Suitability of new subterranean clovers in the Canterbury region

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Abstract

The annual legume, subterranean clover, is adapted to permanent pastures in the summer drought-prone areas of eastern New Zealand. Dry summers over the last decade in Canterbury have renewed the interest from farmers in the use of sub clover. As the previously used cultivars Mt Barker and Tallarook are no longer available, a trial was established at AgResearch Templeton to evaluate a new series of cultivars and breeding lines from Australia together with recent New Zealand selections. The lines were sown in rows in May 1993 and assessed for seed set, autumn seedling regeneration and spring growth under sheep grazing for 4 years.

The new Australian cultivars had improved seed set and consistently better seedling regeneration and herbage yield compared with older cultivars. The late-flowering, small-leaved and densely branched types were best adapted to the Canterbury environment. The late-maturity cultivars Denmark and Leura, selected from Sardinian germplasm, re-established 50% more seedlings and produced 25% greater late winter/ spring growth than Mt Barker and Tallarook in the third year. The New Zealand selection Ak 948 had similar performance to Denmark and Leura but the remaining selections were mediocre by the fourth year. The Sardinian ecotype breeding material appeared well-adapted to Canterbury conditions and future cultivars based on this material may be most suitable. Further trials are required in harsher sites to confirm these cultivar recommendations.

Keywords: Australian cultivars, dry regions, herbage yield, seedling regeneration, subterranean clover, *Trifolium subterraneum*

Introduction

Subterranean clover (*Trifolium subterraneum)* is a winter-active annual legume adapted to permanent pastures in the summer drought-prone areas of eastern New Zealand where it has a role in finishing lambs during late winter/spring. Sub clover was widely sown in these summer-dry regions in the 1940s, mainly with the Australian cultivars Mt Barker and Tallarook, but only spasmodically since (Suckling *et al.* 1983). Lack of new sowings, repeated droughts and poor grazing management has resulted in the current low proportions of sub clover in pastures and uneven distribution across regions.

Extensive evaluations of Australian-bred sub clover cultivars throughout summer-dry hill country regions in the late 1980s (Chapman *et al.* 1986; Sheath & MacFarlane 1990; Williams *et al.* 1990) showed the unsuitability of early-flowering cultivars for New Zealand climatic and grazing conditions. Late-flowering types such as cv.Tallarook, which were prostrate and densely branched showed better reseeding, regeneration and herbage yields across most sites, although the mid-flowering cultivars Woogenellup and Nangeela were best adapted to the dry hill country of North Canterbury (Hoglund 1990). Tallarook has high oestrogen content that can pose fertility problems in breeding livestock and recent Australian programmes have aimed at selecting sub clovers with low formononetin levels. Tallarook and Mt Barker are now regarded as outclassed cultivars and are no longer available from Australia.

In recent years, a large pool of genetic material has been developed in Australian programmes and the late maturity group contains new material and recently bred cultivars of potential value to New Zealand conditions. Within New Zealand, a breeding programme using sub clover populations collected from the North Island hill country has identified a number of lines suitable for development of a cultivar adapted to summer-dry hill country (Dodd *et al.* 1995a). However, at this stage the New Zealand selections are not commercially available.

The objective of the study was to evaluate the most recent cultivars and breeding lines from Australia, to compare with the locally selected North Island material and provide information on the most suitable sub clover for use in summer-dry regions of the South Island.

Material and methods

Genetic material

The genetic material consisted of 15 Australian cultivars, 100 mid-late flowering lines from the

Australasian Subterranean Clover and Alternative Legume Programme (ASCALIP), and five New Zealand selections developed at Whatawhata and Palmerston North (Table 1). Cultivars bred prior to 1980 were classed as old and those after 1980 as new. The 100 Australian breeding lines were divided into those developed from Australian germplasm (82), Mediterranean ecotypes (10) and Sardinian ecotypes (8). Sub clovers are categorised by flowering date, which is also indicative of the earliness or lateness of the spring peak in growth. The subspecies *subterraneum* are best adapted to free-draining loams and sands, subsp. *yanninicum* to winter waterlogged soils and subsp. *brachycalycinum* to alkaline soils.

