Comparison of oversowing methods for pasture legume establishment on slopes

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Abstract

A field experiment was conducted at Massey University, Palmerston North on a Tokomaru silt loam soil with pH 5.9 to compare the effectiveness of different oversowing methods and to determine the characteristics of legume species that affect establishment from oversowing. Three legume species; white clover (*Trifolium repens* L.), subterranean clover (*T. subterraneum* L.) and Maku lotus (*Lotus pedunculatus* Cav.) and four oversowing treatments; paraquat, burning, hard grazing before sowing plus treading afterwards, and hard grazing with no treading of the sown seed were studied in a factorial experiment using a RCB design with four replicates. The seed was oversown by hand broadcasting into plots of 2 m^2.

The effect of oversowing methods on seedling survival was paraquat > burning > hard grazing with treading > hard grazing with no treading. Seedling density was not related to proportion of herbage mass, showing that there was a distinction between seedling survival and productivity. Maku lotus plants survived particularly well, but produced little herbage mass under the prevailing conditions. The establishment characteristics of the seedlings of the three species varied, particularly seedling size. Subterranean clover had the largest seedlings and was less sensitive to plant competition than the other two species. The paraquat treatment resulted in the greatest herbage mass of the sown legumes, but produced a lower total herbage mass than the other oversowing treatments.

Additional key words: *seedling density, herbage yield, competition, paraquat, burning, hard grazing, treading,* Trifolium repens, T. subterraneum, Lotus pedunculatus

Introduction

The key to pasture improvement in hill country is the introduction of high producing, vigorous legumes to provide nitrogen and high quality feed following the improvement of soil nutrient deficiencies (Levy, 1970). Nevertheless, establishment of legumes like white clover, subterranean clover and lotus into hill country swards is difficult because:

1) a cultivated seedbed is difficult due to steep slopes,
2) suppression, or temporary removal of the existing vegetation is difficult, and
3) the resultant seedbed conditions represent a hostile environment for seed germination and seedling survival (Macfarlane and Bonish, 1986; Campbell, 1992; Awan *et al.*, 1993).

To establish legumes on steep hill slopes requires oversowing methods that give effective establishment, and that are also economically and ecologically effective. Oversowing methods usually consist of techniques for suppressing the existing sward (e.g., herbicide, hard grazing, burning) and for improving the seedbed conditions (e.g., treading by stock, Campbell, 1992). Additionally, successful establishment from oversowing will depend on the establishment characteristics of the legume species used (Macfarlane and Bonish, 1986; Woodman *et al.*, 1992; Awan *et al.*, 1993). The aim of this study was to compare the effectiveness of different oversowing methods and to determine the characteristics of legume species that affected establishment from oversowing.

Material and Methods

The experiment was located at Massey University, Palmerston North on a Tokomaru silt loam soil with a pH of 5.9. The trial site had a northeastern aspect on a slope of 23°. The pasture was perennial ryegrass (70%), white clover (20%), flat weeds, rushes and other grasses (10 %). The average soil temperature was 7.7°C during winter and 17.3°C during summer with an average (50 year) annual rainfall of 995 mm.

Three legume species, white clover (*Trifolium repens* L.) cv. Grasslands Feathermark, subterranean clover (*T. subterraneum* L.) cv. Woogenellup and Maku lotus (*Lotus pedunculatus* Cav.) cv. Grasslands Maku, and four oversowing treatments were studied in a factorial experiment using a Randomized Complete Block design with four replicates. The three legume species were chosen for their different growth characteristics, different seed sizes and their usage in different environments. Details of the four oversowing treatments are given in Table 1. The seed rate used, seed germination percentage at room temperature (20°C) and number of seeds sown per m^2 are given in Table 2. The sowing rates used were similar to commercially used rates.

The seed was sown by hand broadcasting on 1 June, 1988 in plots of 2 m^2 and then trodden by sheep at 400 ewes/ha for half an hour, except for the no-treading treatment. Rhizobium cultures for the legume species were sprayed on the site ten days after sowing. The site was fenced to exclude stock. After seedling emergence the plots were cut and grazed to 1000 kg DM/ha to decrease plant competition, on 30, 105, 133 and 150 days after sowing (DAS).

A quadrat of one square metre (55.6 x 180 cm) was used to count the seedlings in each plot at weekly intervals. The quadrat was sub-divided into eight divisions to improve counting accuracy. At 175 days after sowing the herbage was harvested to ground level and the samples separated into the components: sown legumes, grasses, clovers, weeds and dead matter. All samples were dried at 80°C to calculate the dry matter (DM) yield. Data were analyzed by analysis of variance using the SAS package (SAS Institute Inc. 1991).

Table 1. Description of oversowing treatments.

