Development of white clover (*Trifolium repens* L.) cultivar Grasslands Challenge (G23)

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Abstract

Grasslands Challenge (Trifolium repens L.) white clover was developed to incorporate potential growth benefits, and disease resistance, in two double cross hybrids (Mediterranean × New Zealand) identified in evaluations at Kaikohe. Thirty-three elite selections of hybrids and New Zealand material were polycrossed for seed production. Progeny testing resulted in 27 parental lines with improved resistance to leaf disease and stem nematode (Ditylenchus dipsaci) relative to Grasslands Pitau. Testing of the maternal lines for seedling characteristics resulted in the deletion of one parent. A bulk line was evaluated in mini plots, and a hill country grazing trial, and showed improved growth to the control. In a grazing trial conducted in the Manawatu, Challenge showed outstanding winter production. The selection has a high stolon density in combination with a medium to large leaf size. This will allow Challenge to recover quicker from drought stress and grazing pressure. The plant type and early results indicate Challenge will be best suited to a rotational grazing management, particularly in regions where significant cool-season growth occurs. Plant Variety Rights were granted in 1997, and commercial seed should be available in 1998.

Keywords: Grasslands Challenge, leaf disease, Mediterranean hybrids, stem nematode, *Trifolium repens*

Introduction

White clover (*Trifolium repens* L.) is the most important pasture legume growing in northern New Zealand, providing improved feed quality and nitrogen fixation for grass growth. Cool-season growth and disease resistance have been identified as the major improvements needed in white clover lines grown in Northland (Cooper & Williams 1983). The use of Mediterranean germplasm has already been shown to significantly improve the performance of clover growth in regions with relatively mild winters (Goold & Douglas 1976).

At Kaikohe, Lambert *et al.* (1969) showed that Grasslands Pitau had a higher production potential than Grasslands Huia. Summer-growing Ladino material crossed with Pitau has been used to breed Grasslands Kopu for intensively grazed lowland pastures (van den Bosch *et al.* 1986). The cultivar Grasslands Challenge was developed to further improve the disease tolerance and cool-season clover production of a large-leaved variety.

Materials and methods

Breeding

Challenge white clover was bred from material identified in two trials conducted in 1976 and 1978 at the AgResearch Kaikohe station which evaluated 120 accessions of overseas and New Zealand white clovers compared with Pitau and controls. Two double cross hybrids (Mediterranean × Huia, C2156, C2164) provided excellent cool-season production, with some improvement in spring and summer growth and good tolerance to stem nematode (Ditylenchus dipsaci) and clover rust (Uromyces trifolli). In 1980, it was decided to develop an improved white clover line based on the performance of the two hybrid lines, and to include some adapted New Zealand material. In 1981, 26 elite plants from the two Mediterranean hybrid lines C2156 and C2164, and four Pitau stem nematode resistance selection C3344, and three Huia re-selection C2872 were selected on their good agronomic performance and polycrossed for seed production at Kaikohe in summer 1981/82. After progeny testing, a bulk (C6712) was made of the 27 parents, which was later used for evaluations.

In 1992, 20 plants from each of the parent lines were evaluated at Lincoln for seed production characteristics of uniformity, leaf size, flowering and potential seed yield. One parent did not meet the requirements for the cultivar in terms of leaf size or disease resistance and was deleted. The best four plants from each line were evaluated for seed yield and in 1993 a single plant was chosen from each of the 26 lines and used as the base for procuring nucleus seed in 1994/95. Seed supply will be maintained from these 26 families.

Progeny testing

A trial was planted in autumn 1982 at Kaikohe on an alluvial soil (Wairoro clay loam) with 43 lines replicated 6 times in randomised blocks. Plots consisted of 2 rows of 5 plants, spaced 30 cm within rows, 60 cm between rows and 90 cm between plots. After an establishment period the trial was grazed quickly using a high sheep density 18 times over a 4-year period. Before each grazing, individual plants were visually assessed for total herbage mass on a 0–5 scale, relative to Pitau control. Incidence of pests and disease and leaf sizes were recorded during the winter in 1983.

