

# Caucasian clover/ryegrass produced more legume than white clover/ryegrass pastures in a grazed comparison

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## Abstract

The potential of caucasian clover to improve the legume content of lowland New Zealand pastures should result in enhanced animal performance. Liveweight gains from eight flocks of ewe lambs rotationally grazing irrigated ryegrass pasture with caucasian or white clover at two levels of soil fertility (Olsen P values 10 or 22) were compared during years 2 (1998/1999) and 3 (1999/2000) of an ongoing grazing experiment in a lowland environment. Clovers were sown in December 1996 and ryegrass in March 1997 into the pure clover swards. Lamb liveweight gains were similar in year 2 (1130 kg/ha/yr), but in year 3, gains were greater on pastures sown with caucasian than on those sown with white clover (1290 vs. 1110 kg/ha/yr). Spring liveweight gains per head per day averaged 170 g/hd/d in year 2, and in year 3 were greater from caucasian than white clover pasture (180 vs. 160 g/hd/d). Caucasian clover pastures had more legume on offer than pastures sown with white clover in year 2 (26% vs. 17%) and year 3 (19% vs. 12%). In year 3, 39% of the total legume on offer in caucasian clover pastures was volunteer white clover. Soil fertility had little influence on results. Early years of this grazing experiment showed that caucasian clover can establish as well as white clover if sown alone, and that sowing caucasian clover can result in lowland pastures with an increased total legume content which may improve liveweight gains.

**Keywords:** legume content, *Lolium perenne*, pasture production, sheep liveweight gain, *Trifolium ambiguum*, *T. repens*

## Introduction

Caucasian clover (*Trifolium ambiguum*) has demonstrated persistence and competitiveness in New Zealand hill and high country pasture (Allan & Keoghlan 1994; Scott 1998; Woodman *et al.* 1992). Caucasian clover is now also recognised as having potential in lowland intensive farming systems where white clover (*Trifolium*

*repens*) suffers abiotic (drought, high soil-surface temperatures) and/or biotic (grass grub, nematode, virus, weevil) stress. For example, caucasian clover has survived summer drought and nematode attack better than white clover on light volcanic soils in coastal Bay of Plenty (Watson *et al.* 1998; Watson *et al.* 1996a). Where perennial grass competition presents the major stress on pasture legumes, caucasian clover has also been more productive than white clover in lowland irrigated (Moss *et al.* 1996) and unirrigated pastures (Black & Lucas 2000).

The ability of caucasian clover to improve the legume content of lowland pastures should result in corresponding increases in animal production (Askin *et al.* 1987; Harris *et al.* 1997; Stevens *et al.* 1993). Caucasian clover nutritive value and acceptability by livestock are similar to white clover (Allinson *et al.* 1985; Hill *et al.* 1995), and liveweight gains from lambs grazing pure stands are comparable to those from birdsfoot trefoil (Sheaffer *et al.* 1992). However, livestock production from caucasian clover and white clover in mixtures with perennial grass have not been compared.

The objective of this research was to compare liveweight gains from lambs grazing perennial ryegrass (*Lolium perenne*) pastures sown with either caucasian clover or white clover at high or low soil fertility. Results are presented from the second (year 2) and third (year 3) spring, summer, autumn seasons of an ongoing grazing experiment.

## Materials and methods

The grazing experiment at Lincoln University, on a Templeton silt loam, used a 2<sup>2</sup> factorial design in a Latin square arrangement where ryegrass pastures sown with caucasian clover or white clover were compared at high or low soil fertility with eight replicates. Eight flocks of lambs each grazed four plots of the same treatment so that there were two animal replicates of the 2<sup>2</sup> design.

Hexaploid 'Endura' caucasian (6 kg/ha) or 'Grasslands Demand' white (2 kg/ha) clovers were sown in December 1996 into 0.04 ha plots. Superphosphate (9% P, 12% S) was applied at 1 t/ha to the 16 high-

fertility plots after sowing. Lime was applied at 1 t/ha to all plots after sowing. Caucasian clover seed was inoculated heavily with the specific *Rhizobium* strain ICC148 (Pryor *et al.* 1998). Post-emergence herbicides were used to control dicotyledonous weeds. 'Grasslands Ruanui' zero endophyte (*Neotyphodium lolii*) ryegrass seed was direct-drilled at 15 kg/ha into the pure clover turf in March 1997. The high-fertility plots had an Olsen P of 22 and the low-fertility plots had an Olsen P of 10 in May 1998 (Table 1). Sulphur superphosphate (8% P, 19% S) was applied at 250 kg/ha to the high-fertility plots in November 1999. Plots were irrigated regularly over summer using a soil water budget based on weekly rainfall and evapotranspiration data.