Treatment	Description
1. Hard grazing and treading	Sheep grazing to decrease herbage cover to 1000 kg DM/ha one and week before sowing.
2. Burning and treading	Hard grazing (as in 1) followed by burning with a flame thrower and to scorch off the vegetation and leave the soil surface almost completely exposed.
3. Paraquat and treading	Hard grazing (as in 1) followed by blanket spraying of paraquat (25% a.i.) at 3 ℓ plus 9 ℓ of water per ha applied two days before sowing. The paraquat (trade name of Gramoxone) contained the dichloride salt in the form of soluble concentrates.
4. No treading	Hard grazing (as in 1) but no treading with sheep after sowing.

Table 2. Germination and establishment characteristics of the three legumes species.

	Grasslands Feathermark white clover	Grasslands Maku lotus	Woogenellup subterranean clover
Seeding rate (number/m^2)	650	650	100
Seed size (mg/seed)	0.62	0.69	1.10
Germination @ 20°C (%)	65	84	99
Maximum seedling density (number/m^2)	71	93	64
Seedling density @ 175 DAS (number/m^2)	20	25	28
Seedling weight (mg DM/plant)	215	44	453
Seeds which failed to germinate (% of seed sown)	83	82	35
Seedlings which failed to survive (% of seed which germinated)	72	73	56
Seedlings established (% of viable seed sown)	4.7	4.6	28.3

Results

Weather

The total rainfall during the experimental period (June to December 1988) was 738 mm which was much higher than the 50 year average (599 mm). The whole experimental period remained wet, and it was especially wet during the first four months which created sluggish growth conditions and ultimately impaired seedling survival (Table 2). The air temperature during the experimental period was similar to the last fifty average.

Seedling establishment

The seed germination percentage, on the seed bed, was higher for subterranean clover (65%) than for white clover (17%) and Maku lotus (18%). Out of these germinated seedlings only 44, 27 and 28% plants survived to 175 DAS for subterranean clover, Maku lotus and white clover, respectively (Table 2). Overall, the seedling establishment from viable seed sown was less than 5% for white clover and Maku lotus and 28% for subterranean clover at 175 DAS. Although Maku lotus had the greatest number of seedlings at 40 DAS (see below), the individual seedlings were only 44 mg DM per plant at 175 DAS compared with 215 and 453 mg DM per plant for white clover and subterranean clover, respectively (Table 2).

Response of establishment treatments over time

The mean seedling density at 120 DAS was significantly greater for the paraquat treatment (51/m^2) than for all other oversowing treatments ($P \leq 0.05$; Fig. 1). The mean number of seedlings per unit area for the other treatments was 29/m^2. The order of effectiveness in terms of seedling density per unit area of the oversowing treatments was paraquat>burning>hard grazing with treading>hard grazing with no treading ($P \leq 0.05$; Fig. 1). For all legume species the decline from the peak density was greatest in the paraquat treatment (Fig. 1). There was no significant interaction between species and oversowing treatments.

Response of legume species over time

The maximum seedling density (mean of all oversowing treatments) for Maku lotus, white clover and subterranean clover was 93, 71 and 64/m^2, respectively occurred at 40 DAS (Fig. 2, Table 2). Nevertheless, at the conclusion of the trial there were significantly more seedlings of subterranean clover than the other two species, as a result of the rapid decrease in seedling density for white clover and Maku lotus between 40 and 60 DAS (Table 2). The rate of decline from maximum seedling density was greatest for Maku lotus and least for subterranean clover (Fig. 2).

Although the average final seedling density for the legume species ranged from 20 to 28 per m^2, the variation in seedling size among species was more marked. At 175 DAS the mass per seedling of subterranean clover was ten times greater than that of Maku lotus (Table 2). Subterranean clover seedlings were twice the mass of white clover seedlings (Table 2).

Herbage yield

Seedling density for the legume species did not equate to the proportion of the legume species in the herbage mass (Table 3). The percent contribution of the

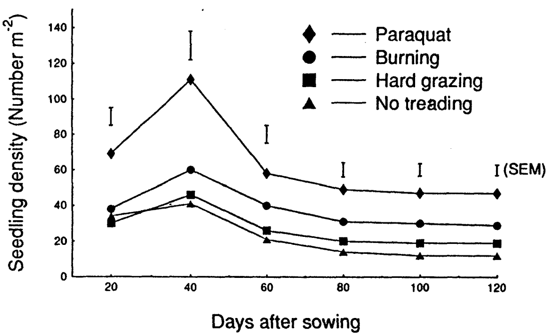

Figure 1. The average response of seedling number per unit area to four oversowing methods up to 120 days after sowing.

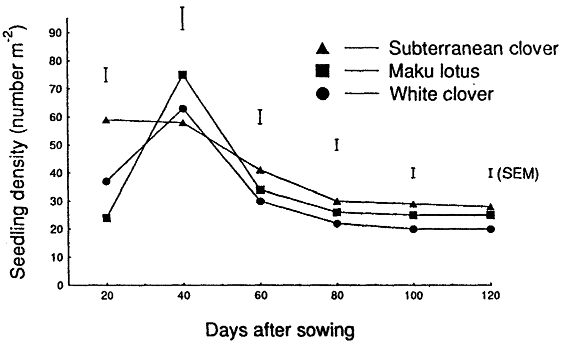

Figure 2. The average response of seedling number per unit area for three legume species upto 120 days after sowing.

