Potential and pitfalls of caucasian clover in southern New Zealand

D.R. STEVENS[1] and B. MCCORKINDALE[2]
[1] *AgResearch Invermay, Private Bag 50034, Mosgiel*
[2] *Agriculture New Zealand, P.O. Box 148, Balclutha*
david.stevens@agresearch.co.nz

Abstract

The potential of caucasian clover (*Trifolium ambiguum* M. Bieb.) to produce high quality forage and to establish in on-farm conditions was tested in southern New Zealand. Caucasian clover was established alone and after one year the plots were oversown with ryegrass, in November. After a further 6-month establishment period, dry matter (DM) yield and botanical composition were measured over the following two years. A 2 x 2 factorial design tested the effects of early or late flowering ryegrass and frequent (2 weeks in spring, 4 weeks in summer and autumn and twice during winter) or infrequent (4 weeks in spring, 6 weeks in summer and autumn, and once in winter) defoliation. Plots defoliated frequently produced less dry matter than infrequently defoliated plots (13260 and 16180 kg DM/ha respectively in year 1 and 9980 and 12250 kg DM/ha respectively in year 2, $P<0.01$) and had a lower percentage of caucasian clover (62 and 68% respectively in year 1, $P<0.05$; 50 and 56% respectively in year 2, $P<0.05$). Ryegrass flowering date had no effect on total, seasonal or compositional yields. On-farm experimentation investigated establishment methods, included direct drilling, pasture to pasture and following a brassica crop. Caucasian clover was sown alone at 4 kg/ha coated seed (Prillcote®) with 375 kg/ha drilling superphosphate (0-9-0-11) in November 2000. Four rates of nitrogen (0, 25, 50 and 100 kg/ha urea (46% N)) were applied in February, after emergence. Plant numbers were lowest in the direct drilled paddocks, intermediate in the pasture to pasture sowings and greatest following a brassica crop (3.5, 6.5 and 10.6 plants/m^2 respectively, $P<0.05$). Rhizome length, taproot length and taproot weight were not significantly affected by either establishment method or nitrogen fertiliser. Competition from weeds, especially grasses, was the biggest single factor influencing plant number. Though caucasian clover has the potential to produce large amounts of high quality herbage, establishment problems restrict its' use.

Keywords: defoliation, establishment, fertiliser, growth, methods, *Trifolium ambiguum*

Introduction

Caucasian clover (*Trifolium ambiguum* M. Bieb.) is a slow establishing, long lived perennial pasture legume. It has a large network of fibrous roots and spreads by rhizomes. Once established it has shown the ability to produce high quality spring and summer forage and competes well with companion grasses in some regions of New Zealand (Watson *et al.* 1996; Moss *et al.* 1996; Black & Lucas 2000).

Lowland southern New Zealand has a reliable rainfall and consistently produces large quantities of pasture. White clover based pastures provide good clover growth for the first two to three years after establishment, after which management manipulations such as hard late spring grazing, cattle grazing and chemical topping are required to improve summer clover production and achieve high animal performance. Caucasian clover, once established, produces well during summer (Black *et al.* 2000; Moss *et al*. 1996) and fixes nitrogen in amounts similar to white clover (Widdup *et al.* 2001). This makes caucasian clover a potential substitute for white clover.

Before the potential of caucasian clover can be reached, two key issues must be addressed. The first is the inability of caucasian clover to tolerate frequent grazing (Lucas *et al.* 1998), as management practises in southern New Zealand include long periods of frequent or continuous grazing. A second feature is the slow establishment of caucasian clover (Widdup *et al.* 1998). Sowing caucasian clover alone has been used with some success (Watson *et al.* 1996). Sowing methods may have a role in the success of initial plant establishment. Nitrogen fertiliser may also help increase root mass through stimulating extra shoot and leaf growth.

This study aimed to determine the on-farm potential of caucasian clover through the investigation of the response of caucasian clover to grazing management and various on-farm establishment practices in southern New Zealand.

