Proceedings of the New Zealand Grassland Association 50: **189-I 96 (7989)**

PERFORMANCE OF WHITE CLOVER AND LOTUS CULTIVARS AND LINES ON THE EAST OTAGO PLATEAU

J.M. Keoghan, W.J. Fraser and R.P. Heenan
Invermay Agricultural Centre, MAF, Mosgiel

Abstract

The performance of *55 Lotus pedunculatus Cav.* and *33 Trifolium repens* L lines of diverse type and origin was assessed on acid, infertile soils on the East Otago Plateau at 3 sites representing an altitudinal sequence of increasing severity of climate.

Among the *L pedunculatus* lines, a diploid NZ selection 04701 showed the best combination of attributes with high herbage yields. moderate rhizome spread at the highest sites and considerable tolerance to out-of-season frosting. G4701, its tetraploid equivalent G4702 and a selection from within the cultivar 'Grasslands Maku' for rapid germination at low temperatures, produced the highest yields averaged *over* the 3 sites in the altitudinal sequence. The use of these lines is likely to enhance the role of lotus in tussock grassland pasture systems.

Within white clover, a hybrid line C5413. which has been included in the pre-release Southern white clover cultivar G26, performed well, indicating that it has wide adaptability for both fertile lowland and low-fertility hill and high country situations on the southern South Island. The Southland Selection C5844, which is derived from Southland ecotypes, had the best combination of attributes for the East Otago Plateau.

This selection merits serious consideration for release as a 'Tahora-like' cultivar for moist, infertile hill and high country in the southern South Island.

Keywords: Trifolium *repens*, *Lotus* pedunculatus. evaluation, herbage yield, spread, dominance, frost damage, South Island.

INTRODUCTION

'Grasslands Huia' white clover (Trifolium *repens* L.) has been the traditional pasture legume used for tussock grassland development. Recently, however, breeding and selection have focused more on the identification and development of plants for specific regions, environments and farming systems. The release of 'Grasslands Tahora' white clover is tangible evidence of this approach. Tahora has shown greater production and persistence than Huia and 'Grasslands Pitau' when hard grazed on wet infertile North Island hill country (Williams et a/. 1982) and when Set stocked at high stocking rates on fertile lowlands (Brock 1988). Similarly, 'Grasslands Maku' lotus *(Lotus pedunculatus* Cav.) has been identified as an alternative to conventional clovers on moist, acid and infertile tussock grassland soils (Scott & Mills 1981). Although not bred specifically for this environment (Barclay & Lambert 1970), Maku lotus is well suited edaphically to these areas, although the usefulness of this tetraploid cultivar is restricted in some high country environments and management systems (McIntosh et *al.* 1984; Wedderburn & Lowther 1985; Keoghan 8 Burgess 1987).

This paper reports on the performance of 55 lotus and 33 white clover cultivars and lines of diverse type and origin, on acid and infertile soils in an altitudinal sequence of increasing severity of climate on the East Otago Plateau. Of greatest importance were Grasslands lotus cultivars and selections, and hybrids and selections from the white clover regional breeding programme for Southland (Widdup 1985; Widdup 8 Boleyn 1986; Widdup 8 Hickey 1989). The performance of red clover *(Trifolium pratense* L.) and birdsfoot trefoil *(Lotus corniculatus* L.) in this

trial helps place some aspects of lotus and white clover performance into better perspective.

MATERIALS AND METHODS

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

Table 1: Soil and climatic characteristics of three sites representing an altitudinal sequence on the East Otago Plateau

	Waipori	Castle Dent	Ailsa Craig
Altitude(m)	500	750	1050
Soils			
pH	4.7	4.6	4.6
Olsen P (µg/ml)	7	3	6
SO_4-S (µg/g)	13	7	6
Climate[1] (Dec - April, 1988)			
Mean soil temperature (°C)	11.0	10.4	9.7
Mean air temperature (°C)	9.7	8.8	7.7
Days of frost	9	26	34

[1] Invermay Agricultural Centre Radio Telemetry System

At each site, the 55 *Lotus pedunculatus* and 33 white clover (*Trifolium repens*) lines formed part of a trial of 169 lines of a wide range of legume species, arranged in rows in each of 4 replicates in a 13 x 13 lattice design to reduce intra-replicate variation. Resident vegetation was removed with glyphosate along a narrow planting strip. Nodulated seedlings, inoculated with a recommended strain of *Rhizobium,* were transplanted into the sites during spring/early summer 1983/84 in 8-plant rows, 30 cm apart between plants, 2 m between rows. The trial areas received basal lime (1 .O t/ha) and molybdate superphosphate (250 kg/ha, 9% P and 11% S) in the first year and maintenance superphosphate (125 kg/ha) in the succeeding years.

