Breeding and selection for improved white clover production and persistence in New Zealand

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Abstract

White clover in New Zealand fixes nitrogen and provides improved feed quality in grass swards. Breeding programmes to further improve the persistence and yield of white clover have resulted in three pre-cultivar releases and a number of elite selections.

G.23 was selected from New Zealand x Mediterranean crosses for cool season production, plus improved spring and summer growth with greater resistance to stem nematode and rust than 'Grasslands Pitau'. G.26 was selected from crosses between Southland ecotypes and productive genotypes from New Zealand, the Mediterranean region and France for persistence and production. It has improved spring-summer yields and good leaf disease tolerance compared with 'Grasslands Huia'. G.39 was selected, from collections from Northland sheep farms, for improved productivity compared with Huia. It has good resistance to rust and stem nematode. Recent breeding lines have also been developed from collections made in the Crau region of Southern France, from large leaved New Zealand x Mediterranean crosses that have high stolon growing point densities and from a line from Syria that exhibited improved survival in summer drought.

The improvement in clover content over existing cultivars is highlighted by results from trials at a range of sites throughout New Zealand.

Additional key words: Trifolium repens, *yield, cultivars, selections*

Introduction

White clover (*Trifolium repens* L.) is the most important forage legume in New Zealand. It provides nitrogen through nitrogen fixation and improves pasture quality. Past breeding programmes have produced four cultivars. 'Grasslands Huia' is a general purpose cultivar providing sustained production in a wide variety of environments (Williams 1983). 'Grasslands Pitau' was selected from crosses between Huia and introduced Spanish germplasm and provides improved cool season growth (Barclay 1968). 'Grasslands Kopu' was selected from crosses between Pitau and ladino germplasm and provides improved summer growth and stem nematode resistance (van den Bosch *et al.*, 1986). 'Grasslands Tahora' was selected from collections from moist hill country and provides substantial increases in clover yield under a range of hill country farming conditions (Williams 1983).

Breeding programmes have been undertaken in Northland and Southland for improved adaptation to these areas. Selections for high yielding, large leaved types with good persistence under rotational sheep grazing have also been made, and a line with good persistence in summer droughts has been identified. The aim here is to review briefly the breeding of each of these and compare their agronomic performance with the four existing cultivars.

Breeding Material

G.23

Selected at Kaikohe from crosses between New Zealand and Mediterranean germplasm for cool season production. Selection criteria were superior spring and summer growth, and greater resistance to stem nematode and rust diseases than Pitau.

G.26

Selected from crosses between Southland ecotypes and either Huia, Pitau, French lines or some hybrids between New Zealand and Mediterranean germplasm for improved yield compared with Huia, and greater tolerance to foliar rusts and sooty blotch (Widdup *et al.*, 1989).

G.39

Selected from white clover germplasm collected from Northland steep/hill country for improved productivity, and stem nematode and rust resistance compared with Huia.

'Stoloniferous large leaf' (SLL)

Selected from crosses between New Zealand and overseas germplasm, predominantly from the Mediterranean and USA, for high stolon densities in grazed swards and large leaf sizes in spaced plants. High stolon point density is important in ensuring persistence (Caradus & Williams 1981, 1989). However, there is a general trend for high stolon growing point density to be associated with small leaves and low productivity. The aim here was to identify germplasm with high stolon grown point density without sacrificing leaf size and production.

'Crau Plains'

Selected from germplasm collected from the Crau Plains of southern France for high yields compared with Kopu, at Palmerston North.

'Syria'

Bred from plants of a Syrian population that survived summer droughts in a grazed grass sward at Palmerston North.

Evaluations

These pre-release cultivars and elite breeding lines were evaluated in trials at Kaikohe, Palmerston North and Gore.

G.23 at Kaikohe and Palmerston North

Pure swards of Pitau, Kopu and G.23 were sown in plots (3 x 1 m) at Kaikohe (5 replicates) and Palmerston North (4 replicates). Plots were mown to a height of 2.5 cm when swards reached 12 cm height. At Kaikohe leaf size of G.23 was similar to that of Kopu during winter (Table 1). Over 2 years at Palmerston North (a total of 8 cuts) and nearly 3 years (a total of 20 cuts) at Kaikohe, dry matter yields of G.23 in the cool season (autumn/winter) were 17% greater at Kaikohe and 14% greater at Palmerston North than those of Pitau (Table 1). However, yields were similar to that of Kopu, both in the cool season and throughout the year. There was a clear relationship between cool season growth and leaf size (Table 1) with the larger leaved lines having greater cool season growth. Cool season growth was incorporated into Pitau by hybridization of Huia with a large leaved Spanish line (Barclay 1969). G. 23 was derived also from crosses between New Zealand and Mediterranean germplasm, the latter also tending to be large leaved. The large leaved character of Kopu came from ladino germplasm introduced into Pitau, which while not necessarily ensuring cool season growth did not suppress it.