Table 1 The Australian breeding lines/cultivars and New Zealand selections of *T. subterraneum* planted at Templeton, Canterbury with associated flowering time and plant morphology.

Line/selection	Subspecies	Flowering date[1]	Plant morphology[2]
Breeding lines (82)[3]	*subterraneum*	Mid-late 1–19 Oct	1.5–3.75
Mediterranean ecotypes(10)	*subterraneum*	Mid-Late 10–26 Oct	3.00–3.75
Sardinian ecotypes (8)	*subterraneum*	Mid-late 5–24 Oct	3.5–4.5
Whatawhata WS 536	*subterraneum*	Late 24 Oct	3.5
Whatawhata WS 1737	*subterraneum*	Late 24 Oct	3.5
Whatawhata WS 1801	*subterraneum*	Late 18 Oct	3.25
Palmerston North Ak 920	*subterraneum*	Late 24 Oct	3.25
Palmerston North Ak 948	*subterraneum*	Late 15 Oct	4.25
Australian cultivars			
Dalkeith 1983[4]	*subterraneum*	Early 13 Sep	2.0
Seaton Park 1967	*subterraneum*	Early 24 Sep	1.75
Trikkala 1976	*yanninicum*	Early 26 Sep	2.5
Gosse 1992	*yanninicum*	Mid 8 Oct	2.25
Junee 1984	*subterraneum*	Mid 10 Oct	3.0
Woogenellup 1960	*subterraneum*	Mid 10 Oct	1.75
Clare 1955	*brachycalycinum*	Mid 10 Oct	1.5
Mt Barker 1920	*subterraneum*	Mid-late 12 Oct	2.75
Goulburn 1991	*subterraneum*	Mid-late 12 Oct	3.75
Karridale 1984	*subterraneum*	Mid-Late 14 Oct	2.5
Nangeela 1930	*subterraneum*	Late 16 Oct	2.5
Denmark 1991	*subterraneum*	Late 16 Oct	3.5
Larisa 1970	*yanninicum*	Late 20 Oct	2.5
Leura 1991	*subterraneum*	Late 23 Oct	3.25
Tallarook 1930	*subterraneum*	Late 26 Oct	3.75

[1] Date of the start of flowering at Templeton in 1993
[2] 1=open, large leaved – 5 = dense, small leaved
[3] Number of lines
[4] Year of release

The evaluation trial was situated at Templeton, Canterbury on a light Eyre soil with an Olsen P level of 12 and pH 5.8. In April 1993 the trial area was sprayed with glyphosate, cultivated and the sub clover lines drilled with a Hege91 precision seeder on 5 May 1993. All lines were inoculated with a recommended subterranean clover *Rhizobium* strain then 1 g of seed was drilled in a 2 m row with 1 m between rows. The trial was a randomised block design with five replications.

Trial management

Following establishment over autumn/winter 1993, the plots were rotationally grazed with sheep at monthly intervals in the spring. In 1994 and 1996, the trial was rotationally grazed in autumn/winter and set stocked in the spring. In March 1995, the trial was direct drilled with Kara cocksfoot to form a pasture sward. Plots were rotationally grazed in spring 1995 so that herbage DM assessments could be made from selected plots.

Seed set was assessed from eight, 5-cm-diameter cores taken from all plots across three reps in late January 1994. The % hardseed was estimated from this sample as the ungerminated seed following incubation on moist filter paper at 20°C. In 1994–1996, seedling regeneration was assessed during March/April using a visual score. Throughout the trial duration, vigour of the lines was visually scored prior to grazing with approximately five grazings/ year. Herbage DM yield was cut in late winter/spring 1995 (August, October, November) from a set of lines representative of the range of herbage yields. Regression analysis was then used to provide an estimate of DM yield from the vigour scores of other plots obtained at those times.

