kg/ha superphosphate annually.

The standing herbage of each line was scored visually (0 low — 5 high) four times a year at the Alexandra and Tekapo sites. Each time, samples of the range of visual scores were cut to 2 cm, dried and weighed and regression analysis was used to give estimates of actual herbage mass. After each sampling the plants were grazed by sheep. Plant habit and shoot density were scored periodically at these sites.

At the Tara Hills and Lammerlaw sites, all rows were cut to 2 cm, two to four times annually to measure herbage mass. Plant habit and frost damage were scored at Tara Hills.

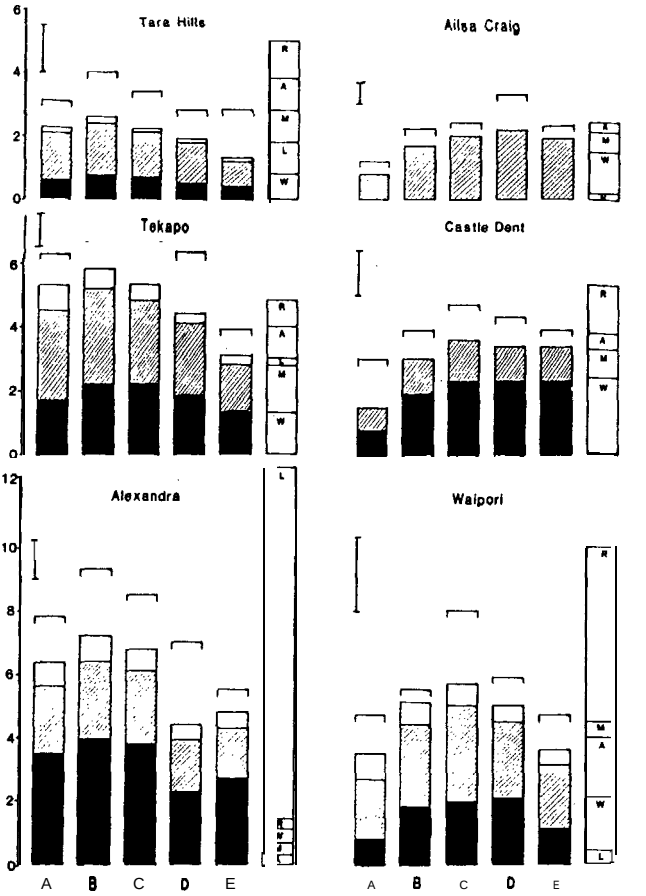
RESULTS AND DISCUSSION

Field evaluatlons

Figure 1 and Table 2 partition the lines into 5 groups based on the climate of origin and growth habit of each line. Although the mean herbage production of each group is presented, there was considerable variation within groups. The performance of the best lines indicates the extent of this variation.

Group A, the South American lines, was never one of the top 2 producing groups at any of the sites (Figure 1). Its best performance was at Alexandra, but as altitude increased and temperature and fertility decreased performance declined. The autumn growth of the group at Alexandra, only 10% of the annual yield, contrasts with the active cool season growth in the North Island of South American material (Charlton et a/. 1978). South American lines were erect with low shoot numbers (Table 2) which can lead to poor recovery after repeated defoliation. Frost damage during autumn and spring was most prevalent in this material (Table 2).

Genetic material originating from the Mediterranean and mild temperate regions of Europe (Group B) performed best at the intermontane basin sites (Alexandra, Tekapo and Tara Hills). At these sites, production ranged from 2.5t to 7t DM/ha/annum and occurred over a long growing season (October-April). The best introductions came from Portugal (S1039) and France (S1755). This material also recovered well from drought stress and continued to grow into late summer and autumn. However, the performance of this group declined at the colder, more



Group

A South American (Brazil, Uruguay, Chile, Argentina)
B Mediterranean/mild temperate (Portugal, Yugoslavia, Italy, France, Israel, South and West U.S.A.)
C Maritime Europe/cold temperate (U.K., Holland, Denmark, Czechoslovakia, Sweden, Germany, Poland)
D Continental (Canada, North and Central U.S.A., Russia)
E Middle East (Afghanistan, Iran, Turkey)

Controls

R Pawera Red Clover
A Commercial Alsike Clover
W Huia White Clover
M Maku *Lotus pedunculatus*
L WL318 Lucerne

Best Line
Autumn
summer
Spring
LSD (5%)

Figure 1: Mean seasonal herbage production (tonnes DM/ha) of *Lotus corniculatus* introductions at six sites in the South Island tussock country, 1984-86.

Table 2: Growth habit, shoot density and frost damage of *Lotus corniculatus* introductions.