Pre-release cultivars and breeding lines at Palmerston North

Nine cultivars, pre-release cultivars and breeding lines were compared in small plots (50 x 75 cm)

TABLE 1: Comparison of G.23 with Grasslands cultivars grown in mown pure swards for nearly 3 years at Kaikohe and 2 years at Palmerston North.

Character	Cultivar				p	$LSD_{0.05}$
	Huia	Pitau	Kopu	G.23		
Winter leaf size (mm) [1]						
- Kaikohe	12.5	16.7	22.9	21.8	***	1.6
Cool season production (kg/ha)						
- Kaikohe	7419	8342	9555	9732	***	636
- Palmerston North	6082	6892	7251	7832	**	641
Total clover production (kg/ha)						
- Kaikohe	24899	24639	28273	27704	***	1094
- Palmerston North	18259	18421	20355	20812	**	1158

[1] width of middle leaflet

planted into a perennial ryegrass (*Lolium perenne* L.) sward. Thirty seedlings were transplanted into each plot in autumn 1986. Plots were arranged in a randomised block design with 3 replicates, and 50 cm spacing between plots. The trial was grazed 7 times per year for 2.5 years by 15 - 20 sheep for 1 to 3 days at each grazing. Intervals between grazing varied from 24 days in spring to 60 days in winter.

Before each grazing, stolon growing point density was measured in a 12 x 16 cm quadrat, and clover content by dissection after harvesting a 50 x 8 cm quadrat. The sample was sorted into clover and grass, the number of clover leaves counted and the clover and grass components weighed dry. Individual or average leaf weight was calculated by dividing total clover leaf weight by number of leaves harvested, and used as an indicator of leaf size.

The stolon growing point densities of G.39, G.26, SLL and Crau Plains were significantly ($P<0.05$) greater than those of existing cultivars of similar leaf size (Table 2). This should ensure increased persistence of the new lines and is a major factor in improved yields over existing cultivars. The proportion of clover and clover dry weight in the sward were consistently high over the 2.5 years of the trial for G.39, G.26, SLL, Crau Plains and G.23.

The improved production of G.23 compared with Kopu in this trial (Table 2) was not evident in the mown trials at Kaikohe or Palmerston North (Table 1) and may be the result of different defoliation regimes. The greater stolon growing point density of G.23 may be effective in increasing production only under grazing rather than mowing compared with Kopu.

Persistence during summer drought at Palmerston North

'Syria' was compared with Huia, Pitau, Kopu and Tahora in small plots (50 x 50 cm) in a grass sward (a mixture of perennial ryegrass and browntop - *Agrostis tenuis* Sibth.) in an area prone to summer drought at Palmerston North. Low rainfall from mid December to early January in 1986-87 and 1987-88 caused considerable clover death in most plots. Establishment and management was similar to that of the previous trial.

'Syria' had a leaf size between that of Tahora and Huia and while the proportion of clover in the sward was significantly greater than that of Tahora only in years 1 and 2, it persisted better than Huia, Tahora and Kopu through two dry summer periods (Table 3). 'Syria' had 30% greater stolon growing point density than Huia (Table 3). This trial has highlighted that there is variation within white clover in ability to persist through short term droughts. Selections of better performing genotypes from within the 'Syria' have been made for further evaluation in such areas.

G.26 at Gore

Grasslands Huia and G.26 were compared in plots (15 x 15 cm) under rotational sheep grazing. Plots were sown with white clover at 3 kg/ha and 'Grasslands Nui' perennial ryegrass, at 15 kg/ha. Over 3 years herbage yield was measured before each grazing by cutting representative quadrats to 2-3 cm, and sorting into clover and grass before weighing dry. After 15 months, stolon characteristics were measured by taking 5 cm diameter pasture plugs and recording

TABLE 2: Stolon growing point densities, leaf size and clover content of pre-release cultivars and breeding lines compared with existing Grassland cultivars at Palmerston North. Values are means of 17 harvests over 2.5 years.

