OVERSOWING LEGUMES INTO PERENNIAL PASTURE: CAN WE DO IT BETTER?

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Abstract

Insufficient percentage of pasture legumes in perennial pastures on non-arable soils is a widespread problem. Establishment from oversown legume seed is often less than 5%. Summer fallowing of pasture doubled white clover growing point density in the 4 years post-fallowing, and decreased grass tiller density by 75% immediately after the fallow. An establishment model based on field experiments predicted establishment of oversown legumes was greatest from sowing in the second half of February. The model splits establishment into two stages, germination and survival of seedlings, and uses the inputs soil temperature, soil surface moisture, wind run, and minimum air temperature.

Key words: Pasture legumes, oversowing, establishment model, fallowing, germination

Insufficient pasture legume in perennial pastures is a widespread problem in non-arable and extensively grazed areas of Australia and New Zealand. Lack of legume decreases the ecological and economic sustain-ability of perennial pastures through the resulting poor nutritive value of the forage and nitrogen deficiency. The percentage establishment of legume seed oversown into perennial pastures is usually very low, often less than 5% (3, 1).

Results from two research programmes aimed at increasing the proportion of legume in non-arable perennial pastures are presented. Summer fallowing of pastures is an alternative to herbicide to decrease the competitiveness of existing pasture species against establishing legume species. However, the long term impact of fallowing on tiller and legume growing point density has received little attention (4).

Several models of establishment of oversown pasture species, largely with soil moisture as the key input, have been developed (2). A preliminary model of establish-ment of oversown legume species is used to summarise a series of field experiments on oversowing a range of perennial and annual legume species. The emphasis is on comparing the relative sensitivity of legume establishment to seed germination and to the survival of seedlings.

Materials and methods

Summer fallow

Hill pasture on AgResearch's Ballantrae Hill Research Station near Woodville, Hawkes Bay was ungrazed from October to January, and subsequent changes in grass tiller and white clover growing point density were monitored for the next four years. The major grass species present were *Agrostis capillaris*, *Anthoxanthum oderatum*, and *Lolium perenne*. Full details of the experiment are in Nie *et al*. (4).

Table 1: The long- term effects of summer fallowing of perennial hill pasture on the growing point density of white clover and the tiller density of perennial grasses.

Harvest	White clover growing point density (no./m^2)	Grass tiller density (no./m^2)
pre-fallow	1500	25,000
post-fallow	500	6,000
1yr post- fallow	1500	36,000
3yrs post-fallow	2800	28,000
4yrs post-fallow	3000	26,500
SEM	350	1,000

Table 2: Measured and model predicted values for the mean seedling establishment index at 90 days after sowing (DAS) for seven legume species oversown on perennial hill pasture.

Sowing date	Seedling establishment index at 90 DAS	
	Measured	Predicted
27 March 1992	0.10	0.13
10 April 1992	0.06	0.04
12 June 1992	0.08	0.06
26 June 1992	0.04	0.05
05 April 1993	0.09	0.14
22 June 1993	0.11	0.09
10 Sept 1993	0.06	0.10
Mean	0.08	0.09
SEM	0.004	

Establishment model

A model of establishment for legume seed broadcast into existing hill pasture was generated from seven experiments at AgResearch's Poukawa station, near Hastings in Hawkes Bay. The site had a 21^o slope and soil of moderate fertility (Olsen P 16 mg P/g, pH 5.7). The climate is dry in summer, 30 year mean annual rainfall is 790 mm, and frosts are frequent in winter.

A randomised complete block design with at least seven legume species and four blocks was used for each experiment. The species were *Trifolium subterraneum*, *T. fragiferum*, *T. hybridum*, *T. ambiguum*, *T. vesiculo-sum*, *T. respinatum*, and *Lotus corniculatus*. Table 2 shows the oversowing dates. The pasture was sprayed with glyphosate (12 l/ha, 36% a.i.) 21 days before broadcasting 500 viable seeds per plot (1 m x 1 m), which were then trodden by 400 ewes/ha for 30 min. Appropriate Rhizobium was used for each species. Experiments were grazed to maintain pasture cover between 500 and 1000 kg DM/ha. Seedlings were counted every 15 days for 120 days. Full details are in Awan (1).