Rows were assessed visually for vigour, legume dominance and frost damage and rhizome or stolon spread was measured (plant diameter at 4 points chosen at random along each plot). Herbage DM yield was determined from a 30 cm wide strip cut along the full 2.4 m length of each row. In the first 3 full seasons of growth, plots were trimmed with a mower immediately after yield assessment. In 1986/87 the trial areas were mob grazed with sheep after yield assessment. The number of harvests varied with site from 3 at Waipori to 2 at Castle Dent and Ailsa Craig.

The 55 lotus accessions represented a broad range of origins and types from mild Mediterranean climatic zones to cool temperate, from NZ (16), Australia (1), Mediterranean and mid Europe (22), Chile and Argentina (11) and USA (5). The NZ lines included Maku (4n), 2 selections from within Maku for more rapid germination at low temperature (Selections 1 & 2), G4703 (2n) and G4704 (2n) with Mediterranean parentage and G4701 (2n) and G4702 (4n), selections based only on NZ material.

White clover accessions also represented a wide range of origins, including 8 crosses with Southland ecotype parentage (Table 2).

Table 2: Description of white clover cultivars and lines (from Widdup, pers. comm)

Morphological Group	Cultivar/Line	Origin
A	C4143 cv. Tamar	Netherlands
	C5062 cv. G. Kopu	New Zealand
	C2526 cv. Haifa	Israel
	C5067 cv. Aran	ireland
	C4216 Portugal x Huia	New Zealand
	C4264 UK x Huia	New Zealand
	C4854 cv. Clarence Valley	Australia
	C4140 cv. Crau	France
	C-4254 Germany x Huia	New Zealand
	C4255 Italy x New Zealand	New Zealand
	C5066 cv. Donna	England
	C4954 cv. G. Pitau	New Zealand
	C4227 France x Huia	New Zealand
B.	C2118 cv. Blanca RVP	Belgium
	C5413 Huia x Ararata	Southland
	C320	New Hampshire via Australia
	C4280 Denmark x Huia	New Zealand
	C5396 Huia Parent x Lumsden	Southland
	C4852 cv. G. Huia	New Zealand
	C2127 cv. Kersey	England
	C2416 cv. S100	England
	C5394 Huia Breeders x Merino Downs	Southland
C.	C5471 (Hill Country x Huia) x Wyndham	Southland
	C5452 Tahora x Wendonside	Southland
	C5000 cv. G. Tahora	New Zealand
	C5643 Southland Selection 1	Southland
	C5644 Southland Selection 2	Southland
	C5446 Te Awa x Hokonui	Southland
	C2417 cv. S164	England
	C3754 Kent Wild White	England
	[a]C2098 cv. Trevise	France
	C2771	Italy/USA
	c2779	Italy/USA

Group A = very large leaves, big stolons and erect growth habit — low morphological score
Group B = medium leaves, average stolon numbers — medium morphological score
Group C = very small leaves, many stolons and prostrate growth habit — high morphological score
[a] Trevise, C2771, C2779 not grouped in morphological sequence.

RESULTS AND DISCUSSION

Annual herbage yields

The mean of lotus out-yielded white clover by 55% (Table 3). The yield difference between the two species was highest at the low and mid altitude sites (62 and 87% respectively) but only 28% at the highest site. Highest ranked white clover swards were similar in yield to lowest ranked lotus swards. Among the lotus lines, G4701, G4702 and a selection from within Maku for rapid germination at low temperatures, produced the highest yields averaged over the three sites and were highly ranked at each site. Among the white clover lines, C4264, an F, hybrid between Huia and UK material, C5413, a hybrid between Huia and a local ecotype, used in the pre-release Southern cultivar G26 (Widdup et al. 1989), and a 'Tahora-type' selection from 66 Southland ecotypes (Selection 2), ranked highest for yield.