Shorn Coopworth ewe lambs, stratified for liveweight ( $32 \pm 7$  kg), were allocated to eight flocks in February of each year. Each flock rotationally grazed a 0.16 ha farmlet of four plots of the same treatment from September 1998 to June 1999 in year 2 and from September 1999 to May 2000 in year 3. Rotations were short in spring/early summer ( $16 \pm 2$  days) and long ( $28 \pm 2$  days) in late summer/autumn to provide a grazing management strategy suitable for both clovers (Lucas *et al.* 1998). Plots were not grazed in winter. Stocking rate averaged 45 sheep/ha and was adjusted using a put-and-take method at each weighing to achieve similar pasture allowances for all flocks (2.4 kg DM/hd/d in year 2 and 2.6 kg DM/hd/d in year 3). Anthelmintic drenches and pour-on dip were administered when necessary to control sheep parasites. Pastures were topped in late spring–summer to reduce ryegrass and annual grass (barley grass (*Hordeum* spp.) and goose grass (*Bromus hordeaceus* syn *B. mollis*)) seedheads in pastures.

### Measurements

Pre- and post-grazing pasture masses were measured using a capacitance meter. The capacitance meter was calibrated against five dry matter (DM) cuts of both pre- and post-grazing pasture mass per treatment and re-calibrated in each 'pasture season' according to L'Huillier & Thomson (1988). Pre- and post-grazing legume contents were determined by dissecting a sub-sample of bulked, mixed herbage from 20 random cuts per plot. Legume and grass components sampled in the autumns of 1998 and 1999 were analysed for crude protein (CP) and organic matter digestibility (OMD).

Sheep were weighed before and after every second rotation in spring/early summer and each rotation in late summer/autumn. Sheep were not weighed from 23 December 1998 to 2 March 1999 but grazing days (Gd) per farmlet (mean 382 Gd) were recorded.

Dry matter production and legume content were measured independently of the grazing sheep within one caged area per plot over 20 growth periods of  $28 \pm 2$  days from September 1998 to June 2000. New areas to be excluded from grazing were mown to 30 mm at the start of each 28-day period. After every period, herbage within one 0.2 m<sup>2</sup> quadrat per plot was cut to 30 mm above ground level and sub-samples from these cuts were dissected to determine botanical composition before drying.

### Statistical analysis

Significant ( $P < 0.05$ ) agronomic treatment differences were determined using two-way analysis of variance according to the Latin square design. Liveweight gain differences were determined according to the 2<sup>2</sup> factorial design for the two animal replicates.

## Results

### Pasture mass and grazing days

Pre-grazing pasture mass in year 2 was similar across all four treatments and averaged 2210 kg DM/ha (Table 2). The mean pasture mass on offer in year 3 was also similar between clover treatments, but greater ( $P < 0.05$ ) in high-fertility rather than low-fertility pastures (2490 vs. 2330 kg DM/ha). Post-grazing pasture mass averaged 1240 kg DM/ha in year 2 and 1330 kg DM/ha in year 3. Total grazing days per farmlet in year 2 averaged 1535 Gd. In year 3, the sum of grazing days was similar between clover treatments, but greater ( $P < 0.05$ ) from high- than low-fertility farmlets (1543 vs. 1454 Gd).

### Pasture legume content

Caucasian clover pastures had a higher ( $P < 0.05$ ) pre-grazing legume content than pastures sown with white clover in year 2 (26% vs. 17%) and year 3 (19% vs. 12%) (Table 2). Legume content was similar between fertility treatments in both years. Of the percentage of legume on offer in the caucasian clover pastures in year 3, 39% was identified as volunteer white clover.

