Effect of sowing rate on herbage yield of four legume species oversown in hill country

M. H. Awan[3], D. J. Barker[1], P. D. Kemp and M. A. Choudhary[2]

Plant Science Department, Massey University, Private Bag 11222, Palmerston North.
[1] AgResearch, Private Bag 11008, Palmerston North
[2] Agricultural Engineering Department, Massey University, Private Bag 1122, Palmerston North.
[3] Miss E L Hellaby Indigenous Grasslands Research Fellow

Abstract

The legume percentage in the hill and high country pastures of New Zealand is often low. When increasing the legume content of hill pastures by oversowing a higher than normal sowing rate has been suggested, but there is little information on the effect of higher sowing rates. Furthermore, use of new legume species requires information on the effect of sowing rate on their establishment from oversowing.

To determine the appropriate sowing rate for oversown legume species, a trial was conducted at the AgResearch Hill Country Research Station, Ballantrae at 310 m altitude on a north west (sunny) aspect during 1993. The soil was Ngamoka silt loam with a pH of 5.4 and low soil fertility (Olsen P 10 µgP/g soil). The seed rates were 100, 500, 1000 and 2000 viable seeds/m^2, and seed was hand broadcast on 19 April, 1993 in plots of one m^2. The legume species used were: subterranean clover (*Trifolium subterraneum* L.), persian clover (*T. resupinatum* L.), white clover (*T. repens* L.) and strawberry clover (*T. fragiferum* L.) The trial comprised three randomised complete blocks. The site was blanket sprayed with 36% glyphosate prior to sowing. The sown seed was trodden with sheep.

The highest sowing rate gave the highest ($P<0.05$) seedling density per unit area and highest legume herbage mass. The maximum contribution of legumes to pasture yield at seven months after sowing occurred at 1000 seeds/ m^2 for subterranean clover (70%) and at 2000 seeds/m^2 for persian clover (30%). The two perennial legume species contributed less than 10% of the total herbage mass. The plots were then grazed by sheep and following grazing the herbage contribution from the legumes was increased for the perennial legumes and decreased for the annual legumes. Overall, results showed that if seed rate was increased from 500 to 1000 seeds/m^2, then the herbage contribution of legume species oversown in hill country will be increased. That is, sowing rates greater than those usually recommended would increase the legume contribution to total herbage mass.

Additional key words: *Sowing rate, seedling density, herbage mass, hill country,* Trifolium subterraneum, T. resupinatum, T. repens, T. fragiferum.

Introduction

Almost all of the hill country pastures in New Zealand are lacking in a reasonable percentage of legume (20 - 30% of total herbage mass; White, 1990). Legumes are important for providing high quality feed and improving the soil nitrogen status (Levy, 1970). A range of new legume species and cultivars have been evaluated for this purpose (Charlton, 1991; Woodman *et al.*, 1992; Awan *et al.*, 1993), and more than 20 legume cultivars have been certified (Rumball, 1983). The availability of these new legume species / cultivars has created a need for appropriate technology for their establishment by oversowing into hill country pasture.

Traditional sowing rates recommended for the establishment of legume species may be suitable for full cultivation and undersowing, but oversowing in hill country may benefit from higher sowing rates than those recommended in most areas for legume species, i.e., 5 kg/ha (about 100 seeds/m^2) for subterranean clover and 3 to 4 kg/ha (about 500 seeds/m^2) for white clover (Scott *et al.*, 1985; White, 1990). An increased sowing rate might be a cheap and simple method to increase the percentage of legumes in hill country pastures, but there is little information on the optimum sowing rate for oversowing legume species in hill and high country pastures, especially for new species and cultivars. Further information on the effect of different sowing

rates on the establishment of new legume species / cultivars, especially when oversowing, is required. Accordingly this study aimed to determine the effect of different sowing rates on the total herbage mass of four legume species (2 annual and 2 perennial) oversown into a hill country sward. These species were chosen for their different characteristics and different seed sizes.

