

The positioning of white clover cultivars in New Zealand

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Abstract

The breeding history of 10 white clover cultivars bred in New Zealand is described. The cultivars are compared for leaf size, cyanogenesis and stolon growing point density. Leaf size and stolon growing point density were negatively associated although more recent cultivars (Prestige, Demand, Sustain and Challenge) had higher stolon growing point densities than older cultivars of similar leaf size. Both leaf size and peak flowering period, and leaf size and cyanogenesis level were positively associated among the 10 New Zealand cultivars. The agronomic performance of cultivars is summarised on the basis of preferred management, key seasonal performance, disease tolerance, and climatic and edaphic adaptation.

Keywords: adaptation, breeding, cultivars, cyanogenesis, flowering, leaf size, white clover

Introduction

White clover breeding began intensively in New Zealand in the late 1920s, coinciding with similar programmes in the U.K., Denmark, Sweden, Finland and Australia (Caradus 1995). All these early programmes selected for improved agronomic performance of major ecotypes. In New Zealand this led to the commercialisation of a selection called New Zealand White or New Zealand Certified Mother, which later in the 1960s became known as Grasslands Huia and New Zealand Permanent Pasture, a smaller-leaved selection which was later withdrawn. Over the next three decades a further nine white clover cultivars have been bred in New Zealand. Aran, a large-leaved cultivar in common use in New Zealand is included for completeness and for morphological comparison with New Zealand cultivars. Aran was bred in Ireland, from germplasm collected in southern France (V. Connolly *pers. comm.*).

Breeding history of New Zealand white clover cultivars

Grasslands Huia

Selected from New Zealand wild white No. 1 strains collected from Hawke's Bay and North Canterbury for yield and persistence under grazing (Levy 1932). Final

selection of the seven parent genotypes was completed in 1957 and New Zealand Certified Mother Seed renamed Huia in 1964.

Grasslands Pitau (G. 4700)

Selected from a backcross between Huia and a hybrid between Huia and a cool-season active Spanish ecotype for improved winter growth (Barclay 1969). Begun in 1957, with the selection of 12 Spanish genotypes that were crossed with the 7 Huia parent genotypes. The resulting 84 progeny were evaluated at Kaikohe, Palmerston North, Lincoln and Gore for seasonal production and rust resistance (*Uromyces trifolii*). Approximately 35 genotypes were selected from each site in 1960 and backcrossed to Huia; progeny were again evaluated at the four sites and a final selection made of 62 progeny lines. One genotype from each of these was included in a polycross to become the nucleus of Pitau, in 1962. Further testing occurred over the next decade before release in 1975.

Grasslands Tahora

Selected for high yield and persistence under set-stock sheep grazing in moist hill country, combining small leaf size and high stolon growing point density, from ecotypes collected from New Zealand moist hill country (Williams 1978a; 1983). From more than 2000 collected genotypes, 126 were selected and polycrossed in 1976. Progeny were tested in a low fertility, hill country pasture for 4 years, leading to the selection of 20 progeny lines which were also known to flower adequately in lowland. The parents of each of these lines were included via polycross to become Tahora, which was released in 1982.

Grasslands Kopu (G. 18)

Selected for stem nematode resistance and yield on intensive lowland dairy farms from crosses between Grasslands Pitau and genotypes from three USA ladino cultivars (Williams 1978b; van den Bosch et al. 1986). Eleven pair crosses between elite Pitau and ladino genotypes, selected for stem nematode resistance and yield, were made in 1976. These were progeny tested under grazing in the Manawatu and Northland up to 1980 and then the resulting cultivar was further tested until its release in 1986.

Grasslands Demand (G. 26)

Selected from crosses between Southland ecotypes and productive genotypes from New Zealand, the Mediterranean and southern France for early spring and summer growth, and for persistence in Southland (Widdup et al. 1989). From 1975 to 1980, 320 white clover lines from both New Zealand and overseas were evaluated under grazing in Southland, and lines identified as either persistent or high yielding. Genotypes from persistent and high yielding lines were pair crossed to produced 80 lines. Progeny tests identified 24 lines that significantly outyielded Huia in all seasons, from which 58 parent plants were finally selected to produce Demand in 1990.