Methods

Experiment 1: Potential production in Southern New Zealand

Caucasian clover, cv Endura, seed was broadcast at 3kg/ha and raked into the soil, with 250 kg/ha molybdic superphosphate (0-9-0-11) on 23rd October 1997 in 1 x 2 m plots on a Wingatui silt loam soil at the Invermay Agriculture Centre, Mosgiel, New Zealand. One year after establishment in November 1998 the plots were oversown with ryegrass at 18 kg/ha, after a close defoliation. The ryegrass was given 6 months to establish before dry matter yield and botanical composition were

measured over the following two years from 1st June 1999.

The experiment was a 2 x 2 factorial design in a completely randomised block. Two fine-leaved ryegrass cultivars of differing flowering date, Aries HD, (standard flowering) and an experimental breeding line (late flowering) were sown. Two defoliation regimes were imposed. One defoliation was frequent (2 weeks in spring, 4 weeks in summer and autumn and twice during winter) and the other infrequent (4 weeks in spring, 6 weeks in summer and autumn, and once in winter). Plots were mown to 2-cm at each defoliation. A fertiliser return was applied on an annual basis, based on 3.5% K and 0.35% P in the herbage, as a mixture of muriate of potash (0-0-35-0) and superphosphate (0-9-0-11).

Pasture yield and botanical composition were measured at each cut. Data were combined and analysed season by season using a standard analysis of variance (GENSTAT, Version 4.2).

Experiment 2: On-farm establishment

Six farms were chosen throughout South and West Otago on relatively similar clay downs sites. Caucasian clover, cv Endura, was sown alone at 4kg/ha coated seed (Prillcote®) in early to mid-November 2000 with 375 kg/ha drilling superphosphate. Sown areas ranged from 1.5 to 2.5 ha. Post-emergence herbicide was applied to all farms. One site was sprayed with Preside at 65 g/ha, but some plant damage was noted, and the rest of the sites were sprayed with MCPB at 6 ℓ/ha.

The experiment was a completely randomised 3 x 4 split plot design. Main plots were three establishment methods, which were direct drilling, grass to grass, and following a swede crop. Two farms were used for each main plot. Sub-plots were four nitrogen fertiliser treatments, which were 0, 25, 50, or 100 kg urea/ha, applied in early February 2001.

Direct drilling was done 7-10 days after spraying with 2.88 kg/ha glyphosate (Roundup Xtra 480 g/ℓ a.i.), with a tilling coutler drill, followed by a cover harrow. Grass to grass was done by cultivation after spraying with 1.44-1.92 kg/ha glyphosate, with approximately 2 weeks from grass to sowing, with seed oversown onto a rolled seed bed and cover harrowed. Following a swede crop the establishment was done without chemical spray at one site and with 1.44 kg/ha glyphosate at the other to control Californian thistles before cultivation and roller drilled.

The plots were left for 8 to 10 weeks before the first defoliation. Three of the farmers (one per establishment method) used grazing before topping while the other three topped first. Those three farmers continued to graze at regular intervals while the other three only grazed the plots once more before assessment.

Plots were measured on the 29 and 30th of May 2001. Plant numbers were counted in ten 0.295m^2 quadrats per plot. Between six and thirteen plants were removed from each plot, depending on availability. Measurements included number of vegetative crowns, the number and length of underground rhizomes, the length and dry weight of the root, and the presence or absence of nodules.

Results

Experiment 1: Potential production in Southern New Zealand

Pasture production (Table 1) was not significantly affected by defoliation regime for the first winter and

Table 1 Seasonal and annual total yields (kg DM/ha) of caucasian clover/ryegrass pastures under differing defoliation regimes or when sown with ryegrasses of differing flowering dates.

		Defoliation Regime		Ryegrass Type		
		Frequent	Infrequent	Early Flowering	Late Flowering	LSD
1999-2000						
	Winter	420	450	460	400	123
	Spring	6280	6880	6870	6490	727
	Summer	4720 a[1]	6760 b	5740	5750	290
	Autumn	1840 a	2100 b	2060	1870	254
	Annual	13260 a	16190 b	15130	14510	721
2000-2001						
	Winter	590 a	820 b	730	680	99
	Spring	3270 a	4790 b	4180	4180	376
	Summer	4800 a	5600 b	5260	5140	211
	Autumn	1020	1040	1030	1030	156
	Annual	9680 a	12250 b	11200	11030	522

[1] differing letters denote significant difference (P<0.05).

spring, and the final autumn, but was significantly lower ($P<0.05$) for the remainder of the experiment when frequently defoliated. The heading date of the ryegrass chosen as a companion species had no significant effect on seasonal or annual pasture production (Table 1).