Mini plot trial

In mid April 1986, a trial of C6712 (Challenge) and 12 other lines (Table 2) was planted adjacent to the progeny test area. Mini plots of 5×5 plants 10 cm apart were established by inserting glasshouse raised clover plants into a paraquat-sprayed grid. Resident clover had earlier been eliminated using dicamba at 2 l/ha. There were 8 replications of trial lines in randomised blocks. Relative herbage yield was visually estimated (0–10 scale) while growing with competition from perennial ryegrass over winter 1986 to spring 1987. Resistance to invading pests and diseases was recorded. Immediately after notings the trial was defoliated using semi-hungry mature sheep. Uneven residuals were trimmed by rotary mower as required.

Hill country grazing trial

Eight white clover lines including Challenge (Table 3) were sown at 5 kg/ha with perennial ryegrass (*Lolium perenne*) and cocksfoot (*Dactylis glomerata*) on a north slope on a northern podzol (Wharekohe silt loam) at Kaikohe in 1990. There were 4 replicates of plots 4 m × 12 m established in randomised blocks. Pasture probe measurements and cut quadrats were used to measure herbage accumulation, and grass, clover and other species dry matter yields. The trial was rotationally grazed by high sheep numbers when pasture cover was 1500–2000 kg/ha DM.

Manawatu grazing trial

A trial conducted by Caradus *et al.* (1993) tested 8 white clover lines (Table 4) sown in April 1987 with perennial ryegrass under 4 nitrogen levels of 0–225 kg N/ha per year. The trial was conducted on a free-draining Manawatu fine sandy loam overlaying sand and gravel. The trial design was split plots of 3 replicates with N levels as main plots, and cultivars as subplots. Sheep were communally grazed at intervals of 4–7 weeks, depending on seasons, grazing being completed in 2–3 days. DM for clover, grass and other species was measured before each grazing by cutting a 0.5 m² quadrat

from each plot. On two occasions in 1989 and 1990 stolon characteristics were measured on 5 plugs (5 cm diameter) per plot.

Results

Compared with Pitau control, from February 1983 to January 1987 all of the selected lines showed improved growth on one or more notings, 14 lines were poorer between 1 to 5 notings. Five lines, C5242, C5244, C5251, C5255 and C5256, were poorer in the second cool season and. since cool-season growth was a major objective, these lines were rejected. The selected lines had fewer symptoms of rust and leaf diseases and showed better resistance to stem nematode than Pitau. Leaf size measurements in 1987 (Table 1) indicate Challenge is larger leaved than Pitau and slightly smaller than Grasslands Kopu.

Table 1 Leaf sizes of central leaflet (mm) of approximately 60 plants.

Character	Cultivar						
	Huia	Pitau	Kopu	G23	pLSD	0.05	
Winter leaf size — Kaikohe (mm)	12.5	16.7	22.9	21.8	***	1.6	

In the mini plot evaluation all lines had good establishment. From the first summer Challenge showed significantly superior vigour to Pitau (Table 2). The poor performance of the Spanish line C1067 is attributed to stem nematode, which was used as an indicator to verify that the disease was present throughout the trial paddock. Measurements were discontinued after September 1987 when vigorous lines had colonised between plots.

Under rotational sheep grazing on the hill site at Kaikohe, DM yield was measured from April 1990 to May 1994. Challenge white clover showed some improvement compared with Pitau in all trial years and similar yields to Kopu (Table 3).

Further south, the Manawatu grazing trial showed no significant cultivar × N interaction for clover yield or the proportion of clover in the sward over the three years of trial duration. Over summer–autumn, Challenge showed similar growth to Kopu and some improvement over Pitau. During winter, Challenge was significantly better than all cultivars. Plugs taken from the trial for proportion of clover showed that Challenge proportion was greater than that of Aran, Kopu and Pitau. (Table 4). Stolon density measurements were highest for Demand and Tahora, and Challenge had a significantly higher density than Huia, Pitau, Kopu and Aran (Table 5).

Table 2 Growth of the white clover lines in miniplots at Kaikohe relative to Grasslands Pitau in six seasons.