Grasslands Prestige (G. 39)

Selected for high yield, tolerance to stem nematode and leaf diseases, and persistence under sheep grazing from ecotypes collected and evaluated in Northland (Cooper & Chapman 1993). A white clover ecotype collection from 10 sheep and beef farms in Northland was made during a dry summer, in 1979. Over the next 5 years, 23 elite genotypes were identified which had high yields under grazing and good tolerance for stem nematode and leaf rust. These were polycrossed and progeny tested, in Northland for forage yield and Canterbury for seed yield, to identify 11 elite lines. The parental genotypes of these 11 lines were combined to produce Prestige in 1990.

Prop (Whatawhata Early Flowering)

Selected for early and prolific flowering and yield in dry hill country from ecotypes collected from summer dry hill country in Waikato, south Auckland and Coromandel (Macfarlane & Sheath 1984). Originated from a polycross among 50 plants selected from steep, north-facing hillsides at Whatawhata Research Centre in 1979–80 (Anon 1993).

Grasslands Challenge (G. 23)

Selected from crosses between New Zealand and Mediterranean germplasm for improved cool season growth in Northland, plus good spring and summer growth with good resistance to stem nematode and leaf rusts (B.M. Cooper *pers. comm.*). In 1976, 120 lines of New Zealand and crosses between New Zealand and overseas lines were evaluated under grazing (Cooper & Williams 1983) to identify, in 1981, 33 genotypes from 4 lines of both New Zealand and Mediterranean origin. Progeny from a polycross of the 33 genotypes were evaluated for cool season activity in Northland and seed yield potential in Canterbury to identify 26 elite parent seed lines. The best genotype from each of these seed lines were selected and polycrossed to produce Challenge in 1994.

Grasslands Sustain

Selected for high stolon growing point density without sacrificing leaf size and production from crosses between New Zealand and overseas germplasm, predominantly from the Mediterranean and USA (Caradus unpublished). In 1973, crosses between elite overseas white clover genotypes and Huia were made and progeny tested for yield, through three cycles of recurrent selection. In 1986, five lines, with medium-large to large leaf size, were identified as high yielding and grown in a grazed grass sward. Over the next 3 years measurement was made of stolon growing point density. Two lines with high stolon growing point densities relative to their leaf size were identified. Twenty genotypes of each were selected and crossed in two polycrosses. Half sibs were progeny tested and measurements of seasonal forage yield, and stolon growing point density made in the Manawatu and seed yield potential in Canterbury, leading to the selection of 15 lines. The parental genotypes of these lines were combined to produce Sustain in 1994.

Le Bons

Selected for strong seedling vigour, *Sclerotinia* resistance and high yield in Canterbury from crosses between five cultivars including Irrigation, Pitau, Dusi and Ross (N. Cameron *pers. comm.*).

Description of New Zealand white clover cultivars

There is a positive association between leaf size and cyanogenesis levels for white clover cultivars used in New Zealand, with the exception of Kopu, which has a lower cyanogenesis level than other large leaved cultivars (Figure 1). There is a negative association between leaf size and stolon growing point density, although the most recent Grasslands cultivars, Prestige, Demand, Sustain and Challenge all have higher stolon growing point densities than older cultivars of a similar leaf size (Figure 2). There is a positive association between leaf size and peak flowering period, although Pitau and Challenge are earlier flowering than other large leaved cultivars (Figure 3). There is also variation for the length of the flowering period with Prop having a particularly long flowering period.

