

Effect of sowing method and fertiliser application on establishment and first season growth of Caucasian clover

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Abstract

A trial to measure the effects of establishment techniques and fertiliser application on seedling establishment and early root and rhizome development of Caucasian clover (*Trifolium ambiguum*) was sown in early October 1992, on a low-fertility, depleted short tussock grassland site at Mesopotamia Station, South Canterbury. Three sowing techniques, broadcasting, sod seeding and strip seeding, each with, two rates of fertiliser, 150 or 300 kg/ha molybdc sulphur superphosphate, were used. By mid December, 48 and 38% establishment had occurred in the strip and sod seeding respectively, but only 9% in the broadcast. Strip seeding was the most successful technique, resulting in earlier rhizome and tap-root development and wider lateral spread of rhizomes. However, both strip seeding and sod seeding resulted in all plants developing rhizomes 9 months after sowing. Plants from broadcasting were small with few rhizomes in the first season. The higher fertiliser rate improved establishment and growth, particularly in the strip seeding treatment. By using a strip seeding technique Caucasian clover was established as rapidly as white clover and plants of both species were similar in size after 5 months.

Keywords: broadcast seeding, establishment, fertiliser, rhizomes, sod seeding, sowing methods, *Trifolium ambiguum*, *Trifolium repens*, tussock grasslands

Introduction

Caucasian clover shows great promise as a very persistent, competitive legume for the South Island hill and high country. It is a deep-rooted, drought-tolerant, spring- and summer-growing legume which can tolerate low winter temperatures and heavy frosts, and recovers quickly after drought (Dear & Zorin 1985; Woodman *et al.* 1992). Caucasian clover has an extensive root and rhizome system (Daly & Mason 1987) which acts as an important store for nutrients (Strachan *et al.* 1994). Allan & Keoghan (1994) found that Caucasian clover persisted under a wide range of

grazing management systems because the rhizomes and growing points were below ground level. Vegetative spread was observed by Dear & Zorin (1985) who found 4-year-old Caucasian clover cv. Monaro produced 74 daughter plants/plant and, had rhizomes nearly 500 mm in length.

Reports of slow establishment (Lucas *et al.* 1980; Scott 1985) and the lack of seed supplies have restricted the commercial use of Caucasian clover. This has led to proposals that rhizome fragments could be used as a means of establishment (Scott & Mason 1992). However, in contrast to Lucas *et al.* (1980), Lowther & Patrick (1992) reported seedling establishment of white clover and Caucasian clover to be similar.

The aims of this establishment trial were to measure the effects of sowing technique and fertiliser application on Caucasian clover seedling establishment and early root and rhizome development on a low-fertility, summer-moist, high-country site.

Material and methods

Experimental site and design

The experiment was sited on depleted, unimproved tussock grassland dominated by fescue tussock (*Festuca novae zelandiae*), brdwntop. (*Agrostis capillaris*) and *Hieracium pilosella* situated at Mesopotamia Station in the upper Rangitata valley. The soil, a Mesopotamia silt loam, is acid (pH 5.2) and low in phosphorus (Olsen P 6) and sulphur (S 2 ppm). The site is 500 m above sea level and has a mean annual rainfall of 940 mm. The experimental site was burnt to remove litter and sown with Caucasian clover (*Trifolium ambiguum* Bieb.) cv. Monaro on 1 October 1992 using the Lincoln Ventures/AgResearch experimental plot drill. Rainfall was reasonably evenly distributed during the establishment year with 133 mm of rain in the two months following sowing out of a total for spring of 167 mm (Table 1).

Seeds were scarified and commercially prepared as a special batch by inoculating with *Rhizobium* strain CC283B followed by coating with tine lime at a rate of 0.7 lime : 1.0 seed. Although no *Rhizobium* counts were done the inoculant was applied at 5 times the recommended rate, with the aim that the number of viable *Rhizobium* present on the seed would not be limiting. The inoculated, coated seed was stored at

Table 1 Seasonal rainfall and soil temperatures at Mesopotamia station, Rangitata valley, for the period 1992-1994.