Caucasian clover produced 65% and 53% of the total herbage during 1999-2000 and 2000-2001 respectively (Table 2). Frequent defoliation reduced the percentage of caucasian clover produced during both years. The percentage of ryegrass in the pasture was unaffected by defoliation regime, averaging 30 and 38% in the two years respectively (Table 2). The percentage of other species was greater in frequently rather than infrequently defoliated plots in both years (Table 2). The amount of white clover was very low, averaging 1 to 1.5% of the total dry matter produced. Ryegrass heading date had no significant effect on the botanical composition of the plots throughout the trial.

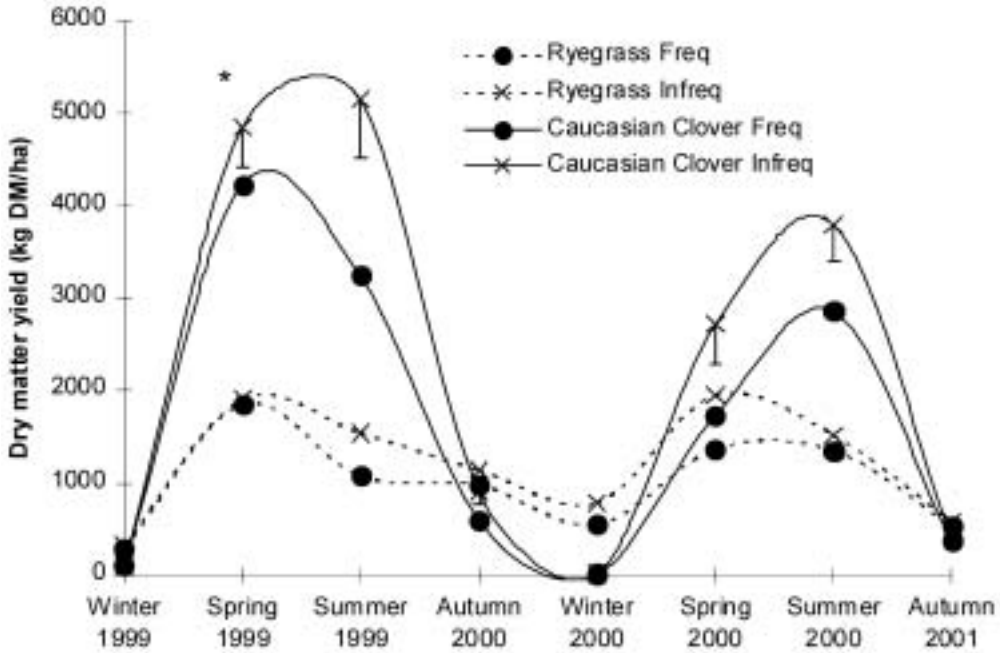
The dry matter yield of caucasian clover was greater during spring and summer in both years when infrequently defoliated compared to frequent defoliation (Figure 1). This difference was also present during the

Table 2 Annual botanical composition (% of dry weight) of caucasian clover/ryegrass pastures under differing defoliation regimes or when sown with ryegrasses of differing flowering dates.

		Defoliation Regime		Ryegrass Type		
		Frequent	Infrequent	Early Flowering	Late Flowering	LSD
1999-2000						
	Caucasian Clover	62 a[1]	68 b	63	67	5.4
	Ryegrass	31	30	32	29	5.8
	Other Species	6 a	1 b	4	3	1.3
	Dead	1	1	1	1	0.5
2000-2001						
	Caucasian Clover	50 a	56 b	53	53	6
	Ryegrass	38	39	38	39	5
	Other Species	11 a	3 b	7	7	1.9
	Dead	1.5	1.5	1.6	1.4	0.3