Materials and Methods

The trial was conducted during 1993 at the AgResearch Hill Country Research Station, Ballantrae, in the Ruahine Ranges of the lower North Island. The research site was at 310 m altitude on a north west (sunny) aspect. The soil was Ngamoka silt loam with a pH of 5.4 and moderate soil fertility (Olsen P 10 μgP/g soil). The legume species used were subterranean clover (*Trifolium subterraneum* L.) cv. Karridale, persian clover (*T. resupinatum* L.) cv. Kyambro, white clover (*T. repens* L.) cv. Grasslands Tahora and strawberry clover (*T. fragiferum* L.) cv. Grasslands Onward. The percentage of viable seed was obtained from a germination test at room temperature (20°C), and germination was 90, 78, 81 and 75% for subterranean, persian, white and strawberry clovers, respectively. The seed of persian clover was scarified with sand paper before the start of the germination test. The seed rates used for the four legume species were 100, 500, 1000 and 2000 viable seeds/m^2. The equivalent sowing rates for the four legume species are given in Table 1. The site was blanket sprayed with 4.32 kg a.i./ha of 36% glyphosate which is equivalent to 12 ℓ/ha of Roundup* (Jagschitz, 1978), twenty one days before sowing which is the usual practice (Awan *et al.* 1993). The seed was hand broadcast during autumn (19 April, 1993) in 1 m^2 plots. Appropriate inoculum was not used for individual species and as seedlings appeared green and healthy, it was assumed that these seedlings were infected by the resident rhizobia. After oversowing, plots were trodden by sheep at 400 ewes ha^{-1} for 30 min. The trial area was fenced to exclude animals.

The factorial combination of four legume species and four seed rates was arranged in three randomized complete blocks. Statistical analyses were by analysis of variance using the GLM model of the SAS package (SAS Institute Inc. 1991). Seedling density was determined at monthly intervals for four months. A one m^2 quadrat was used to count the seedlings in each plot. The quadrat was sub-divided into four for accurate counting. Seven months after sowing the herbage yield was determined from two 0.1 m^2 quadrat cuts per plot cut at ground level, and whole samples were separated into resident species and sown legumes. To calculate dry matter (DM) the samples were washed, then dried at 80°C for 24 hours. The plots were then grazed by sheep to a residual herbage mass of approximately 1000 kg DM/ha and one month later the herbage yield was again measured as previously. Ten months after sowing, five plants from each plot were randomly selected, cut to ground level, and dried for 24 hours at 80°C and weighed. Rainfall and air temperature were measured about 1 km from the trial site.

Results

Weather

The annual rainfall for the trial year was 1150mm and the average for the last 24 years is 1200mm. Monthly

* The mention of the name does not imply a recommendation on the part of the authors or their respective organizations.

Table 1. Species used and sowing rates of viable seed (kg/ha).

	No. of seeds sown per m^2			
	100	500	1000	2000
Annual species				
1. Subterranean clover cv. Karridale	5.0	25.0	50.0	100.0
2. Persian clover cv. Kyambro	0.7	3.5	7.0	14.0
Perennial species				
3. Strawberry clover cv. Grasslands Onward	1.25	6.25	12.5	25.0
4. White clover cv. Grasslands Tahora	0.7	3.5	7.0	14.0

rainfall for the months of March, April, May and June, 1993 was 135, 111, 76 and 155mm, respectively. The air temperature was also typical for the site and during the trial year average monthly minimum and maximum temperatures were 11.2oC and 21.7oC for January and 7.5oC and 14.7oC for August, 1993, respectively.

Seedling survival

There was a significant interaction between the sowing rate and legume species for seedling density ($P<0.05$). On average, the highest sowing rate produced the highest seedling density for all four legume species, but there was no significant difference between 1000 and 2000 seeds/m^2 for white clover ($P<0.05$, Fig. 1). The highest sowing rate treatment (2000 seeds/m^2) produced the maximum seedling densities of 702, 659, 572 and 345 for subterranean clover, strawberry clover, persian clover and white clover, respectively. The establishment (% of viable seed sown) of white clover was lower than for other species particularly at the highest sowing rate (2000 seeds/m^2; Fig. 1). Overall, seedling establishment was 24 and 19% for strawberry clover and white clover, and 37 and 26% for subterranean clover and persian clover, respectively at 120 days after sowing (DAS).

Herbage mass contribution

The two annual legume species had a significantly higher herbage mass than the two perennial legumes in absolute terms and as percentage of total herbage ($P<0.05$, Fig. 2). The maximum contribution of the