Measurement		Seasonal distribution				Total rainfall
		spring	Summer	Autumn	Winter	
Rainfall (mm)	1992/93	167	191	235	406	646
Mean daily temperature (°C) [#]	1992/93	NA	NA	8.0^{##}	4.2	
Mean daily temperature (°C) [#]	1993/94	10.0	16.5	11.1	3.7	

Soil temperatures at 10 cm depth
From 16 April to the end of May
NA Not available

4°C for 1 day before sowing. The trial was a balanced incomplete block design with plots consisting of paired comparisons of all treatments. The trial was replicated twice with each paired plot 20 m in length. Seeding rate was **calculated** to place 100 viable seeds per metre of row. Treatments consisted of 3 methods of establishment: an experimental strip seeding system, direct seeding into the sod or broadcast. The strip seeding system, described fully by Horrell et al. (1991), used an inclined dished disc to cut and invert a ribbon of turf, placing it adjacent to the drilling strip. Next, a spring tine cultivated the soil and banded the fertiliser at a nominal depth of 50 mm. Finally a seed couler sowed the seed at a shallow depth (approximately 10 mm) and a press wheel firmed the seed bed. Two rows 150 mm apart were sown in the weed free 200 mm strip of bare soil. The sod seeding system used a Duncan 760 till seeder with a 'Baker' inverted T couler form of direct drilling, with fertiliser placed with the seed. It was also drilled in two rows 150 mm apart. The broadcast treatment was sown by the plot drill with seed and fertiliser falling directly from the **coulters** and spreading over a 200 mm wide strip.

Each of the establishment **methods** was sown with either 150 or 300 kg/ha of molybdenic sulphur super phosphate (8% P, 20% S). Basal boron was applied as a solution of borax (11% B) at 10 kg B/ha.

Trial measurements and data analysis

Early emergence and establishment was measured on 14 December 1992 with plant counts made along two 500 mm lengths of row from each paired treatment in each plot.

On 12 March 1993, one spade spit 200 x 150 mm was dug across each of the paired rows of sod and strip seeding treatments at median sites. Due to lack of uniform plant numbers in the broadcast treatment, spits were dug to obtain a minimum of 5 plants/treatment. Samples were washed and measurements recorded on nodulation, rhizome number/plant and rhizome length. Dry weights of shoots (above-ground herbage), roots and rhizomes were determined.

At the end of the first growing season on 6 July

1993, one 150 mm wide turf was dug across the paired rows of the sod seed and strip seeding treatments. The turfs were long enough to include all lateral rhizome development. Five plants were randomly selected for measurement from the broadcast treatments. Measurements were the same 'as the first sampling plus additional measurements of secondary rhizome number and length.

An adjacent fertiliser trial comparing responses of Monaro Caucasian clover and Grasslands Tahora white clover to rates of phosphate and sulphur was also sampled. Both species were established on 1 October 1992 using the strip seeding technique. The treatment sampled for this study had 50 kg/ha of both phosphorus and sulphur applied at sowing time. Three spits were **dug** from this Caucasian clover and white clover trial on 19 April 1993, and root, rhizome, stolon and leaf material measured.

The Genstat statistical package was used to analyse the paired plot design.

Results and discussion

Germination and establishment

The strip seeding system was the most successful method for establishment of Caucasian clover with 48% of seed sown establishing. This was closely followed by the sod seeding treatment (**38%**), while broadcasting produced comparatively poor results (9%) (Table 2). It is assumed that the **success** of strip seeding was due to a combination of effects including the physical removal of competing resident vegetation, cultivation to form a seed bed, formation of a microclimate and placement of fertiliser in a band below the seed. These all combined to enhance germination, nodulation and establishment of the seedlings and subsequent growth of roots and rhizomes (Tables 3 and 4). Similar results with the strip seeder have been achieved with other legume species by Lowther et al. (1991) and **Woodman** (1993). The sod seed technique was also satisfactory, indicating the importance of seed being placed in the ground close to fertiliser for establishment and subsequent growth in this

