Caucasian clover for improving summer production in northern regions of New Zealand

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Abstract

Caucasian clover (CC) and white clover (WC) pastures were established on a Bay of Plenty dairy farm in September 1994 and undersown with ryegrass (RG) in July 1995. Yields of mown RG–CC plots surpassed those of RG–WC plots from December to April in the second year after establishment (1995/96), producing 1362 kg (26%) extra DM/ha during this period. In 1996/97 yields of RG–CC plots surpassed those of RG–WC from October to April, producing 1531 kg (43%) extra DM/ha in December–April. In grazed RG–CC plots during December-May 1996/97, RG yields were slightly reduced (371 kg/ha, –12%) in comparison with RG–WC plots, and extra production resulted from greatly increased total legume yield (2155 kg/ha, 187%). Pasture legume content during summer–autumn averaged 24% for RG–WC and 54% for the RG–CC pastures. The superior performance of CC over WC appeared to relate to its protected underground growing points, and tap-root retention, facilitating better pasture cover during summer, and greater tolerance of pests including grass grub and clover cyst nematode. Caucasian clover shows promise as a perennial legume which may offer improved availability of high quality forage at a time of year when clover growth is often insufficient for good animal performance. Caucasian clover clearly has potential in northern as well as southern regions of New Zealand.

Keywords: dairy pasture, *Lolium perenne*, northern New Zealand, pasture pests, *Trifolium ambiguum*, *Trifolium repens*

Introduction

Pasture-based animal production in New Zealand is frequently limited by the reduction in quality and quantity of forage in summer and autumn. Higher levels of pasture clover during this period could increase dairy production by at least 10% (Caradus *et al*. 1996), possibly add to manufacturing quality of milk (Vertes & Hoden 1989) and at the same time dilute the effects of grass-associated mycotoxins.

Studies on coastal Bay of Plenty dairy farms showed that hot dry summer conditions severely reduce white clover (*Trifolium repens* L.) (WC) growing point density. In addition, root-invading clover nematodes enhanced clover loss and delayed subsequent recovery of clover in autumn (Watson *et al.* 1994). Poor clover levels going into winter pasture can result in pasture clover levels becoming chronically reduced, leading to further degradation in pasture yields and species composition, and ultimately herd performance. One way of retaining pasture clover may be by using an alternative species to white clover, which spreads underground so that growing points are protected from excessive surface temperatures and overgrazing. One such plant is caucasian clover (*Trifolium ambiguum* Bieb.) (CC). The natural distribution for CC is restricted largely to alpine and steppe regions east of the Black Sea and running into eastern Turkey and Iran (Bryant 1974). The alpine origins and rhizomatous habit of the plant meant early interest in Australasia was mainly for soil conservation use in high country areas. However, once it is established, it has also been shown to produce well in lowland pasture (Stewart & Daly 1980).

CC is sufficiently closely related to WC that the species can be artificially hybridised. It shares many attributes with WC, including its high nutritional value and digestibility (Peterson *et al.* 1994). It also has wide morphological variability and ability to persist under adverse conditions, including low soil fertility and drought, but responds readily to high fertility situations (Virgona & Dear 1996). Its major distinction from WC is that it spreads underground from rhizomes rather than from surface stolons. It is slow to establish cover in the first year while the young plants produce these underground stems from which vertical shoots subsequently emerge. This means the plant has frequently compared poorly in species evaluations where first-year performance has been a major determining factor. Young rhizomes do not penetrate grass readily, so that establishment of a vigorous rhizome network (and crown density) can be delayed 2–4 years by dense grass cover (Moorhead *et al.* 1994; Hill & Mulcahy 1995). Once established, CC has shown more persistence and a wider range of adaptability in harsh temperate environments than WC.