Table 3: Annual yields of *Lotus pedunculatus* and *Trifolium repens* (kg DM/ha) for 3 sites over 2 seasons

L pedunculatus Cultivar or line	DM (kg/ha)	*T. **pens* Cultivar or line	DM (kg/ha)
Maku	2640 (10)	Huia	1450 (20)
Maku Selection 1	3290 (1 =)	Tahora	1430 (22)
Maku Selection 2	2680 (6)	Kopu	1290 (27)
G4703 (x NZ)	2960 (4)	Pitau	1500 (17)
G4704 (x Port.)	2100 (35)	Southland 1	1520 (15=)
G4701	3180 (3)	Southland 2	1690 (3)
G4702	3290(1=)	c5413	1810 (2)
S1961 (Yugoslavia)	2930 (5)	C4264	1920 (1)
s1957 (UK)	2870 (6)	Clarence Valley	1110 (32)
S1916 (Chile)	1790 (55)	Haifa	1090 (33)
SED	315	SED	225
		Southland (8)	1510
		Others (25)	1460
		SED	70 N.S.
		Southland (8)	1510
		Others (25)	1460
		SED	70 N.S.
		Group A	1470
		Group B	1560
		Group C	1460
		SED	80 N.S.
Mean of *L pedunculatus*	2280	Mean of *T. repens*	1470 LSD 1% = 130

Values in parenthesis refer to rankings for each species.

G4704 lotus and Kopu white clover, both erect cultivars selected for cool-season activity, produced significantly less herbage DM than the top-ranked lines of their respective species. The free-seeding, cool-season-active Haifa and Clarence Valley were the lowest ranked white cluver cultivars. There was no significant difference between the three morphological groupings of white clover or between the 8 Southland and the other 25 white clover lines.

Legume dominance

The yield advantage for lotus over white clover is further accentuated if sward composition differences between the two species are considered. Visual estimates of legume dominance were made at all sites in 1986/87 (Table 4).

These observations reflect the greater ingress and growth of resident grasses (mainly browntop) in the white clover than the lotus swards; whereas the legume component in white clover swards was on average subdominant by 1986187, lotus was, on average, codominant. Level of dominance increased with increasing severity of climate in both species: 2.8 at Waipori, 3.4 at Castle Dent and 3.9 at Ailsa Craig for white clover, and 3.7, 4.2 and 4.2 for lotus. At each site, the mean for lotus was highly significantly greater than for white clover.

These observations were confirmed by the detailed botanical analyses carried out on Huia, Tahora and Maku in an adjacent trial at each of the 3 sites (Floate et a/. 1989).

Table 4: legume dominance in *L. pedunculatus* and *T. repens* swards for three sites in 1986/87.

L. pedunculatus Dominance (1-5)*		*T. repens* Dominance	
Mean Of *L. pedunculatus* 3.9		Mean Of *T. repens* 3.1 (LSD 1% = 0.12)	
Maku	4.2 (9)	Huia	3.6 (2)
Maku Selection 1	4.2 (1)	Tahora	3.6 (2)
Maku Selection 2	4.2 (8)	Kopu	2.9 (27=)
G4703	4.3 (5)	Pitau	3.1 (17=)
G4704	3.6 (26=)	Southland 1	3.2 (13=)
G4701	4.2 (10)	Southland 2	3.7 (1)
G4702	4.4 (2)	c5413	3.3 (9)
SED	0.27	SED	0.23
		Southland (6)	3.3
		Others (26)	3.1
		LSD (5%)	0.14
		Group A	3.0
		Group B	3.2
		Group C	3.3
		SED	0.06

• 1.0 = Merely present; 2.0 = Frequent; 3.0 = Subdominant; 4.0 = Codominant; 5.0 = Totally dominant. Values in parenthesis refer to rankings for each species.

Table 5: Spring vigour (1966) and autumn yield in 1965 — Waipori

Species/line	Spring vigour (o-5)'	Autumn yield (kg/ha)
L. *pedunculatus* mean	1.0	530
T. *repens* mean	1.2	90
LSD (1%)	0.1	65
Maku Selection 1	1.5 (2)	890 (6)
G4704	1.4 (3=)	930 (4)
G4701	1.1 (14=)	340 (24)
G4702	1.7 (1)	1000 (3)
SED	0.23	200
Huia	1.2 (16=)	Negligible
Tahora	1.1 (18=)	100 (15)
Kopu	1.6 (1=)	330 (1)
Pitau	1.5 (3=)	200 (5)
Southland 2	1.0 (23=)	Negligible
SED	0.26	110
Southland T. *repens* (6)	0.99	Negligible
Other T. *repens* (25)	1.22	100
LSD 1%	0.20	60
Pawera red clover	4.4 (1)	2190 (1)
St603 L. *corniculatus* (Yugosalvia)	3.3 (1)	1490 (1)
SED (whole trial)	0.31	90

• 0 = lowest — 5.0 = highest vigour
Values in parenthesis refer to rankings within each species:

Group C lines of white clover were significantly more dominant than Group A lines and the 8 'Southland' lines were signficantly more dominant than the other lines as a whole. Southland Selection 2 ranked highest among all white clover lines and Kopu among the lowest. Among the lotus lines, the highest yielding cultivars (Selection 1 and G4702) also ranked highest for dominance.