environment. However, in drier environments the close proximity of fertiliser may be detrimental (**Woodman pers. comm.**). The poorer establishment from broadcasting can be attributed to a combination of factors but the main adverse influence may have been the substantial ground cover of 30-50% *Hieracium pilosella* leaves which would have resulted in a high proportion of seed landing on the prostrate rosettes rather than bare ground. In addition, both germinating seed and *Rhizobium* are very susceptible to desiccation when on the surface of the soil; this drying effect would have been further aided by lack of litter cover due to burning. About 80% of the plants in the broadcast plot were small and yellow at the March sampling. Some were un-nodulated while others had small pale nodules which could be the result of ineffective and/or late nodulation by Caucasian clover rhizobia. Alternatively this could be the result of nodulation by resident white clover rhizobia which may form small ineffective nodules on Caucasian clover (Patrick & Lowther 1993; **Ronson pers.comm.**). It is possible that the most recent recommendation for inoculation (Patrick & Lowther 1994) would have given better nodulation in the broadcast situation. However, the excellent nodulation of direct-drilled plants indicates that there were adequate numbers of rhizobia specific to Caucasian clover present for seed which is placed in soil rather than broadcast on the surface.

Root and rhizome development

A characteristic of Caucasian clover is its rapid early root development and by March 1993 some tap-roots ~from-the-strip-seeding-technique-had-reached-more than 700 mm depth. In contrast the broadcast plants had reached only 200 mm depth. At that time, root dry matter to 150 mm depth in the strip seeding system was more than double that of plants which were sod seeded, and almost 5 times the weight of broadcast plants (Table 3). There was an interaction between sowing method and fertiliser, with a larger response to the higher level of fertiliser in the strip seeding treatment. The root growth responses in March 1993 were presumably due to the same combination of factors which enhanced germination and establishment mentioned earlier; the poorer growth of roots from sod seeding was assumed to be due to competition from **browntop** and *Hieracium*, particularly for nutrients such as phosphate (**Jackman & Mouat 1974; Svavarsdóttir pers. comm.**).

By March 1993, rhizome development was evident on many plants of the sod seeded and strip seeding treatments although rhizome length and percentage of plants with rhizomes were greater with strip seeding

Table 2 Effect of establishment technique on percentage of Caucasian clover plants per metre of row in December 1992.

Establishment technique		
Broadcast 9	Sod seeding 39	Strip seeding 48
SED 4.44		($p < 0.001$)

Table 3 Effect of establishment technique on root weight (g/plant) to 15 cm depth, March 1993.

Fertiliser (kg/ha)	Establishment technique			Mean	SED
	Broadcast	Sod seeding	Strip seeding		
150	0.143	0.276	0.526	0.316	0.055
300	0.157	0.376	0.657	0.464	
Mean	0.150	0.326	0.693	Interaction	
SED	0.067	($p < 0.001$)		SED 0.095	($p < 0.05$)

(Table 4). By July 1993 all plants in these two treatments had developed rhizomes. Few plants from broadcasting exhibited rhizomes either in March (Table 4) or in July. The rhizomes produced by the strip seeding system in March were 5 and 10 times the length of the sod seed and broadcast treatments respectively. Even at this early sampling, some rhizomes were 150 mm long in the strip seeding treatments. The reasons for this excellent rhizome development under the strip seeding system can be attributed to the plants establishing in a 200 mm wide cultivated seedbed free from strong *Hieracium* and **browntop** root competition. The sod seeded plants were subject to both inter and intra-specific competition as individual plants not only received substantial pressure from other Caucasian clover plants along the drill line, but any sideways growth resulted in strong competition from resident vegetation which formed a very dense root mat.

Table 4 Effect of establishment technique on percentage plants with rhizomes, average rhizome length, and root/rhizome:shoot ratios, in March 1993.