**Table 1** Soil Quick Test means from the 26 May 1998 sampling of four high-fertility (plus fertiliser) and four low-fertility (no fertiliser) farmlets.

	pH	Ca	K	Olsen P	Mg	Na	S(SO <sub>4</sub> )
High-fertility	6.1	10	13	22	23	10	14
Low-fertility	6.3	10	15	10	27	13	9

**Table 2** Mean pre- and post-grazing pasture masses (kg DM/ha), grazing days per farmlet, pre-grazing legume content (%), and sheep liveweight gain (kg/ha/yr) from caucasian and white clover pastures at high- (plus fertiliser) and low-fertility (no fertiliser) during year 2 (September 1998 to May 1999) and year 3 (September 1999 to May 2000).

Treatment	Pre-grazing mass (kg DM/ha)	Post-grazing mass (kg DM/ha)	Grazing days	Pre-grazing legume content (%)	Liveweight gain* (kg/ha/yr)
----- Year 2 -----					
Caucasian clover	2160	1220	1514	26	1110
White clover	2260	1260	1556	17	1140
High-fertility	2230	1240	1539	22	1150
Low-fertility	2190	1240	1530	21	1110
SEM	35	22	7.1	0.6	11
----- Year 3 -----					
Caucasian clover	2420	1310	1507	19	1290
White clover	2400	1350	1490	12	1110
High-fertility	2490	1350	1543	14	1230
Low-fertility	2330	1310	1454	15	1160
SEM	30	19	4.5	0.8	4

\*Liveweight gain not recorded from December 1998 to March 1999 (mean 382 Gd)

Post-grazing pasture mass had a lower proportion of green clover and grass, and more dead material than in the pre-grazing pasture mass ( $P < 0.05$ ).

**Pasture nutritive value**

In the autumns of 1998 and 1999, the nutritive values of clover species were similar (caucasian clover: 28.5% CP and 85.2% OMD vs. white clover: 28.3% CP and 86.2% OMD). However, the nutritive value of ryegrass from caucasian (22.0% CP and 80.2% OMD) and white (23.1% CP and 81.5% OMD) clover pastures differed ( $P < 0.05$ ), but was similar between fertility treatments.

**Liveweight gain**

Sheep liveweight gains in year 2 were similar across all four treatments during spring (170 g/hd/d) and autumn (127 g/hd/d) and averaged 1130 kg/ha/yr (Table 2). However in year 3, sheep grew faster ( $P < 0.05$ ) on pastures sown with caucasian than white clover (1290 vs. 1110 kg/ha/yr). Liveweight gains per head per day were greater ( $P < 0.05$ ) from sheep grazing caucasian than white clover pastures in spring (180 vs. 160 g/hd/d) and autumn (124 vs. 112 g/hd/d), but were similar in summer (81 g/hd/d) when mean liveweight of ewe hoggets was  $60 \pm 8$  kg. More ( $P < 0.05$ ) liveweight per hectare was produced on high- than low-fertility farmlets (1230 vs. 1160 kg/ha/yr) because of the higher carrying capacity of high-fertility farmlets. Liveweight gains per head per day were similar between fertility treatments.

**Dry matter production from 28-day harvests**

Total DM production after 10 months in year 2 (September 1998 to June 1999) was similar across all

**Table 3** Total dry matter production (t DM/ha) and mean legume content (%) from caucasian and white clover pastures at high- (plus fertiliser) and low-fertility (no fertiliser) during year 2 (September 1998 to June 1999) and year 3 (July 1999 to June 2000).

Treatment	----- Year 2 -----		----- Year 3 -----	
	Total yield (t DM/ha)	Legume content (%)	Total yield (t DM/ha)	Legume content (%)
Caucasian clover	16.6	29	16.8	21
White clover	16.1	18	16.2	13
High-fertility	16.8	24	17.3	15
Low-fertility	15.9	24	15.7	19
SEM	0.35	0.8	0.23	0.9

four treatments and averaged 16.3 t DM/ha (Table 3). Production was also similar between clover treatments after 12 months in year 3 (July 1999 to June 2000), but was greater ( $P < 0.05$ ) from high- than low-fertility pastures (17.3 vs. 15.7 t DM/ha).