With this in mind CC was selected as a model rhizomatous legume to determine if a clover with protected growing points gave advantages over WC in the coastal Bay of Plenty environment. Results of the first two seasons of the trial have been reported previously (Watson *et al.* 1996b). This paper presents data on the performance of WC and CC pastures in the third year after its establishment from maize cropping, concentrating on differences during the summer–autumn.

Methods

The trial site, on a dairy farm at Pongakawa, Bay of Plenty, was on Paengaroa sandy soil derived from Kaharoa ash and had been cropped in maize for the previous 15 years. Grasslands Kopu WC and Endura CC (Wrightson Seeds Ltd. 1995) were sown through a roller drill as pure species in September 1994 into 0.125 ha plots, with 4 replications, after light cultivation (Watson *et al.* 1996b). In July 1995 most of the site was undersown with Yatsyn ryegrass (*Lolium perenne* L.)(RG). A 6 m strip across ryegrass plots was drilled with 1.5 kg/ha chlorpyrifos as the slow release formulation Suscon Green, in anticipation of an outbreak of grass grub (*Costelytra zealandica* White) in the 2nd to 4th years (East & Willoughby 1983). Mowing plots (5 m × 5 m) were established in pure clover and RG–clover areas to determine responses to fungicide and nematicide treatments (Watson *et al.* 1996b). These plots were mown to coincide with grazing of the remaining pasture by a dairy herd. The pastures were grazed in common and have received normal fertiliser applications applied on the farm after establishment (e.g., April 1997, 300 kg/ha as 80% DAP sulphur super/20% muriate of potash; July 1997, 100 kg/ha urea).

From December 1996 Wrightson Nutrition sponsorship enabled measurement of pasture growth from grazed RG–clover pasture. A 10 m long strip was mown to 4.0 cm cutting height diagonally across RG drill-rows, both on and off the Suscon-treated zone. At the following harvest (Figure 1), 5 pasture samples were clipped from along each mown strip for herbage dissection before re-mowing, weighing and sub-sampling of the herbage for DM determination. An adjacent strip was again pre-trimmed, providing a moving transect for estimating grazed yields.

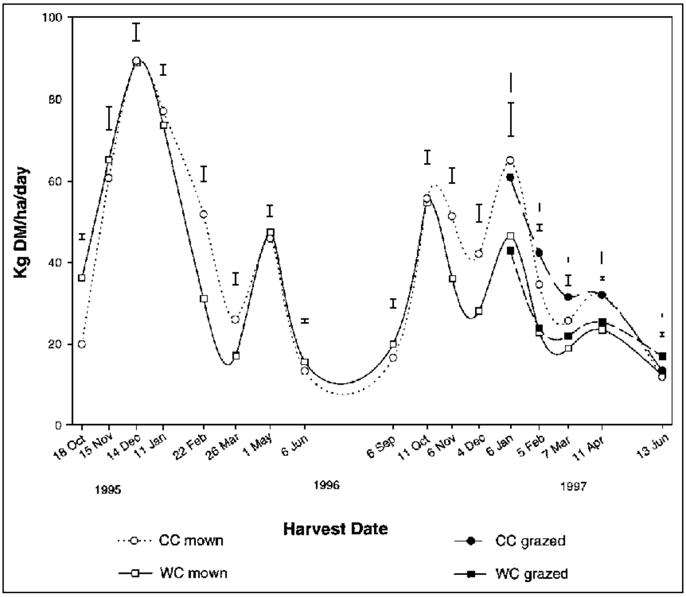
In March 1997, soil insect populations in each of 64 mowing plots were determined by hand sorting 10 soil core samples (10 cm diam. by 10–15 cm deep). In May the sampling was repeated in the grazed pasture area with 20 samples per plot taken both on and off Suscon treated areas. When leaf feeding by the clover root weevil (*Sitona lepidus* Gyllenhal) was noted, clover leaves from herbage dissection samples in June were scored for the number of feeding notches by adult weevils. Plant-parasitic nematodes were sampled using single soil cores (2.5 cm diam. by 10 cm depth) from 5 single WC or CC plants from pure species areas of grazed plots in June. Soil was bulked for each plot and nematodes were extracted using a Whitehead tray system before counting.