	Establishment technique			SED
	Broadcast	Sod seeding	Strip seeding	
Plants with rhizomes (%)	1	43	75	6.50 ($p < 0.001$)
Average rhizome length (mm)	2	4	21	2.26 ($p < 0.001$)
Root/rhizome:shoot ratio	2.49	3.15	3.36	0.21 ($p < 0.001$)

There was continued primary rhizome development in the autumn between the March 1993 sampling and the July 1993 sampling. By July 1993 the strip and sod seeded plants had developed secondary branch rhizomes (Table 5). Individual rhizomes from both the strip and sod seeding systems measured up to 300 mm in length, while the maximum plant width was 485 and 405 mm respectively (Table 5).

Table 5 Effect of establishment technique on the average primary and secondary rhizome length and maximum plant width in July 1993.

	Establishment technique			SED
	Broadcast	Sod seeding	Strip seeding	
Primary rhizome length (mm)	8 [#]	30	78	5.5
Secondary rhizome length (mm)	0	5 [#]	32'	6.5
Maximum plant width (mm) ^{##}	35	405	485	NA

Average of plants with rhizomes and secondary rhizomes.

Plants measured from tip to tip of the two longest rhizomes.

Sampling done in mid spring of 1993 revealed further rhizome growth and development indicating that rhizome extension was not confined to autumn (Moorhead unpublished).

Root plus rhizome to shoot ratio

In contrast to many other clovers Caucasian clover seedlings allocate a much higher proportion of photosynthates into root and rhizome development than growth of leaves (Spencer *et al.* 1975). The root plus rhizome:shoot ratios present in the March sampling (Table 4) were very similar to those found by Daly & Mason (1987) of 2.73 in cv. Prairie, and by Spencer *et al.* (1975) who measured ratios of 2.36 and 3.36 in the diploid cv. Summit and a hexaploid ecotype respectively. These ratios emphasise the characteristic partitioning of nutrient and carbohydrate resources of Caucasian clover during its establishment into its root and rhizome systems. In March 1993 Caucasian clover had produced 10.7 g DM/m row of top growth using

the strip seeding system and 3.7 g DM/m row for the sod seed technique. The herbage production by the strip seeding system (approx. 700 kg DM/ha at the row spacing used) together with the substantial underground biomass suggests that this treatment could have been lightly grazed within six months of establishment (Moorhead unpublished).

Comparison with white clover

Measurements of Caucasian clover and white clover plants drilled with the strip seeder in the adjacent fertiliser experiment showed large differences in their morphology. Individual 6-month-old white clover plants were similar in total leaf DM to Caucasian clover, but white clover plants had only one third the root DM while its stolons were nearly 3 times the weight of Caucasian clover rhizomes (Table 6). Caucasian clover, had longer tap-roots >150 mm compared with 92 mm for white clover. Leaf DM yield was 8.4 g/m row length vs 10 g/m row length for white clover and Caucasian clover respectively.

Conclusions

Results showed the importance of good techniques for rapid establishment of Caucasian clover in moist, low fertility, depleted tussock grassland areas.

The most important conclusions are:

1. The use of either strip or sod seeding will produce large, rhizomatous, well established plants in the first season after sowing.
2. The strip and sod seeding establishment techniques are far superior to broadcasting and will produce a higher proportion of nodulated plants from seed sown.
3. Strip seeding will encourage earlier rhizome development and greater root production, causing faster vegetative spread, but sod seeding (which is the most commonly available technology) is also much superior to broadcasting.
4. By using the strip seeding technique Caucasian clover can be established as quickly and successfully as white clover in this environment.
5. High rates (300 kg/ha) of molybdc sulphur superphosphate placed with or under the seed

Table 6 Comparison of white and Caucasian clover plants on 19 April 1993.

Species	Average plant number /m row	Individual plant DM (g per plant)			Tap root length (mm)	Tap root diameter (mm)	Stolon/rhizome per plant		Leaf number per plant
		Leaf	Root	Stolon/rhizome			Number	Length (mm)	
White	40	0.21	0.26	0.49	92	3.4	5	7.2	16.3
Caucasian	50	0.20	0.81	0.16	>150	4.6	4	4.4	5.2

accelerates plant growth and rhizome development in this environment.

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