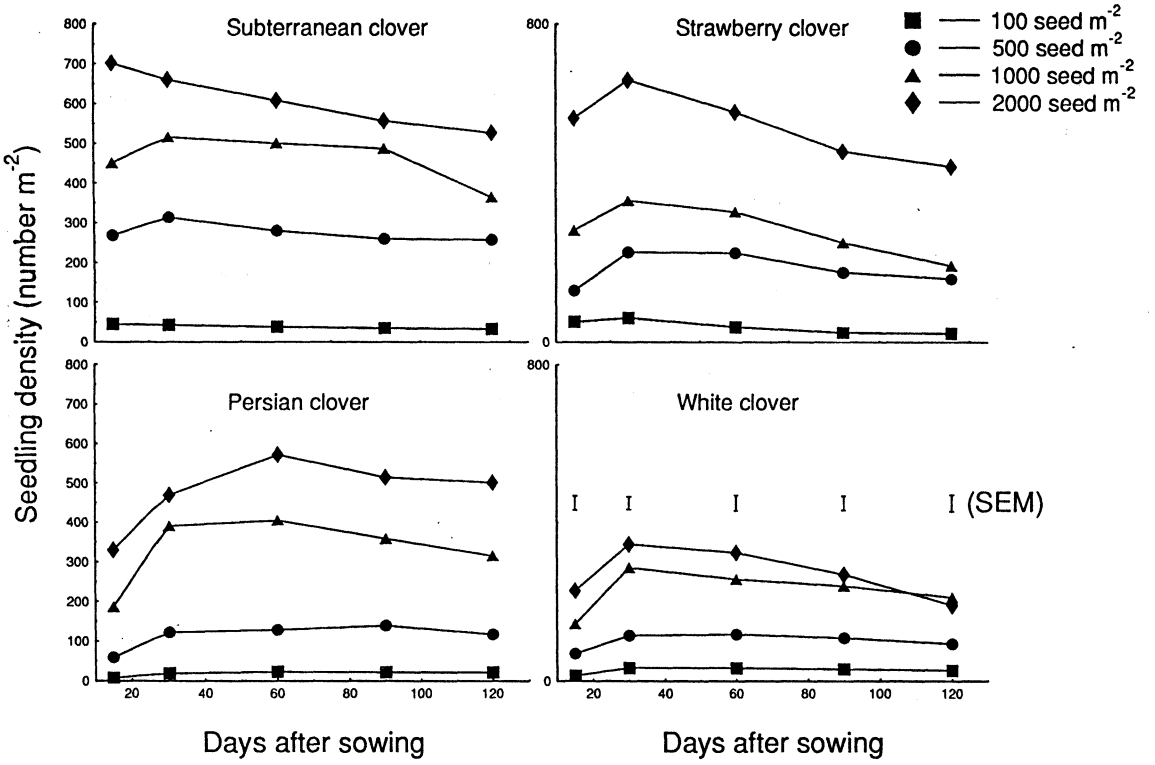

Figure 1. The average response of seedling density for four legume species and four sowing rates over time. SEM bars are for all species.

annual legumes to total herbage mass, seven months after sowing (before grazing), was 71% for subterranean clover at 1000 seed/m^2, and 32% for persian clover at 2000 seed/m^2 (Fig. 2). Strawberry clover and white clover contributed less than 8% of the total herbage mass before grazing at all the sowing rates. The average total herbage mass for all the sowing rates and legume species combined was 2288 kg DM/ha before and 1455 kg DM/ha one month after grazing the site. The herbage contribution of these two perennial legumes increased in the month following the grazing of the plots (Fig. 2), with white clover providing more than 10% of the herbage mass at 1000 seeds/m^2. The maximum percentage of the herbage mass from subterranean clover had decreased from 71% before grazing to 28% after grazing, and for persian clover the decrease was from 32% to 20% (Fig. 2). Overall, the maximum contribution of the sown legume species towards total herbage mass was at either 1000 and 2000 seeds/m^2 (Fig. 2), whereas the relative performance of 2000 seeds/m^2 was stable as the legume species contribution towards total herbage mass was 65 and 55% before and after grazing, respectively.

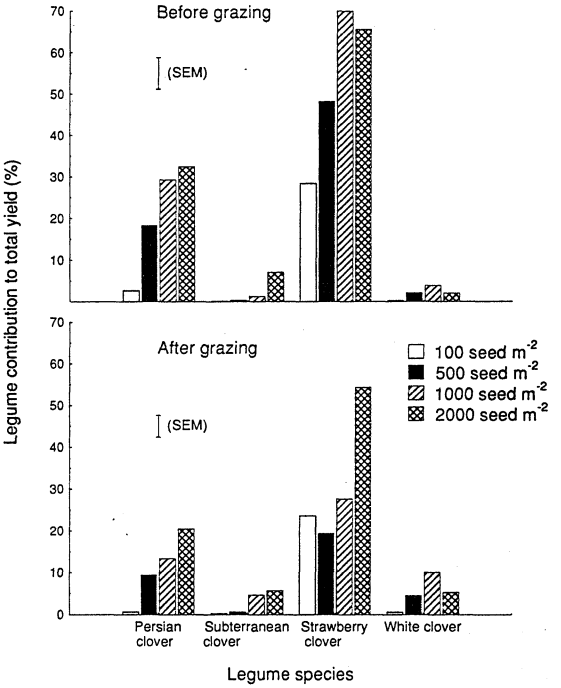

Figure 2. The contribution of four legume species to herbage mass before grazing (7 months after sowing) and after grazing (8 months after sowing) for different sowing rates.