Results

Herbage growth and species composition

Pasture growth rates on this light sandy soil were sensitive to rainfall patterns (Figure 1). In 1995/96 growth rates on mown RG–clover plots peaked in December exceeding 80 kg DM/ha/day but dropped to 20 kg DM/ha/day in March, followed by an autumn peak to 40 kg/DM/ha/day. In 1996/97 growth rates were above 50 kg DM/ha/day by October but a dry late spring period reduced growth rates to 30 and 40 kg DM/ha/day for the RG–WC and RG–CC mowing plots respectively. A second peak occurred in January (45 and 60 kg DM/ha/

Figure 1 Pasture growth rates for mown plots of ryegrass pasture with white or caucasian clover (1995/96 and 1996/97) and grazed pasture (summer–autumn 1996/7). Vertical bars show SED (P<0.05); capped = mown, uncapped = grazed plots.



day respectively) followed by declining growth rates and no pronounced autumn peak. Summer–autumn growth rates for grazed pasture followed a similar pattern to those in mown plots (Figure 1). Yields of mown RG–CC plots exceeded those of RG–WC plots from December–April in 1995/96, the second year after establishment, producing 1362 kg (26%) extra DM/ha during this period. In 1996/97 growth on RG–CC plots exceeded RG–WC from October–April with 1531 kg (43%) extra DM/ha produced in December–April.

In grazed pasture summer–autumn (December–May 1996/97) herbage yields were increased by 31% from 4.73 to 6.18 t DM/ha ($P<0.05$) on RG–CC compared with RG–WC pasture (Table 1). The yields of RG (371 kg/ha, –12%; $P<0.05$) , WC (–65%) and other species (–59%) ($P<0.05$) were less in the RG–CC than in RG–WC plots but total legume yield was markedly increased (2155 kg/ha, 187%; $P<0.01$). A small-leaved local ecotype of WC established and has persisted in CC pasture. "Other species" largely comprised summer grass (*Digitaria sanguinalis* (L.) Scop.) in RG–WC plots going to seed during March and April.

Incomplete randomisation reduced the statistical sensitivity of differences owing to Suscon treatment, although all the main species were responsive, particularly WC. Ryegrass and CC yields were increased by significant amounts for the February–June period ($P<0.05$, not shown). Suscon increased summer–autumn total herbage yield by 18 and 24% for RG–WC and RG–CC pastures respectively. Although the summer–autumn legume DM response to Suscon was greater on RG–CC plots, the percentage increase was greater for WC (64% vs 40%; clover x Suscon interaction $P<0.05$).

Three-year-old grazed RG–WC pasture had a 25 and 45% legume content on –Suscon and +Suscon treatments respectively for the December growth period (January harvest), but this declined to around 15 and 25% for the remainder of the summer and autumn. Legume content over the full summer–autumn period was 18 and 28% of herbage yield (0.87 and 1.43 t/ha respectively). RG–CC pasture achieved 60 and 70% (– and +Suscon) total legume content for December growth and then maintained around 50 and 60% legume content until May when there was a sharp seasonal decline in growth rates as winter dormancy set in. WC in the RG–CC pasture consistently contributed around 5 and 10% to total herbage yield. The combined summer–autumn legume contribution in RG–CC plots was 50 and 56% (2.75 and 3.86 t/ha respectively).