Results and discussion

Climate

Climate recordings were from the Lincoln station, 15 km from Templeton. The moist conditions during autumn–spring 1993 (Table 2) ensured good establishment of the sub clover lines. Moist conditions in autumn 1994 were also conducive to seedling regeneration but from spring 1994 through to regeneration in autumn 1995, rainfall was less than half the long-term mean. These dry conditions provided a challenging test for the seed

Table 2 Seasonal rainfall (mm) from autumn 1993–summer 1996 and long-term mean seasonal rainfall at Lincoln.

	Autumn	Winter	Spring	Summer	Annual
Rainfall 1993/94	190	65	195	190	640
Rainfall 1994/95	146	177	98	82	503
Rainfall 1995/96	89	234	154	63	540
Rainfall 1996/97	160	215	85	170	630
Long-term Rainfall	190	173	147	170	680

setting and seedling regeneration capacity of the lines in the third year.

Flowering and plant type

The Australian cultivars flowered over a 6-week period starting from 13 September with Dalkeith and ending on 26 October with Tallarook (Table 1). The pattern was similar to that recorded in Australia but 2–3 weeks later (Dear & Scandral 1997). The mid-flowering cultivar Junee was bred as a replacement for the older Woogenellup, and the new mid-late flowering cultivars Goulburn, Denmark and Leura (all selected from Sardinian ecotype material) as replacements for Mt Barker and Tallarook. The New Zealand selections were all late-flowering, similar to Tallarook which has been promoted as the preferred ideotype for New Zealand conditions (Chapman *et al.* 1986; Dodd *et al.* 1995a).

The early- and mid-flowering cultivars were large leaved and open in plant type (Table 1). The older mid and late-flowering cultivars Mt Barker, Nangeela and Larisa were intermediate in plant type whereas the new cultivars Goulburn, Denmark and Leura were small-leaved and dense, closer in type to Tallarook and the New Zealand selections. Previous research has shown the importance of the dense, small-leaved habit for persistence under the grazing practices used in New Zealand (Chapman & Williams 1990). At Whatawhata in the North Island, Dodd *et al.* (1995b) reported Denmark and Leura as larger leaved and more open compared with New Zealand selections. Possible reasons for the difference in plant habit of these cultivars in the Canterbury trial could be the expression of a more compact habit in a cooler environment and/or the lack of expression of the dense characteristic of New Zealand selections under the moderate grazing management in this trial. The Sardinian ecotypes were collected from areas where continuous grazing by sheep and goats was practised (P. Nichols, pers. comm.) and these types were consistently small-leaved and dense (Table 1).

Seed set and seedling regeneration

The ability to regenerate a new seedling population each year is critical to the success of sub clover. Most of the cultivars/lines produced moderate-high seed quantities in the first spring (Table 3). The new cultivars Junee, Goulburn, Karridale and Denmark, three of the New Zealand selections and the Sardinian ecotypes developed very high seed yields. The only exception amongst the new cultivars was Leura, which produced low seed yields together with most of the older cultivars including Mt Barker. All the lines showed low-moderate levels of hardseededness (Table 3) which suggested that re-establishment of the population every autumn was mostly dependent on seed set the previous spring.

Table 3 Seeds/m^2,% hardseed and seedling regeneration (relative to Mt Barker=100) of *T. subterraneum* lines/cultivars at Templeton, Canterbury.

Line/selection	Seeds/m^2 Jan 1994	% Hardseed Feb 94	Regeneration Apr 1994	Regeneration Mar 1995	Regeneration Mar 1996
Breeding lines (82)	9200	18	94	93	98
Mediterranean ecotypes(10)	9900	19	85	99	101
Sardinian ecotypes (8)	12400	18	98	111	147*
Whatawhata WS 536	10950	19	132	113	88
Whatawhata WS 1737	10300	19	105	78	69
Whatawhata WS 1801	23500	28	109	100	38
Palmerston North Ak 920	12000	19	123	113	106
Palmerston North Ak 948	25400	21	115	126	144*
Australian cultivars					
Dalkeith	1800	10	55	74	31
Seaton Park	6350	10	105	70	44
Trikkala	10300	16	100	91	50
Gosse	9700	31	82	87	63
Junee	14200	29	118	109	138*
Woogenellup	4200	18	105	96	100
Clare	1500	2	77	65	44
Mt Barker	5100	20	100	100	100
Goulburn	15300	17	95	78	94
Karridale	13900	18	127	87	113
Nangeela	9700	13	140	96	113
Denmark	19300	27	118	126	156*
Larisa	4300	12	86	104	50
Leura	5000	6	68	91	169*
Tallarook	9900	19	136	109	106
LSD(5%)	7200	16	31	42	62