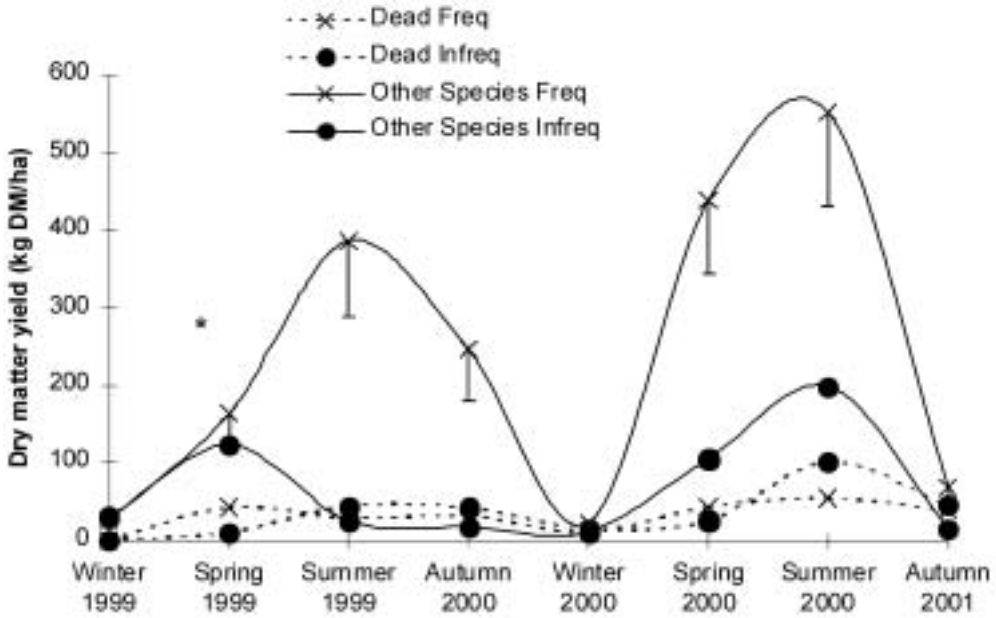
[1] differing letters denote significant difference ($P<0.05$).

Figure 1 The seasonal yields of caucasian clover and ryegrass in caucasian clover/ryegrass pastures over two years when subjected to frequent or infrequent defoliation.



* Significance is denoted by LSD bars.

Figure 2 The seasonal yields of other species and dead matter in caucasian clover/ryegrass pastures over two years when subjected to frequent or infrequent defoliation.



* Significance is denoted by LSD bars.

autumn of 1999-2000. Ryegrass yields were greater in infrequently defoliated plots in the winter and spring of 2000-2001 (Figure 1).

The dry matter yield of other species was higher during spring and summer both years, and during autumn of 1999-2000 in frequently defoliated plots, than in plots infrequently defoliated (Figure 2). The yield of dead material was seldom different in the two defoliation treatments (Figure 2).

Experiment 2: On-farm establishment

The establishment method had a significant effect on plant numbers with direct drilling having the least and following swedes the most plants (Table 3). The use of nitrogen fertiliser in early February had no significant effect on plant numbers. The establishment method caused a difference in nodulation (Table 3) with following swedes having the highest number of plants with nodules while direct drilling had the least. No significant differences between establishment methods were detected in other root and shoot characteristics measured (Table 3).

Discussion

The high yields of caucasian clover under both frequent and infrequent defoliation highlight the potential of the species in lowland southern New Zealand. Maximum yields were obtained under infrequent defoliation, similar to that of a finishing system. Lucas *et al.* (1998) also reported a decline in caucasian clover content after frequent defoliation by sheep.

Table 3 Effects of establishment method, urea fertiliser and grazing on the establishment and development of caucasian clover.

	Establishment method				Urea (kg/ha)				
	DD[1]	GtoG[2]	FS[3]	LSD	0	25	50	100	LSD
Plant number (/m^2)	3.5 a	6.5 ab	10.6 b	5.8	6.2	6.4	7.8	7. 1	2.6
Vegetative shoots (number per plant	2.2	1.8	1.6	0.8	1.8	1.9	2.0	1.9	0.5
Underground rhizomes (number per plant)	1.6	1.9	1.9	3.3	1.5	1.9	2.1	1.8	0.7
Underground rhizome length (mm)	25	64	46	120	46	38	47	48	15
Taproot length (mm)	172	173	157	160	170	163	182	156	30
Root weight (g)	1.1	0.9	0.9	1.8	0.8	1.0	0.9	1.1	0.27
Proportion of plants with nodules	42 a	54 ab	83 b	30	59	66	60	53	22

[1] Direct drilling. [2] Grass to grass. [3] Following swedes.