Insect and nematode pests

Grass grub and Tasmanian grass grub

In autumn 1996, grass grub numbers in grazed pastures RG–WC measured 286 (±27 SE)/m^2 and in RG–CC 196 ± 29/m^2 ($P<0.05$) and Suscon treatment reduced populations by 60 and 45% respectively (Watson et al. 1996a). In May 1997, populations in untreated pastures were similar (111 ± 2/m^2), and Suscon had reduced populations by 55 and 33% (n.s.). Grub feeding under ryegrass crowns weakened the root system and contributed to extensive ryegrass pulling during grazings from February–June. Grass grub populations in untreated, mown RG–clover plots in March were 351/m^2. Grass grub populations in the grazed pasture may possibly have been greater before the May sampling. Numbers of Tasmanian grass grub (*Aphodius tasmaniae* (Hope)) were 79 and 40/m^2 in RG–WC and RG–CC in 1996 and 60 and 28/m^2 ($P<0.1$) in 1997. There was no significant effect of Suscon treatment.

Clover root weevil

Clover root weevil was first discovered on the farm in autumn 1996, with one adult taken in suction sampling on two paddocks (Barker *et al.* 1996). Very low populations of adults and larvae (0.6/m^2) were present in the RG–WC and RG–CC plots in autumn 1997. Leaf notching on clover leaf margins by adult clover root weevil feeding was scored from herbage dissection samples on 13 June after a 63 day regrowth period (Table 2). A slightly greater incidence of clover root weevil feeding on CC could suggest it was marginally favoured over WC. However 57% of the notches on WC leaves from RG–WC plots appeared to have had more than one feeding visit, compared with around 30% of notches on WC and CC growing together in the same plots. The larger size of CC leaves means that a smaller proportion of the leaf area was removed by clover root weevil adult feeding. There was no reduction

Table 1 Accumulated summer–autumn total and component herbage yields on grazed pastures of ryegrass and white (RG–WC) or caucasian clover (RG–CC), and in the presence and absence of Suscon Green treatment for grass grub control.

	kg DM/ha					
	RG–WC	RG–CC	[1]SED	– Suscon	+ Suscon	SED
Total herbage	4728	6180	287*	4927	5981	272
Ryegrass	3016	2645	103*	2718	2943	110
White clover	1151	[2]406	215*	599	958	35
Caucasian clover	-	2900	-	2424	3376	396
Other species	561	229	61**	399	392	76

1. *, **; differences significant at $P< 0.05$ and $P<0.01$ respectively
2. self-seeded WC growing in RG–CC plots

in clover root weevil feeding in relation to the Suscon treatment.

Root nematodes
Only 1% of the clover cyst nematode (*Heterodera trifolii* Goffart) sampled from WC and CC plants were associated with CC ($P<0.01$). Thirty per cent of the lesion nematode (*Pratylenchus* spp.), and 83% of root knot nematode (mostly *Meloidogyne hapla* (Chitwood)) occurred with CC (n.s.). Numbers of spiral (*Helicotylenchus labiatus* Roman) and stubby root (*Paratrichodorus minor* (Colbran) Siddiqi) nematodes were not affected by clover species (Table 3). The proportions of nematode numbers associated with each clover species closely followed accumulated data from long-term monitoring in the grazed pasture.

Table 2 Numbers of leaf feeding notches attributed to clover root weevil adults on leaves of caucasian clover (CC) and white clover (WC) within ryegrass–CC pasture, and on WC in ryegrass–WC pasture, with and without Suscon Green treatment.

	No. notches/ leaf	% leaves with notches	% notches with multiple feeding
CC	1.04 ± 0.09	61 ± 5	34 ± 7
WC with CC	0.50 ± 0.12	36 ± 6	30 ± 9
WC alone	0.78 ± 0.07	46 ± 4	57 ± 7
sign. of CC vs WC	ns	ns	ns
- Suscon	0.86 ± 0.10	53 ± 4	51 ± 5
+ Suscon	0.87 ± 0.09	50 ± 4	43 ± 4
	ns	ns	ns

Table 3 Numbers of five main plant-parasitic nematodes in soil associated with isolated plants of white and caucasian clover within pasture plots in June 1997.