The results of this trial and that of the adjacent trial (Floate et al. 1989) possibly indicate a more rapid transfer of nitrogen to associated grasses in the white clover swards. Nordmeyer & Davis (1977), for example, showed that in spite of greater total nitrogen in lotus plots, more grass grew in white clover plots for a given amount of legume herbage. Also, because most lotus accessions were taller growing than the white clovers and produced more herbage, they would likely have been more competitive with the grass. Furthermore, grass growth would likely have been enhanced if a grazing regime had been used earlier; Lowther (pers. comm.) has shown that under grazing lotus swards have a much higher proportion of grasses than in these altitudinal sequence trials.

Spring vigour and autumn growth

Both species were similar in spring vigour and were markedly less active than either red clover or highly ranked L. corniculatus lines (Table 5).

Within both species, cool-season-active lines, such as the NZ lotus cultivars and selections, Kopu and Pitau, ranked highly for spring growth. Southland Selections were lowly ranked and Huia and Tahora intermediate.

Similarly, both species were significantly less active in autumn than red clover and highly ranked *L. corniculatus* lines, and again cool-season-active lines ranked highest within both species. Southland selections, Huia and Tahora had negligible autumn growth.

Both species concentrated most of their growth in late spring/summer and in white clover, this pattern was clearly more accentuated in Huia, Tahora and Southland ecotype and hybrid material than in cool-season-active cultivars such as Kopu and Pitau.

Within Grasslands lotus cultivars and selections, this pattern was clearly most accentuated in G4701. Lotus, particularly Grasslands cultivars and selections, was markedly more active than white clover in autumn, but both species and *L. corniculatus*, too, were highly vulnerable to severe herbage losses from late autumn frosting. In autumn 1986 herbage from white clover swards was almost totally destroyed by frosting, and was greatly reduced in both lotus species. By contrast, red clover lines showed high frost tolerance at this time, with Pawera and G22 producing more than 1200 kg DM/ha.

Summer frost damage

Lotus and white clover were susceptible to herbage damage from summer frosts. Mean levels of damage were very similar for both species but there were significant differences within species. Cool-season-active cultivars and lines of white clover such as Kopu tended to be more susceptible than those with low cool-season activity such as the Southland white clover selections Within lotus, Grasslands cultivars and selections with Mediterranean parentage such as Maku and G4704 were more susceptible than those based only on New Zealand material (4701 and 4702), and diploids were usually less susceptible than their tetraploid equivalents. Since both the middle and highest sites have a high frequency of out-of-season frosts, the probability of herbage losses is accordingly high.

Plant spread

Measurements of plant diameter in lotus at the 3 sites (Keoghan & Burgess 1987) showed that rate of rhizome spread declined markedly with increasing severity of climate. Mean plant diameter in autumn 1986 declined from 1.65 m at

Table 6: Mean diameter of L. *pedunculatus* and *T. repens* plants in autumn 1988

	Mean plant diameter(m)	
Cultivar/Line	Castle Dent (750 m)	Ailsa Craig (1050 m)
L *pedunculatus* mean	1.3	0.6
T. *repens* mean	1.2	0.7
LSD	N.S.	N.S.
Maku	0.8 (54)	0.6 (24=)
Maku Selection 1	0.9 (51)	0.5 (44=)
G4703	0.8 (52=)	0.8 (24=)
G704	0.5 (55)	0.3 (55)
G4701	1.2 (41=)	0.7 (18=)
G4702	1.2 (37)	0.5 (34=)
SED	0.21	0.24
Huia	1.5 (7)	0.6 (17=)
Southland 2	1.7 (2)	1.1 (2)
Tahora	1.2 (14)	0.7 (15=)
Kopu	1.1 (21=)	0.5 (28=)
Pitau	0.7 (33)	0.5 (25=)
c5413	1.3 (13)	0.8 (10=)
SED	0.25	0.24
Southland (6)	1.4	0.9
Others (25)	1.1	0.6
LSD 1%	0.21	0.18
Group A	1.1	0.6
Group B	1.2	0.7
Group C	1.5	0.9
SED	0.09	0.08

Values in parenthesis refer to rankings within each species.