Table 3. The influence of oversowing method on the dry matter yield (kg DM/ha) of the components of the pasture at 175 days after sowing.

Herbage component	Oversowing treatment					Species sown				
	Hard grazing	Burning	Paraquat	No treading	F test	Maku lotus	White clover	Subterranean clover	F test	SEM[1]
Sown legume	63	58	85	33	*	11	43	127	**	29
Clover	243	203	227	151	ns	188	211	134	ns	85
Weeds	339	333	745	299	ns	402	509	511	ns	124
Grass	2503	2607	382	2393	*	1651	1712	1595	ns	480
Dead matter	692	496	145	667	*	430	382	482	ns	203
Total yield	3839	3695	1584	3544	**	2681	2857	2847	ns	534
% sown legume	1.64	1.57	5.34	0.93	*	0.4	1.5	4.46	ns	5

*: P<0.05, **: P<0.01, ns: P>0.05

[1] SEM for species and oversowing treatments

oversown legume species to the herbage mass was 0.4, 1.5 and 4.5% for Maku lotus, white clover and subterranean clover, respectively. The paraquat treatment significantly decreased the yield of grass and there was a trend for it to increase weed yield (P≤0.10) compared with the other treatments. No treatment significantly affected the yield of the existing clovers and weeds with the mean yield of these being 206 and 429 kg DM/ha, respectively. The yield of dead matter was higher in the hard grazing (692 kg DM/ha) and no treading (667 kg DM/ha) treatments and lower in the herbicide treatment (145 kg DM/ha) (P<0.05, Table 3). The total herbage yield was low (P<0.01) in the paraquat treatment compared with the other oversowing treatments. The yield of the sown legume species in each oversowing treatment was similar except in the no-treading treatment which resulted in a lower yield (P<0.05, Table 3).

Discussion

The establishment of subterranean clover, white clover and Maku lotus was poor with these species contributing less than 5% to the total herbage mass. Nevertheless, establishment from oversowing is usually poor and has been reported to range from 1 - 27% of viable seed sown with a mean of 8% (Campbell, 1974). The most successfully established species was subterranean clover and the most successful oversowing treatment was the use of paraquat.

The characteristics of subterranean clover that contributed to its superior establishment included its large seed size (Awan, 1994 unpublished data), its better field germination percentage even under harsh conditions, its better seedling survival and its greater seedling mass relative to white clover and Maku lotus. Although the number of seedlings per unit area presented a dynamic picture of seed germination and seedling survival it did not indicate the final contribution of the oversown legume to the herbage mass. Greater seedling size has been found to result in better seedling survival (Seager *et al.*, 1992) as well as resulting in greater productivity.

The paraquat treatment had the greatest number of legume seedlings and the highest legume yield. Similarly, Sithamparanathan *et al.*, (1986) and Wedderburn *et al.*, (1993) showed that the use of paraquat improved seedling density, but not necessarily seedling growth. Although paraquat suppressed the growth of the existing sward more than the other treatments it tended to have greater weed growth, but not significantly due to the large variation in weeds on the plots. Wedderburn *et al.*, (1993) pointed out that establishing legume seedlings need to be able to successfully compete with the growth of weeds.

In general, the more successful the oversowing treatment was in removing the existing sward the greater the density of seedlings that established. In agreement with Campbell (1992), post-sowing treading also improved the number of seedlings that established. Thus, the results confirm that reducing the competition on establishing seedlings through the use of herbicide or burning, and improving the seed to soil contact through treading are effective procedures when oversowing legumes into existing swards (Chapman and Fletcher 1985; Macfarlane and Bonish 1986; Sithamparanathan *et al.*, 1986).

Although herbicide use improves establishment of the oversown species it has some disadvantages as well. Use of paraquat decreased total sward production (Table 3, Campbell 1961, Wedderburn *et al.*, 1993) and was expensive. Burning costs less than herbicide, but even in environments suited to easy burning, establishment after burning was poorer than after the use of herbicide (Fig. 1, Campbell, 1961). A major factor affecting establishment from oversowing is competition from the regrowing sward so the effectiveness of the method for reducing regrowth of needs to be balanced against its cost.

Conclusions

Despite the range of oversowing techniques and legume species used, establishment in terms of both seedlings produced per viable seed and herbage mass was poor. Although the best treatment was paraquat it was also the most expensive, and it decreased total herbage mass as well as producing bare ground that could lead to soil erosion and weed invasion. The superior establishment of subterranean clover compared with the other species demonstrated the importance of seedling characteristics in establishment from oversowing.

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