Pasture production rates in year 2 were similar across all four treatments and averaged 63 kg/ha/d (Figure 1). However in year 3, caucasian clover pastures had a higher ( $P < 0.05$ ) mean production rate than pastures sown with white clover (58 vs. 55 kg DM/ha/d). Production rates in November 1998 averaged 98 kg DM/ha/d from all treatments, and in May 1999 dropped to 27 kg DM/ha/d for white clover compared with 18 kg DM/ha/d for caucasian clover ( $P < 0.05$ ). In February 2000, caucasian clover pastures reached 90 kg DM/ha/d compared with 75 kg/ha/d for white clover ( $P < 0.05$ ), but in May 2000 dropped to 11 kg DM/ha/d

compared with 15 kg DM/ha/d for white clover ( $P < 0.05$ ). Over both years, high-fertility pastures had a higher ( $P < 0.05$ ) mean production rate than low-fertility pastures (62 vs. 58 kg DM/ha/d).

### Legume content from 28-day harvests

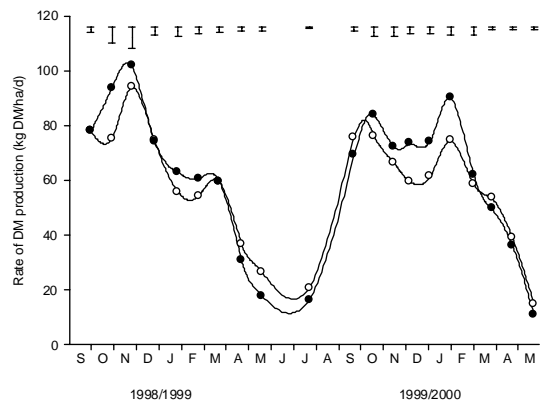
Caucasian clover pastures produced more ( $P < 0.05$ ) legume than pastures sown with white clover during year 2 (29% vs. 18%) and year 3 (21% vs. 13%) (Table 3). Specifically, more ( $P < 0.05$ ) legume was produced in caucasian than in white clover pastures between October and May of each year (Figure 2). In December 1998, caucasian clover pastures reached 40% legume compared with 28% for white clover ( $P < 0.05$ ), but in June 1999 dropped to 4% legume compared with 6% for white clover ( $P < 0.05$ ). Similarly in year 3, caucasian clover pastures reached 34% legume in January 2000 compared with 21% for white clover ( $P < 0.05$ ), before both treatments dropped to 3% legume in June 2000. Of the total legume produced in caucasian clover pastures in year 3, 41% was identified as volunteer white clover. Legume content was similar across fertility treatments in year 2 (24%), but lower ( $P < 0.05$ ) in high- than low-fertility pastures in year 3 (15% vs. 19%) (Table 3).

### Discussion

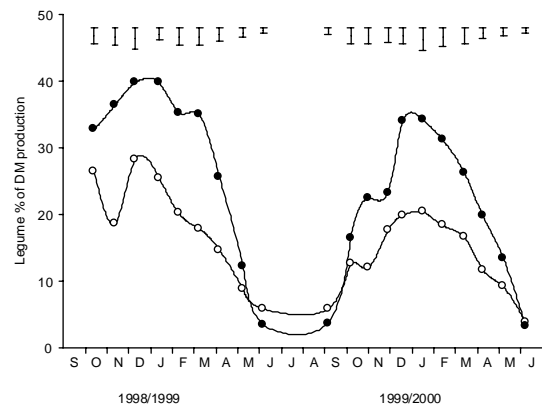
The percentage of legume required to have any significant effect on animal performance is generally considered to be much higher than the current low average of 10–20% found in many New Zealand white clover/ryegrass pastures (Caradus *et al.* 1996; Chapman *et al.* 1995). Thomson (1984) recommended that a mixed pasture should contain at least 30% legume, while Harris *et al.* (1997) showed summer pasture legume contents of 50–65% are required to achieve near maximum, per cow, milk production. In our experiment, caucasian clover pastures showed potential to approach these target legume contents, particularly in summer when legume content averaged 38% compared with only 25% for white clover (Figure 2).

Moss *et al.* (1996) demonstrated higher legume contents (28% vs. 10%) and greater dry matter production (15 vs. 12 t DM/ha) from 3-year-old caucasian clover/ryegrass rather than white clover/ryegrass pastures in an irrigated fertile environment at Winchmore, Canterbury. In our experiment, vigorous caucasian clover growth did not significantly enhance total dry matter production, and annual yields of at least 16 t DM/ha were reached from both clover treatments. This may be attributed to the greater competitiveness of caucasian clover against perennial ryegrass, which resulted in lower grass yields from

**Figure 1** Dry matter production rates (kg DM/ha/d) from caucasian (●) and white (○) clover pastures during year 2 (September 1998 to June 1999) and year 3 (July 1999 to June 2000). Vertical bars represent one standard error of the mean.