Dry weight per plant

The main effects were significant ($P<0.05$, Table 2) whereas the interaction between the legume species sown and sowing rate was not significantly different ($P=0.34$) for the dry weight per plant. Persian clover had a significantly higher plant weight (187 mg/plant) compared to white clover (47 mg/plant) at 300 DAS (Table 2). As sowing rate increased the weight per plant also increased (Table 2). The average dry weight per plant for the sown annual legume species was 161 mg, and for perennial legumes it was only 56 mg.

Discussion

Greatest legume contribution to herbage mass was at either 1000 or 2000 seeds/m^2 for all four species. That is, sowing rates two to three times those usually recommended (Scott *et al.*, 1985; White, 1990) gave the greatest improvement in the percentage of legume in the

Table 2. Dry weight (mg) per plant at 300 DAS for different sowing rates and clover species.

Treatments	Plant weight (mg/plant)
Clover	
Subterranean clover	135
Persian clover	187
Strawberry clover	65
White clover	47
SEM	17
Sowing rate (seeds per m^2)	
100	63
500	116
1000	119
2000	135
SEM	23
F-test	
Species	***
Sowing rate	**
Species x Sowing	ns

** $P<0.01$, *** $P<0.001$, ns - no significant difference

pasture. Although the percentage of the perennial legumes in the pasture can increase after sowing, the percentage of annual legumes derived directly from sowing represents the maximum number of plants for that season. It is suggested that higher sowing rates of at least 1000 seeds/m^2 are warranted when oversowing hill country pastures, even when there is suppression of the existing sward by herbicide prior to sowing.

The increased contribution of the legume species to herbage mass at the higher sowing rates was mainly due to increased plant density, as individual plant weight was similar for all sowing rates except the lowest (100 seeds/m^2, Table 2). Presumably the increased number of plants enabled the sown legume species to be more competitive with the regrowth from the existing sward. In the first 120 DAS there was only a small decline in plant numbers suggesting that there was little within species competition for the sown legume species, even at the highest sowing rate. The similarity in the percentage contribution to herbage mass at 1000 and 2000 seeds/m^2 by persian clover, subterranean clover and white clover suggested that either within or between species competition affected later legume growth. One month after grazing the trial area the herbage mass was decreased by about 65% which enabled the perennial legumes to grow with less competition and thus they produced higher herbage masses whereas the annual legumes had already completed their vegetative growth cycle and their herbage mass decreased.

Although proportionally fewer seeds produced a seedling at higher sowing rates, the total seedlings established increased progressively and these seedlings improved the competitiveness of the sown legume species within the existing sward. Seedling establishment of white clover was lower (19% of total viable seed sown) at 120 DAS than the other sown legumes. In a hill pasture oversowing trial, seedling appearance of Grasslands Tahora white clover 11 weeks after sowing was only 15% of the seed sown using 8 kg bare seed per ha (1413 seeds/m^2; Chapman *et al.*, 1993).

Overall, subterranean clover had the highest net seedling survival (i.e., 35%) of the total seed sown. The better establishment of the annual legume species showed that seed and seedling characteristics such as large seed size (Jurado and Westoby, 1992) and high seedling relative growth rate (Grime and Hunt, 1975) give better establishment independent of the sowing rate, and when oversowing conditions are good. That is, technology can improve successful establishment from oversowing, but establishment is ultimately dependent on the characteristics of the legume species. Seed coating is one way of increasing germination rate (Scott, 1989; Awan, 1994 unpublished data) but the success of using the increased sowing rate demonstrated this is an alternative option to seed coating. The choice between higher sowing rates and seed coating is partly dictated by relative cost.

The results showed that if sowing rate was increased from 500 to 1000 seeds/m^2, then the herbage contribution of legume species oversown in hill country will be increased. That is, sowing rates greater than those recommended would increase the legume contribution to the total herbage mass.

Acknowledgements

We thank AgResearch for permission to use land at Ballantrae, for help during the trial period and for the provision of legume seed.

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