Caucasian clover contents of 20 to 30% have been reported in other trials under grazing with ryegrass (Moss *et al*. 1996; Watson *et al*. 1998; Black *et al*. 2000). This experiment was done under cutting, with no clippings or nitrogen return. Therefore the development of the ryegrass may have been suppressed compared to a normal grazing situation. It is expected that the clover contents will decline with time as the ryegrass strengthens, though to date the ryegrass yields remained relatively low and unchanged between years.

The potential of caucasian clover in this highly fertile lowland soil is demonstrated by the annual yield during the first year of approximately 11 t clover DM/ha of the 16.2 t total DM/ha grown under the infrequent defoliation regime.

On-farm establishment was most effective when caucasian clover was sown following a brassica crop. Differences in final plant numbers may have been caused by sowing depth variations between treatments, slug damage in direct drilled plots, and variations in competition from other plants, but no data was collected to confirm this. Sowing 4 kg/ha of coated seed is the equivalent of approximately 2.3 kg/ha bare seed. The effective establishment after 6 months was calculated to range from 6 to 18% of the seeds sown. This is lower than the establishment measured 43 days after sowing by Hurst *et al*. (2000) who measured 57% without ryegrass and 40% with ryegrass. Sowing depth would have been deepest with direct drilling, though similar with the other two methods.

Changes in the nodule number may have been due to the later sowings with direct drilling, as the same seed line was used for all farms. Recommendations for Prillcote® are for no more than 1 week between processing and sowing. Field inspection showed successful nodulation across all sites by 12 months. The timing of the nitrogen application was delayed due to the cool and dry early summer conditions. The use of nitrogen may have been more effective if used earlier in moist conditions.

Overall the number and length of the rhizomes and root system was relatively low. The re-establishment of both grass and white clover occurred in both grass to grass and direct drilling situations, creating conditions of relatively high competition. The use of a post emergence spray with MCPB would have given better control of weeds following the brassica crop because of the few grass weeds present, while providing little control for the white clover and grass in the direct drilled and grass to grass situations. The cool and dry conditions during summer, as well as the frequent defoliations may also have contributed to the poor spread of the plants. Hill & Mulcahy (1995) found that vigorous competition from grasses at high soil fertility restricted the root and rhizome biomass. They also reported that frequent defoliation in the presence of such competition and drought was detrimental to caucasian clover seedling vigour and rhizome development. The effect of frequent grazing was observed in the current study but was not applied in a controlled way and therefore the results need more investigation. Hurst *et al*. (2000) also reported very low dry matter yields of caucasian clover during the first year when sown in swards with other grasses.

Conclusions

Frequent defoliation reduced the yields of both the caucasian clover and the associated ryegrass, while the flowering time of the ryegrass had no significant effect. Yields measured from this trial indicate that caucasian clover has the potential to produce high yields of high quality forage in southern New Zealand. Infrequent defoliation regimes will help maximise this potential. Winter pasture yields may be compromised when caucasian clover yields are high.

Establishment of caucasian clover under differing on-farm techniques was limited, though most successful after a crop. Initial seedling numbers may have been affected by sowing method, causing variations in sowing depth and exposure to pests. The study recognised that competition from other sown species would be important and sought to reduce that threat to establishment by sowing the caucasian clover alone. The final result of the study showed that excellence in all aspects of establishment is a must before contemplating using caucasian clover. The difficulties in establishing caucasian clover remain a hindrance to capturing its significant potential.

ACKNOWLEDGEMENTS

Thanks must go to Heather Pryor and Bill Lowther who established the plots used in the yield study, the farmers (D Gordon, C Hunter, P Labes, A & B Liggett, A Williamson and D & T Wilson) who volunteered sites for the establishment trial, MeatNZ and WoolPro for the Farmer Initiated Technology Transfer funding for the establishment trial, and Sue Smith and Ian Corson who assisted in field and laboratory work.

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