Line		W^1	Sp	Su	Α	W	Sp	Score ² %
C6712	Challenge			*	*	*	*	121
C1898	NZ × Algeria			*	*	*	*	136
C1898	NZ × Algeria		-	*	*	*	*	120
C6715	$NZ \times Kent$			*	*	*	*	118
C6681	$NZ \times USA$			*	*	*	*	124
\times 24 \times	Root knot							
33	nematode			*	*			111
C3601	G Kopu 1975	*						90
C5890	G Pitau							100
C3344	Pitau nema sel							100
C2941	G Huia	-	-					82
C2872	Huia sel	-						86
C2014	Ladino	-		*		-	-	67
C1067	Spain		-	-	-	-	-	47

- * Significantly better growth than Pitau P 0.05
- Significantly poorer growth than Pitau P 0.05
- 1 W^1 = winter, Sp = spring, Su = summer, A = autumn
- 2 Total for 8 notings relative to Pitau = 100

Table 3 Three-year totals of clover dry matter yield (kg/ha) at Kaikohe hill site under rotational sheep grazing.

Line	Clover yield						
	1990/91	1991/92	1992/93	Total			
Challenge	1204	2179	1657	5040			
Kopu	1305	1684	1648	4637			
Pitau	1064	815	1316	3195			
Huia	1140	1211	1553	3904			
Tahora	875	934	1844	3653			
Demand	727	1424	2105	4256			
Prestige	698	1707	1899	4304			
Prop	759	946	1586	3291			
$LSD_{0.05}$	272	389	597				

Table 4 Seasonal production and proportional content (in brackets) of white clover cultivars. Each value is the mean of three years, and four N levels.

Cultivar	Season							
	Sun	nmer	Aut	tumn	Wi	nter	Sp	ring
Challenge	549	(0.12)	286	(0.15)	421	(0.15)	563	(0.12)
Kopu	514	(0.13)	191	(0.11)	276	(0.11)	398	(0.09)
Pitau	419	(0.10)	158	(0.09)	228	(0.08)	311	(0.07)
Huia	464	(0.11)	156	(0.10)	205	(0.10)	427	(0.09)
Tahora	417	(0.09)	101	(0.06)	122	(0.05)	322	(0.07)
Demand	656	(0.15)	228	(0.12)	205	(0.09)	532	(0.11)
Aran	685	(0.16)	201	(0.10)	171	(0.07)	486	(0.11)

Cultivar \times season interactions were significant at P<0.01 for both clover yield and proportional content.

- LSD $_{0.05-}$ clover yield, for comparison among cultivars = 97
 - clover yield, for comparison among seasons = 86
 - clover content, for comparison among cultivars = 0.024
 - clover content, for comparison among seasons = 0.018

Table 5 Stolon characters of white clover cultivars. Each value is the mean of four harvests.

Cultivar	Prop ⁿ of plugs with white clover	Growing point density (no/m²)
Challenge	0.67	2482
Kopu	0.53	2088
Pitau	0.48	1495
Huia	0.65	2384
Tahora	0.69	2754
Demand	0.83	5094
Aran	0.52	1642
p	***	***
LSD _{0.05}	0.09	84

Discussion

Challenge white clover was developed to exploit the potential of germplasm identified to further improve cool-season growth in northern New Zealand and regions with mild winters. During the progeny testing of Challenge importance was placed on freedom from leaf disease. Although yield losses from leaf spot diseases (Williams 1987) have not been determined, they may cause white clover to become oestrogenic (Wong & Latch 1971) and increase the risk of infertility problems in mating animals. Stem nematode has been reported in a number of trials (Williams & Barclay 1972; Rumball & Cooper 1990) as being associated with the loss of clover vigour in establishing and mature clover swards. Challenge's good tolerance (Cooper & Chapman 1993) of leaf disease and stem nematode has a dual significance in improving both quality and herbage yield.

In the Kaikohe mini plot and hill country trials, Challenge has shown potential to be a productive cultivar

under a rotational grazing system. Further south in the Manawatu, the winter growth exhibited by Challenge indicates it may be a valuable addition to seed mixes when mild winters occur. The adaptation of cool-season growth by Mediterranean material is generally associated with reduced winter hardiness (Corkill *et al.* 1980). The use of Challenge is not envisaged for regions subject to severe winter temperatures.

Challenge is a medium- to large-leaved white clover, smaller than Kopu but it has a stolon density similar to that of Huia. Extra growing points will allow the cultivar to recover quickly after droughts or pasture damage and to colonise pasture gaps, thus minimising the ingress of pasture weeds. Challenge is expected to be used mainly in the North Island in rotationally grazed farm

systems, and in combination with smaller-leaved cultivars. Plant Variety Rights were obtained in April 1997 and limited amounts of seed are expected to be commercially available in 1998.

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