* Lines showing improvement over time

Most lines regenerated high numbers of seedlings in April 1994, but over the next 2 years seedling regeneration of some cultivars/lines deteriorated compared with the standard Mt Barker (Table 3). In particular, the cultivars with earlier flowering and an open plant habit showed poorer seedling regeneration by the fourth year. These open types were more severely grazed by sheep reducing shoot density and therefore reducing the potential to flower and set seed, leading to a progressive decline of the sub clover population.

The late-flowering and small-leaved, dense cultivars Denmark and Leura, the Ak 948 selection and Sardinian ecotypes all showed improved seedling regeneration over time compared to Mt Barker (Table 3). Even though the 1994/95 season was dry, the late-flowering types showed the best regeneration capability over time. There was some contradiction with Leura showing poor seed set and seedling regeneration in 1994 but excellent regeneration in 1996. The low levels of hardseededness, together with a moist autumn in 1996, may explain the good seedling regeneration in Leura plots that year. However, in the long term, Leura may be vunerable in consistently dry environments.

The mid-flowering Junee (a replacement for Woogenellup) also showed improvement and may be useful in the sunny, north-facing hill country regions of Canterbury where the occurrence of early spring droughts would favour earlier seed set. Hoglund (1990) previously promoted the use of Woogenellup based on the performance at the dry North Canterbury Carvossa site.

Herbage yield

All the sub clover lines produced good spring growth in the establishment year except for the early flowering Dalkeith that did not capitalise on the longer growing season (Table 4). During 1994–1995, cultivar performance was highly correlated to flowering time ($r=0.7$ $P<0.001$) with the late-flowering material producing the greatest growth and yield. However, in 1996 and 1997, the correlation was not significant ($r=0.3$ ns) and growth was more variable. Factors such as seed set, ability to survive false strikes, shoot density, and seedling regeneration, all influenced the long-term persistence of the sub clovers.

Over the 4 years, the late-flowering cultivars Denmark, Leura and Nangeela (which is no longer commercially available) produced and maintained the greatest yields (Table 4). Even during the winter-early spring period when growth is important on dry Canterbury hill country, these three late-flowering cultivars continued to produce the greatest yields. The best non-cultivar lines were the Palmerston North selection Ak 948 and the Sardinian ecotypes. The poor performance of the Whatawhata selections relative to Australian material was surprising given the high regeneration ability and herbage yields in North Island trials (Dodd *et al.* 1995a). It is possible the Whatawhata selections are not well-adapted to the lower temperatures and rainfall of the South Island. In addition, the moderate grazing management in this trial allowed the Australian material to express its full potential. Further studies are required, particularly on dry hill country sites and with harder grazing management, as there are risks in making recommendations from one trial.

Table 4 Spring vigour scores (relative to Mt Barker=100) and winter/spring herbage yield (kgDM/ha) of the *T. subterraneum* cultivars/lines evaluated in Canterbury from 1993–1997.

Line/selection	Vigour Nov 1993	Vigour Nov 1994	kg DM/ha Jun–Nov 95	Vigour Sep 1996	Vigour Sep 1997
Breeding lines (82)	135	82	5410	85	75
Mediterranean ecotypes(10)	150	109	5630	70	60
Sardinian ecotypes (8)	170	120	6770	105	90
Whatawhata WS 536	170	145	6050	65	65
Whatawhata WS 1737	115	70	4860	45	25
Whatawhata WS 1801	170	78	6060	80	80
Palmerston North Ak 920	220	90	6810	85	70
Palmerston North Ak 948	170	145	6920	130	135
Australian cultivars					
Dalkeith	60	33	2580	40	35
Seaton Park	130	55	4350	60	50
Trikkala	140	45	4885	85	80
Gosse	120	70	4950	75	65
Junee	150	100	5820	85	85
Woogenellup	100	90	5325	100	80
Clare	125	80	2930	35	35
Mt Barker	100	100	5950	100	100
Goulburn	170	80	6070	95	55
Karridale	170	120	6800	110	105
Nangeela	160	135	7660	120	120
Denmark	170	122	7370	130	100
Larisa	140	135	5485	70	35
Leura	200	165	7170	110	120
Tallarook	190	122	6700	80	100
LSD(5%)	65	55	1950	33	45