Cultivar	Stolon growing point density (no/m^2)	Individual leaf weight (mg)	Percent clover in sward[1]	Clover dry weight (g/m^2)
Crau Plains	959	12.7	25	151
G.39	2233	6.3	24	121
G.26	2038	6.6	24	131
SLL	1799	10.5	31	188
G.23	1032	10.5	25	132
Huia	1068	8.3	16	85
Pitau	959	10.2	21	121
Tahora	1404	5.2	12	72
Kopu	530	13.2	17	89
P	***	***	*	**
$LSD_{0.05}$	428	2.01	9	57

[1] on a dry weight basis

TABLE 3: Comparison of 'Syria' with Grasslands cultivars at a summer dry site at Palmerston North. Persistence scores are based on 1 - low clover content to 5 - high clover content.

Cultivar	Individual leaf weight[1] (mg)	Percent clover in years 1 & 2[2]	Persistence score in 3rd year	Stolon growing point density (no/m²)[3]
Syrian ecotype	7.7	17	3.33	1043
Huia	8.9	12	1.00	802
Pitau	12.2	12	1.33	587
Tahora	5.0	05	0.33	1209
Kopu	15.3	15	0.33	572
P	*	*	*	***
$LSD_{0.05}$	5.9	11	2.30	268

[1] in spring
[2] immediately after recovery from summer drought; on a dry weight basis
[3] averaged over the three years of the trial

stolon growing points, stolon length and stolon dry weight.

G.26 yielded more than Huia during summer, autumn/winter, spring and annually, although total herbage yields were similar (Table 4). G.26 had much higher stolon growing point numbers, stolon lengths and weight per unit area than Huia (Table 4). Thus persistence should be better than that of Huia without a concomitant reduction in yield, as often can occur with increased stolon growing point density (Caradus & Williams 1981, 1989).

TABLE 4: Comparison of G.26 and Huia at Gore. Values are mean of 3 years.

Character	Cultivar Huia	Cultivar G.26	P	$LSD_{0.05}$
Clover yield (kg DW/ha)				
- summer	2330	3320	**	290
- autumn/winter	1030	1570	**	160
- spring	1630	2250	**	260
- annual	4900	7140	**	383
Total herbage (kg DW/ha)				
- summer	5630	5750	ns	-
- autumn/winter	4900	4700	ns	-
- spring	4630	4770	ns	-
- annual	15170	15270	ns	-
Stolon characteristics (at 15 months)				
- stolon growing points/m²	7010	9795	*	1920
- stolon length (m/m²)	100	144	*	29
- stolon dry weight (g/m²)	45	65	*	14

Effect of stem nematode and rust

In spaced plant trials at Kaikohe both G.23 and G.39 have shown less damage caused by both stem nematode (*Ditylenehus dipsaci*) and leaf rust (*Uromyces trifolii*) compared with Pitau and Huia, respectively (Table 5). G.26 similarly was less affected by rust than Huia and Pitau in a trial at Gore (Table 5).

TABLE 5: Comparison of pre-release cultivars with Huia or Pitau for susceptibility to rust and stem nematode damage.

Pathogen/pest type	Cultivar	% of plants severely affected (or disease score)
Rust	Pitau	27
	G.23	3
	Pitau	43
	G.23	12
	Huia	48
	G.39	8
	G.26	(1.9)[1]
	Huia	(2.8)
	Pitau	(2.1)
Stem nematode	Pitau	14
	G.23	0
	Huia	28
	G.23	18

[1] score of 1 = little infection to 4 = severe infection

Conclusions

Improved performance of white clover in grazed mixed swards can be expected following the use of G.23, G.26 and G.39. G.23 will give improved production and is particularly suited to Northland dairy farms. Both G.26 and G.39 have very high stolon growing point densities compared with existing cultivars, but this has not been at the expense of leaf production. They are particularly suited to sheep grazing, G.39 in warmer northern regions and G.26 in cooler southern regions, i.e., regions most similar to the area in which they were bred. While the present trials were conducted using rotational grazing it is also expected on the basis of their morphological type (Brock 1988) that both G.39 and G.26 will perform similarly well under set-stocking. The stoloniferous large leaf selection (SLL) has a remarkably high stolon growing point density compared with cultivars of similar leaf size, and hence yields of this selection will remain high over a number of years. It will be suited to both rotational sheep and cattle grazing. Crau Plains has potential as a large leaf cultivar giving consistently high yields, while selections from the Syrian ecotype may have potential in ensuring persistence during short term droughts.

Selection for increased stolon development while maintaining leaf size is seen as the key to improving yields of white clover selections, compared with existing cultivars.

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