A range of climate variables measured during the experiments were tested for their relationship to germination and survival of seedlings. The relationships with the highest coefficient of determination were used to develop a model that best explained the relationship between the weather and the germination and survival of legume seedlings during the experiments. For the germination period (0-15 DAS, days after sowing) the climate variables that best predicted the percentage of oversown seeds that germinated were ST (100 mm soil temperature) and GSWC (0-50 mm gravimetric soil water content). For the seedling survival period (30-90 DAS) MT (minimum air temperature) and WR (total daily wind run) best predicted the percentage of oversown seeds that produced a seedling. The 15-30 DAS period was regarded as a transition period. Linear equations between ST, GSWC, MT, and WR and the percentage of oversown seeds that produced a seedling were standardised to a 0-1 scale where 1 was the maximum percentage of oversown seeds that had a surviving seedling, for each 15 day period after sowing. The indices (0-1) for ST, GSWC, MT and MR were used in the two equations below. The product of these two equations gave the seedling establishment index at 90 DAS. Statistical methods are described in Awan (1).

Germinated seedling index (0 - 15 DAS) = -175.81 + 33.35 ST + 3.82 GSWC - 0.73 ST GSWC.
Seedling survival index (30 - 90 DAS) = 105.79 - 11.86 WR - 0.33 MT + 0.037 MT WR.

Results and discussion

Summer fallow

Summer fallowing initially decreased white clover and grass growing point densities (Table 1). Four years after the fallowing, grass density was similar to the pre-fallow density. In contrast, the growing point density of white clover was twice the density four years post-fallow as it was pre-fallow (Table 1). In conjunct-ion with the increase in the growing point density of white clover the stolon weight and length increased, but internode length decreased (4). These changes in morphology suggest that the decreased grass tiller density immediately post-fallowing decreased competition sufficiently for white clover to increase in size, and presumably to increase reserves, enabling it to be more com- petitive with grass in the succeeding years.

Establishment model

The model predicted the establishment of pasture legumes from oversowing accurately when compared with the measured establishment in the seven experi-ments sown at different times during two years (Table 2). The four environmental variables used in the model are easily measured, or can be calculated from weather station data. Presumably wind run was an indicator of? water stress, and minimum air temperature an indicator of plant growth, and therefore competition from grass and weeds. Soil temperature and surface moisture have previously been shown to predict germination of oversown seed (2). However, in the field experiments both low and high soil surface moisture were found to be detrimental to germination, with the maximum seed germination between 25 and 37 % GSWC (1). This suggests the response to soil surface moisture of the germination of oversown seed needs to be better defined than simply using rainfall or the likelihood of rain in establishment models. Also, the cold tolerance of? legume species varies with subterranean clover less tolerant than, for example, birdsfoot trefoil so the temperature range for germination used in establishment will be species dependent (1).

Fig. 1 shows that the highest seedling establishment index was 0.25 when seed was oversown in the second half of February. The coefficient of variation for this time was 58%. Although the survival index for seedlings produced from seed oversown from February to July was consistently greater than 0.35, the germinated seedling index during this period was only above 0.5 for seed oversown in February. The germinated seedling index was also greater than 0.5 from October to January, but seedling survival and therefore establishment was very low for seed oversown during this period. Overall, the best time for oversowing legume seed during the two years studied was predicted to be mid to late February, which is in agreement with the views of experienced local farm consultants. Although the model requires further development for it to be used to predict when farmers should oversow in a particular year it does high-light that successful oversowing of legumes is depend-ent on the weather conditions both during germination, and while the seedlings establish. Spring oversowing, for example, would be likely to result in a high germination rate, but a low rate of seedling survival.

Conclusions

Summer fallowing appears to have two major outcomes. It provides a low input method of increasing at least white clover content over time, and it provides less competition from grass tillers for legumes establish-ing from seed oversown after a summer fallow. The model used to interpret the data from seven field experiments on establishment of oversown legumes emphasised the different climate variables that determine seed germination as opposed to seedling survival. The variables used to predict germination were soil temperature and soil surface moisture, and to predict seedling survival were daily minimum air temperature and wind run. In conclusion, increasing the legume component of non-arable perennial pastures is difficult and risky, but is more likely to be successful when summer fallow is used, and the period of the year is clearly identified that provides appropriate conditions for a good germination rate followed by good conditions for seedling survival.

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