Agronomic performance

In general, the small leaved cultivars are more suitable for hard, set-stocked sheep grazing while the large leaved cultivars are more suitable for lax, rotational cattle/dairy grazing (Table 1). Within each leaf size category cultivars differ in their regional adaptation and their seasonal growth. Often regional adaptation is closely related to the site at which selection and breeding was

Figure 1: Comparison of white clover cultivars on the basis of leaf size, relative to Huia, and percentage of cyanogenic genotypes. Information compiled from Caradus et al. (1989, 1990, 1991), D.R. Woodfield (unpublished) and J. Miller (unpublished).

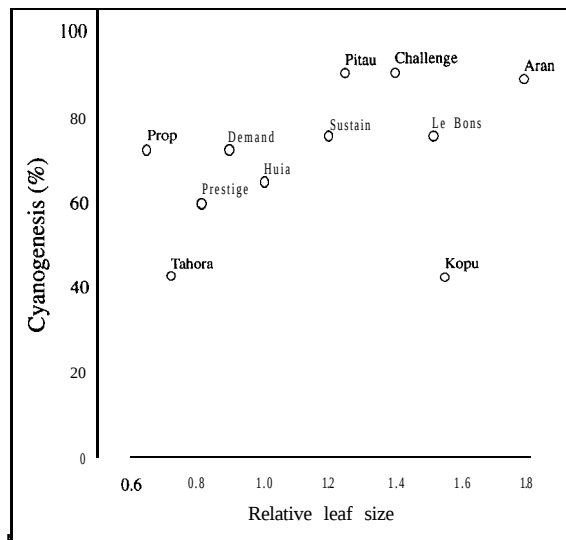
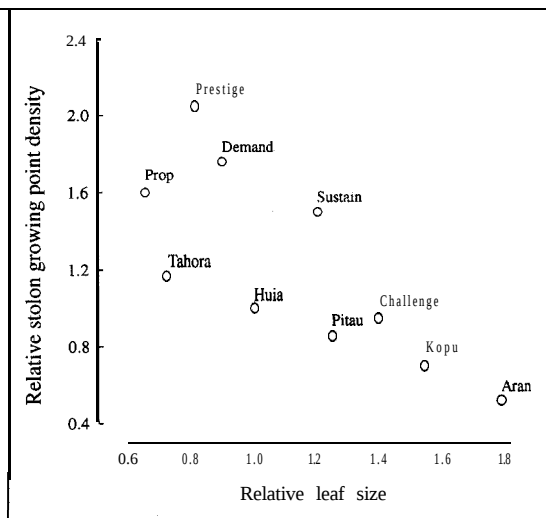


Figure 2: Comparison of white clover cultivars on the basis of leaf size, and stolon growing point density, relative to Huia. Information compiled from Woodfield and Caradus (1994), Caradus et al. (1990, 1991, 1993) and Caradus (1991).



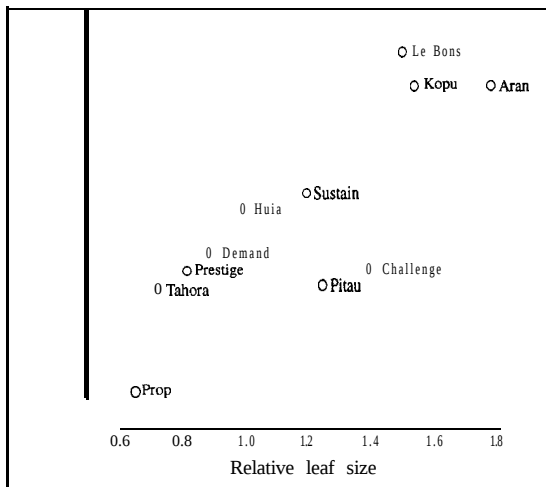
related to the site at which selection and breeding was undertaken. Thus, Prestige, Tahora, Sustain, Pitau, Kopu and Challenge are more suited to the North Island, and Demand and Le Bons more suited to the South Island. The smaller leaved cultivars Tahora, Prestige and Demand can be successfully combined in blends with larger leaved cultivars for dairying and other lowland intensive operations.