Origin	Habit[1]	Shoot Density[2]	Frost Damage[3]
South American	1.7	1.6	2.4
Mediterranean	2.3	2.2	1.7
Mid Europe	2.5	2.3	1.2
Continental	2.7	2.2	1.3
Middle East	3.4	2.3	1.2
LSD (5%)	0.5	0.4	0.6

[1] 1 = erect, 4 = prostrate; [2] 1 = low, 4 = high; [3] 1 = low, 4 = high, (Tara Hills data)

infertile sites. The intermediate growth habit of Group B material (Table 2) was considered suitable for both forage conservation and grazing.

In contrast, genetic material from cold temperate regions of mid-Europe (Group C), proved superior to other groups at the cold upland Otago sites (Waipori and Castle Dent). This material is suited to cold winters and mild summers by limiting growth to the summer months. Even more extreme in this respect was the Group D material from continental regions (Canada and Russia), which was superior to other groups at the Ailsa Craig site. All of the herbage at the two highest sites was produced between November and February with yields from 2-4t DM/ha. The best introductions came from Holland (S1859) and a selection out of the cultivar Leo from Canada (S2103) within Groups C and D respectively. Material from these groups was semi-prostrate (Table 2) and is considered suitable for grazing.

Performance of material from the Middle East (Group E) was moderate to poor at all sites. Plants were not considered for selection because of the mediocre performance of the best lines. Their prostrate growth habit (Table 2) made grazing difficult.

Lucerne was the highest producing control species at the dry, fertile Alexandra site. However, L. corniculatus may still be a good alternative in Central Otago due to its less stemmy growth, lower incidence of pest problems (e.g. sitona weevil and aphids), and good performance on lower fertility soils (Scott and Charlton 1983).

Pawera red clover and alsike produced high yields at the McKenzie and upland Otago sites which is consistent with earlier work (Musgrave 1976, Scott 1985). However, red clover, often the top ranked legume in the first year, produced lower yields by the third year. Alsike declined in yield rank with time at Tara Hills and Waipori which was related to a high incidence of crown and root rots. In contrast, *L. corniculatus* improved with time and Scott (1985) found it to be the most productive and persistent legume after 5 years.

Maku lotus has been recommended as a suitable legume for the wet acid, infertile upland Otago area (Scott and Mills 1981). However, some *L. corniculatus* lines showed superior growth to Maku at Castle Dent and Alisa Craig and with its superior ability to establish by self-seeding, *L. corniculatus* becomes a further option in these areas. The consistently low yields of Huia white clover at all sites demonstrates its poor adaptation to dry or infertile conditions.

Breeding programme

The second stage of the breeding programme is to make polycross isolations based on site and plant performance (Figure 2). The major isolation will contain superior plants from the three dry intermontane sites where *L. corniculatus* is most likely to be used. The majority of the elite plants selected from these sites (Table 3) are from germplasm of the Mediterranean/mild temperate types. A second upland Otago isolation will contain contrasting plant material adapted to cold, moist and infertile areas. Elite plants from these sites (Table 3) are dominated by productive and well adapted germplasm from the cold temperate and continental groups.

Initial Evaluation: Wide Genetic base
Wide Environmental range
1. Alexandra site (DSIR)
2. Tekapo (DSIR)
3. Tara Hills (MAF)
4. Lammerlaws (MAF)

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Selection and Polycrossing to generate two 'Experimental' cultivars

1. 'General' based on elite plants from sites 1, 2 & 3
2. 'Upland Otago' site 4

Progeny Testing

Determine the breeding value of parent plants for a new cultivar(s)

Agronomic Testing

Comparison of 'Experimental' and 'Standard' cultivars

a) Small plot trials at many sites (MAF and DSIR)
b) Management studies at Tara Hills and Tekapo
c) Establishment/Rhizobia studies (MAF)

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Production of bulk seed of **'pre-release cultivar(s)'**

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On-farm trials in a range of environments

- Farmers, DSIR, MAF (Advisory and Research Divisions)

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Commercial Release of Cultivar(s)

Package of Technical information on establishment, management and suitability for different environments.

Figure 2: A regional breeding programme with Lotus *corniculatus*.

Table 3: The percentage of lines which elite plants have been selected.

Origin	Alexandra	Tara Hills	Tekapo	Waipori	Castle Dent	Ailsa Craig
South American	17	16	9	-		
Mediterranean	*56*	*56*	*57*	*36*	8	11
Mid Europe	*22*	*20*	*19*	*31*	*42*	*33*
Continental	5	*4*	11	*31*	*50*	*56*
Middle East	-	*4*	*3*	-		

On the completion of polycross isolations, seed from individual plants will be progeny tested at sites throughout the South Island tussock country. Simultaneously; bulked seed from each isolation, will be tested for agronomic potential in tussock country (Figure 2). 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.

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