Currently, a cultivar bred for commercial use in New Zealand would require the seed industry to develop production capacity with new equipment and technology. Local useage of sub clover would need to increase substantially for a New Zealand cultivar to be economic to produce. The only practical choice available to farmers wanting to use sub clover is to sow Australian-developed cultivars. For the South Island, the new late-flowering cultivars appear to have some potential but in the North Island, these cultivars are not appropriate (Dodd *et al.* 1995a,b) although wider testing in the North Island East Coast is warranted.

Conclusions

1. The new Australian cultivars had improved seed set, seedling regeneration and herbage yield in the Canterbury environment compared to the older cultivars such as Mt Barker and Woogenellup.
2. The late-flowering types with small leaves, dense crowns and tolerance of moderate-high grazing pressure were best adapted. With the popular old cultivar Tallarook no longer available, Denmark and Leura are recommended. Further testing in drier sites is required to test the wider applicability of these new cultivars.
3. The new late-flowering Australian cultivars equalled or surpassed the performance of the North Island selections in the Canterbury trial.
4. Sardinian material appears to be adapted to the cool, dry Canterbury conditions and future Australian cultivars based on this germplasm are likely to be most suitable.

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REFERENCES

Chapman, D.F.; Sheath, G.W.; MacFarlane, M.J.; Rumball, P.J.; Cooper, B.M.; Crouchley, G.; Hoglund, J.H.; Widdup, K.H. 1986. Performance of subterranean and white clover varieties in dry hill country. *Proceedings of the New Zealand Grassland Association 47*: 53–62.

Chapman, D.F.; Williams, W.M. 1990. Evaluation of clovers in dry hill country. 8. Subterranean clover at “Ballantrae”, New Zealand. *New Zealand Journal of Agricultural Research 33*: 569–576.

Dear, B.S.; Sandral, G.A. 1997. Subterranean clover in NSW – identification and use. *In*: AGFACTS, NSW Agriculture. Agfact P2.5.16.

Dodd, M.B.; Sheath, G.W.; Richardson, S. 1995a. Development of subterranean clover (*Trifolium subterraneum* L.) genotypes for New Zealand pastures. 1. Whatawhata persistence evaluation. *New Zealand Journal of Agricultural Research 38*: 33–47.

Dodd, M.B.; Sheath, G.W.; Richardson, S. 1995b. Development of subterranean clover (*Trifolium subterraneum* L.) genotypes for New Zealand pastures. 3. Whatawhata production evaluation. *New Zealand Journal of Agricultural Research 38*: 57–63.

Hoglund, J.H. 1990. Evaluation of clovers in dry hill country. 10. Subterranean clover in North Canterbury, New Zealand. *New Zealand Journal of Agricultural Research 33*: 585–590.

Sheath, G,W.; MacFarlane, M.J. 1990. Evaluation of clovers in dry hill country. 3. Regeneration and production of subterranean clover at Whatawhata, New Zealand. *New Zealand Journal of Agricultural Research 33*: 533–539.

Suckling, F.E.T.; Forde, M.B.; Williams, W.M. 1983. Naturalised subterranean clover in New Zealand. *New Zealand Journal of Agricultural Research 26*: 35–43.

Williams, W.M.; Sheath, G.W.; Chapman, D.F. 1990. Evaluation of clovers in dry hill country. 1. General objectives and description of sites and plant material. *New Zealand Journal of Agricultural Research 32*: 521–526.

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