**Figure 2** Total legume contents (%) in caucasian (●) and white (○) clover pastures during year 2 (September 1998 to June 1999) and year 3 (July 1999 to June 2000). Vertical bars represent one standard error of the mean.



caucasian than from white clover pastures (11 vs. 12 t DM/ha).

White clover demonstrated its greater cool season activity in early spring and late autumn while caucasian clover was more vigorous than white clover in summer. This can be partially explained by earlier findings, which describe caucasian clover as having a higher base temperature (4.2°C) and thermal time requirement or phyllocron (279°Cd) for leaf appearance than white clover (3.1°C, 173°Cd) (Black 1998).

The total legume content of caucasian clover pastures in the third year contained a noticeable proportion of volunteer white clover (probably 'Huia') arising from hard seed surviving in the soil for 16

years since the area was last in permanent pasture. This mixture of the two clover species represents what is most likely to happen even where caucasian clover is sown without white clover because of the widespread presence of white clover seed in New Zealand pastoral land. Elliot *et al.* (1998) discussed the possibility of poor sociability between caucasian and white clover because of rhizobial incompatibility. However, in this and other experimental sowings (e.g., Black & Lucas 2000; Moss *et al.* 1996; Watson *et al.* 1996b), caucasian clover has appeared to be complementary rather than competitive towards white clover.

Liveweight gains from lambs grazing all four treatments were within the expected range for perennial ryegrass-dominant pasture with 10–30% legume (Askin *et al.* 1987; Ryan & Widdup 1997). The relatively low pasture allowances and the use of ewe lambs would have limited liveweight gain potential. In contrast, the use of zero endophyte 'Ruanui' ryegrass and the maintenance of a high proportion of green leaf material in the pastures ensured herbage of high nutritive value. In addition, caucasian and white clover forage had similar high nutritive values, which supports similar findings by Allinson *et al.* (1985). Animal disorders and production depressions associated with wild-type endophyte from infected ryegrass (Fletcher *et al.* 1999) were also avoided by the use of zero-endophyte ryegrass.

The relatively low pasture allowance and pre- and post-grazing pasture masses in year 2 would have limited our ability to convert the higher total legume content on offer in the caucasian clover pastures into a significant difference in liveweight gain. In contrast, the significant difference in liveweight gain between clover treatments in the third year may have been assisted by the slightly greater pasture allowance on offer and greater pre- and post-grazing pasture masses. This could have presented increased opportunities for clover selection by the sheep (Askin *et al.* 1987).

While this paper is focused on pasture production, legume composition and sheep liveweight gain, it should be noted that both clovers established successfully from an early December sowing and the use of appropriate post-emergence herbicides. The direct-drilling with ryegrass 4 months later in March was more successful in caucasian than white clover plots partly because the white clover stolons presented more resistance to the drill coulter but also because white clover was more active than caucasian clover as temperatures declined through April and May. This sowing strategy has also been successful in other experimental sowings (e.g., Watson *et al.* 1996b).

The small differences in pasture and animal performance between fertility treatments indicated that

the initial soil fertility was adequate for sheep production from pasture. It is anticipated that these responses will become more obvious in subsequent years as soil fertility in the low-fertility treatments slowly declines while the high-fertility treatments are maintained at Olsen P>20 and sulphate-S>8. There may be a decline in legume content in the white clover-plus-fertiliser treatment as soil nitrogen builds up and ryegrass becomes more competitive. It remains to be seen if caucasian clover can maintain its vigour against ryegrass as soil nitrogen increases over time. If this interaction is demonstrated it will provide a strong incentive to sow caucasian clover in pastures which are designed to last more than about 6 years.

## Conclusions

The preliminary results from this ongoing comparison of caucasian with white clover in ryegrass pastures, showed that caucasian clover can make a significant contribution to lowland livestock production systems. Specific conclusions were:

1. Excellent caucasian clover/ryegrass pastures can be established by sowing caucasian clover in spring and direct-drilling the ryegrass in the following autumn.
2. Caucasian clover/ryegrass pastures plus volunteer white clover have higher total legume contents than white clover/ryegrass pastures.
3. Increased sheep liveweight gains can be demonstrated from pastures with enhanced total legume content.

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