	----------------- [1]No./250 ml soil -----------------		
	White clover	Caucasian clover	SED
Heterodera	4.14 (89)	0.52 (1)	0.57*
Meloidogyne	1.96 (18)	3.99 (86)	0.87
Pratylenchus	3.89 (96)	3.67 (40)	0.89
Helicotylenchus	(110)	(196)	
Paratrichodorus	(37)	(37)	

[1]Statistical analysis on $\log_e$ transformed data (with raw means shown in parentheses)

Discussion

Herbage yield
Under the conditions of establishment on this site, CC outperformed WC in the 2nd and 3rd years, showing particular advantages in summer–autumn. This period can have determining effects on white clover persistence and, through forage quality and quantity, on seasonal milk production. Pasture-fed production provides New Zealand dairy farmers with their greatest advantage in international competitiveness. Pasture-based output is enhanced by vigorous clover, as a quality forage and a cheap source of soil nitrogen. For these reasons improved summer–autumn pasture clover content could provide advantages for the dairy industry. CC in this trial showed potential to meet suggested targets for 50% clover content in summer pasture (Harris 1997).

Pests
There was little evidence to suggest that CC and WC differ widely as a food source for our major insect pests. Grass grub numbers in RG–CC were similar to those in RG–WC pasture, consistent with observations by Dymock *et al*. (1989) that the clover species supported similar larval growth rates. Grass grub numbers often peak in the 2nd to 4th year in new pasture, after which numbers tend to stabilise at lower populations as a result of build-up of diseases, or reduced food quality from reduced pasture clover content. In this trial it will be interesting to determine if grass grub numbers follow this pattern or continue to increase on CC until major damage occurs. Tasmanian grass grub had slightly reduced populations in CC compared with WC pasture in 2nd and 3rd years. This may be related to the ovipositional preferences for TGG favouring open ground cover in January (Willoughby pers. comm.). Nothing is known about the effect of clover root weevil in CC but recent experience in Waikato WC pasture suggests that populations will increase rapidly in the next year or two.

CC supported much reduced populations of the root invading clover cyst nematode than WC. However, populations of the root knot nematode, *M. hapla*, were higher under CC. The apparently greater susceptibility of CC for *M. hapla* may negate some of the advantages of cyst nematode resistance. The predominant root knot nematode in the North Island is *M. trifoliophila* Bernard & Eisenbach, which has been shown to reduce seedling vigour of both WC and CC (Watson unpubl. data).

Although it can be difficult to establish, CC has a reputation for persistence, and a greater range of adaptability than WC for soil fertility, grazing management and climatic extremes. The major production advantages from CC-based pasture in this study occurred in the summer–autumn period in the second year and from spring–autumn in the third year.

Extra DM was largely from legume production, thus adding to forage quality and quantity at a time of year when both can limit animal performance. This study suggests for the first time that CC may have a role both in dairying systems, and in northern temperate areas of New Zealand.

Since successful establishment is vital to achieving early advantages from CC, factors which probably contributed to good establishment and production in the present study should be noted:

- sowing after cropping to ensure reduced pest and disease burdens at planting;
- use and optimum treatment of efficient nodulating bacteria to maximise early nodulation;
- adequate sowing rate to maximise early leaf cover and spread of nodulating bacteria;
- early spring sowing to establish a good root system before onset of summer drought and to ensure a strong healthy plant size going into the first winter;
- sowing as pure species using a roller drill, with later undersowing of grass to minimise plant competition until rhizome initiation;
- light grazing during the first six months to maximise leaf growth and root–rhizome development;
- use of adequate fertiliser to achieve the growth potential of the plant.

Conclusions

CC is slow to establish but has shown potential to make a greater contribution to summer and autumn forage quality and production than white clover as soon as the second year. CC has similar acceptability and nutritional qualities to WC for stock and is compatible with rotational dairy grazing systems. While it has a similar host status to WC for pasture insect pests such as grass grub, Tasmanian grass grub and the clover root weevil, it may have greater pest tolerance because of its contrasting growth habit.

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