Cyanogenesis is primarily used as a classification characteristic (Caradus et al. 1989), particularly to distinguish between ladinis (acyanogenic) and other large leaved types. However, it also has some indirect influence on agronomic performance in New Zealand. Moderately high cyanogenesis levels in leaves of cultivars and breeding lines are associated with improved yield and persistence (Caradus & Williams 1989).

Cultivars differ in their key seasonal growth patterns, although this can be influenced by region and management. However, some consistent patterns do emerge across a number of studies (Table 1). Cultivars that have excellent autumn/winter growth are Challenge, Kopu, Prestige, Sustain, Pitau and Le Bons. Good summer growth has been observed for Prestige, Demand, Sustain and Aran.

There are a range of pests and diseases that can limit the potential of white clover. Prestige is the most disease tolerant cultivar (Table 1). Stem nematode resistance is also recorded for Sustain, Challenge and Kopu, and leaf

Figure 3: Comparison of white clover cultivars on the basis of leaf size, relative to Huia, and peak flowering period (P.T.P. Clifford *pers. comm.*).



rust resistance recorded for Prop, Tahora and Challenge. Prestige is the only cultivar showing useful field tolerance/resistance to clover flea (Cooper 1984).

Adaptation to short-term drought is an important attribute since much of New Zealand pasture periodically experiences low soil moisture levels. Prop was bred for dry hill country, and was selected for prolific, early

Table 1: The positioning of white clover cultivars in New Zealand.

Cultivar	Type	Climate adaptation/ land class	Stock class/ Management	Key Seasonal performance (rel. Huia)	Pest and disease tolerance
Prop	Small	North Island dry hill country	set-stock sheep	winter/spring	leaf rust
Tahora	Small	North Island moist and dry hill country, and dry lowland	set-stock sheep	autumn	leaf rust
Prestige	Medium/small	Hill and rolling country northern North Island, and dry lowland	set-stock and rotational sheep	winter/spring/summer	stem nematode, leaf rust, clover flea
Demand	Medium/small	Hill and rolling country South Island, and moist lowland	set-stock and rotational sheep	spring/summer/autumn	
Huia	Medium	General	rotational sheep	(mid-spring)	
Sustain	Medium/large	Rolling – flat	rotational sheep/ cattle/dairying	autumn/winter/summer	stem nematode
Pitau	Medium/large	Flat, warm winter	rotational cattle/dairy	winter	
Challenge	Large	Flat, warm winter	rotational cattle/dairy	autumn/winter	stem nematode, leaf rust
Kopu	Large/ladino	Flat, North Island	rotational dairy	winter	stem nematode
Le Bons	Large	Flat, North and South Island	rotational dairy	winter	
Aran	Very large	Flat, North Island	rotational dairy	summer/autumn	

Information compiled from Caradus (1990; 1991), Caradus et al. (1990; 1991; 1993), Moloney et al. (1988), Keoghan et al. (1989), Brock (1988), Caradus & Mackay (1991), Lancashire et al. (1985), Cooper & Chapman (1993), Chapman et al. (1993), Chapman & Fletcher (1985), Anon (1994), Widdup & Turner (1983), West & Steele (1986), Widdup et al. (1989), N. Cameron (*pers. comm.*).

Demand has shown good vegetative persistence in dry North Island hill country (van den Bosch et al. 1993) and dry lowland Canterbury (Woodfield unpublished). Tahora has shown good persistence in summer dry lowland areas of the North Island (Brock 1988).

Low soil fertility, especially phosphorus, is a constraint on white clover yield and persistence. All white clover cultivars need phosphatic fertiliser for optimal performance. Trials in low fertility hill country have demonstrated that Tahora and Prestige are the cultivars with the best yield and persistence (Cooper & Chapman 1993; Caradus unpublished).

None of the cultivars have shown a clear superiority in their tolerance to high levels of nitrogen fertiliser (Caradus et al. 1993), although larger leaved upright cultivars should be more competitive with associated grasses.

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