Waipori, to 1.22 m at Castle Dent and 0.59 m at Ailsa Craig. Measurements at Castle Dent and Ailsa Craig in autumn 1988 indicated that there were close parallels between the 2 species (Table 6).

There was no significant difference in mean spread between the two species at either site but the decline was greater in the lotus. NZ lotus cultivars with Mediterranean parentage (Maku, Maku selections, G4703 and G4704) and the cool-season-active white clover cultivars Pitau and Kopu were lowly ranked for spread at both sites. The white clover Southland Selection 2 ranked highly for spread at both sites. There was a highly significant positive correlation between morphological score and spread in white clover.

When swards were visually scored with an index that combined spread and cover density, mean values were 1.47 for Group A, 1.88 for Group B and 2.36 for Group C (SED = 0.12) where 1 .0 is very poor spread and cover, 2.0 moderate and 3.0, very good spread and cover.

CONCLUSIONS

Among the 55 ***L pedunculatus*** cultivars and lines, G4701 showed the best overall combination of productivity, spread and frost tolerance. G4701, its tetraploid

equivalent G4702 and a selection from within Maku for rapid germination at low temperatures were the highest ranked cultivars for yield over the three sites and were highly ranked at all sites. This confirms earlier results (Keoghan & Burgess 1987) and reinforces their conclusion that the use of these lines is likely to enhance the role of lotus in tussock grassland pasture systems.

Results from these trials, together with those from lowland areas (Widdup & Boleyn 1986; Widdup et al, 1989) indicate that hybrid white clover material such as C5413 (Huia x Ararata) has wide adaptability for both fertile lowland situations and low-fertility hill and high country in the south of New Zealand. C5413 is part of the pre-release Southern cultivar G26 (Widdup et al. 1989).

Among the 33 white clover cultivars and lines, Southland Selection 2(C5844), which was derived from 66 Southland ecotypes (Widdup 8 Boleyn 1986), had the best combination of attributes for the East Otago Plateau environment. This selection merits serious consideration for release as a 'Tahora-type' cultivar for moist, infertile hill and high country pastures in the southern South Island.

Acknowledgements

Most of the cultivars and lines described in this paper were supplied by Grasslands Division of DSIR. The authors gratefully acknowledge the help from Grasslands Division scientists, Margot B. Forde and Keith H. Widdup.

References

Barclay, P.C.; Lambert, J.P. 1970. The breeding and testing of Lotus *pedunculatus* Cav. in New Zealand. *Proceedings XI International Grassland Congress: 278-81.*

Brock, J.L. 1988. Evaluation of New Zealand bred white clover cultivars under rotational grazing and set stocking with sheep. *Proceedings* NZ *Grassland Association* 49: 203-206.

Floate, M.J.S.; Enright, P.D.; Woodrow, KE. 1987. Effects of time and altitude on the performance of pastures based on six alternative legumes for aid tussock grasslands. Proceedings NZ Grassland Association 50:

Keoghan. J.M.; Burgess, R.E. 1987. The search for an improved Lotus *pedunculatus* for high country pastoral systems *Proceedings NZ Grassland Association 48:* 125-29.

McIntosh, P.D.; Enright, P.D.; Sinclair, AG. 1984. Fertilisers for Lotus and clover establishment on a sequence of acid soils on the east Otago uplands. NZ *journal of experimental agriculture 12:* 119-29.

Nordmeyer, AH.; David, M.R. 1977. Legumes in high country development *Proceedings NZ Grassland Association 38:* 119-25.

Scott, R.S.; Mills, E.G. 1981. Establishment and management of Grasslands Maku Lotus *in* acid, low-fertility tussock grasslands. Proceedings NZ Grassland Association 42: 131-41.

Wedderburn. M.E.; Lowther, W.L. 1985. Factors affecting establishment and spread of Grasslands Maku lotus in tussock grasslands. *Proceedings NZ Grassland* Association 46: 97-101.

Widdup, KH.; Boleyn, J.M. 1986. Improved performance from screening and hybridising of white clover germplasm in Southland. NZ Agronomy Society Special Publication No. 5: 301-305.

Widdup, KH.; Hickey, M.J.; Stevens, D.R.; Ryan, O.L. 1989. A white clover bred for southern regions *Proceedings NZ Grassland Association 50:*

Williams, W.M.; Lambert, M.G.; Caradus, J.R. 1982. Performance of a hill country white clover selection. *Proceedings NZ Grassland Association 43:* 188-95.