Pasture legume establishment from oversowing in drought-prone hill country

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Abstract

Plant and environmental factors that affect pasture legume establishment from oversowing were examined in a series of experiments at Poukawa Research Station near Hastings. A combination of 2 sowing seasons and 2 soil conditions gave cool/dry, cool/wet, warm/dry and warm/wet. The rainfall in the trial year (1992) was 933 mm compared with the mean of 771 mm. Eleven species (5 annual and 6 perennial legumes) from *Lotus*, *Medicago* and *Trifolium* genera were used. Establishment was poor, less than 10% of total herbage yield (6 and 8 months after oversowing for the cool and warm seasons, respectively) being contributed by any of the legume species. The major cause of poor establishment was poor germination. Eighty percent of sown seed failed to produce a seedling. Although germination was worse under cool (8°C) conditions, particularly for subterranean clover, the major cause of poor germination was not identified. The usefulness of new legume species in dryland hill pastures will depend on the species being suited to establishment from oversowing and a better definition of the factors that affect successful oversowing.

Keywords: drought, herbage yield, hill country, *Lotus*, *Medicago*, moisture, oversowing, pasture establishment, plant density, temperature, *Trifolium*

Introduction

The legume species used in drought-prone hill country of Wairarapa and Hawkes Bay have not changed in recent years. White and subterranean clovers are used on hill country, and lucerne and red clover are used on arable land (Booth & Gibbs 1969). A range of new species and cultivars are now being evaluated for use as forage and fodder (D. Smith pers. comm.; Woodman *et* al. 1992). While key aspects of any evaluation are the seasonal productivity and persistence of the legume species, the adoption of new species by hill country farmers will probably depend on the ease and cost of their introduction into existing pastures.

This paper reports the results after one year of an examination of the plant and environmental factors that affect the successful establishment of legume species oversown into dryland hill country pastures.

Materials and methods

The trial was conducted at the Poukawa Research Farm (AgResearch) 12 km south of Hastings, on a south east aspect, a slope of 21° and elevation 55 m. The trial area had moderate soil fertility (Olsen P 17 µgP/g soil) and the soil was Crownthrope silt loam (pH 5.7). The 30-year annual rainfall was 771 mm and for the trial year (1992) was 933 mm.

The trial design was 11 legume species, sown on 4 occasions with different temperature and moisture conditions with 4 replications on each occasion. A factorial combination of 2 sowing seasons: warm (soil temp 17°C) and cool (soil temp 8°C); and 2 soil conditions: wet (average gravimetric soil water content was 37.3% for warm and 46.3% for cool seasons) and dry (average gravimetric soil water content was 29.4% for warm and 40.6% for cool seasons), was used. The five annual legume species used were *Trifolium subterraneum* (subterranean clover) cv. Karridale, *T. resupinatum* (persian clover) cv. Kyambro, *T. vesiculosum* (arrow leaf clover) cv. Yuchi, *Medicago murex* (murex medic) cv. Zodiac and *M. trunculata* (barrel medic) cv. Paraggio. The six perennial legumes were *Lotus corniculatus* (birdsfoot trefoil) cv. Grasslands Goldie *L. pedunculatus* (lotus) (Grasslands Maku), *T. ambiguum* (caucasian clover) cv. Monaro, *T. hybridum* (alsike clover), *T. fragiferum* (strawberry clover) cv. Grasslands Onward and *M. sativa* (lucerne) cv. Grasslands Oranga. Data were analysed as a two-factor pooling of a single-factor randomised complete block experiment using the random effect model (Steel & Tot-tie 1981; I. L. Gordon pers. comm.). The analysis of variance of the data was done with the General Linear Model procedure of the Statistical Analysis System.

The 176 experimental units of 1 m x 1 m were each sown with 500 viable seed by hand broadcasting according to the following schedule.

Sowing conditions	Sowing date
Warm season and dry soil conditions:	27 March 1992
Warm season and wet soil conditions:	10 April 1992
Cool season and dry soil conditions:	12 June 1992
Cool season and wet soil conditions:	26 June 1992

To reduce the competition from existing vegetation Roundup (35% glyphosate) was blanket sprayed at 12 l/ha (Jagschitz 1978) about 22 days before each sowing. Before sowing, dead material was mown to ground level. After sowing, the plots were trodden by sheep. Blitzem antislug pellets were scattered around the plots. Rhizobium appropriate to each legume species was sprayed on plots. The trial area was randomly grazed by ewes 120 and 210 days after sowing of seed to reduce herbage cover to 1000 kg DM/ha.

All the seedlings in the plots were counted with the help of a quadrat at each measurement time, and herbage yield was estimated from 2 quadrat cuts (0.1 m^2) from ground level.

Results

Climatic conditions

The trial year was abnormally wet. Average gravimetric soil water content was 31.2% in April and subsequently was 40-44% throughout the remaining trial period (up to December 1992). The rainfall pattern was not typical and during July and October 1992 was 157 and 166 mm, respectively.

Average soil temperature at 10 cm depth was 11.9, 8.1, 8.5, 6.1, 7.2, 9.4, 12.6 and 16.5°C for respective months April to November 1992. The average maximum and minimum screen air temperature was 24.4°C and 2.3°C in March and 14.7°C and 1.9°C in June, respectively.

Plant density

Initial average seedling density was much higher for the warm season but by 120days after sowing (DAS) there was no significant difference between seasons (Figure 1). The dry and wet soil conditions were not significantly different ($P>0.05$).

The interactions of the individual species with season or soil condition were significant ($P<0.05$). Subterranean clover and barrel medic had the highest seedling density (>100/m^2) at 30 and 120 DAS in the warm season but seedlings failed to appear by 30 DAS in the cool-wet condition. At 120 DAS barrel medic and subterranean clover produced the maximum seedling density in the warm season, whereas birdsfoot trefoil, strawberry clover, persian clover and arrow leaf clover had the greatest seedling densities in the cool season (Table 1). After about one year, the birdsfoot trefoil and strawberry clover were the only species persisting among the local naturalised white clover.

The maximum seedling number was recorded between 20 and 60 DAS in the warm and 60 and 120 DAS in the cool season. The rate of seedling appearance was greatest (3.23 seedling/m^2/day) in warm and dry conditions and was least (0.75 seedling/m^2/day) in cool and wet conditions.

Botanical composition

The contribution of oversown legume species to the total dry matter was significantly different for different sowing seasons but not for soil conditions ($P<0.05$). Measurements were made after 8 and 6 months for the warm and cool seasons, respectively. Persian clover had the highest percentage (9.8%) of total herbage yield under cool season and dry soil conditions, whereas alsike clover and strawberry clover had the highest percentage under cool and wet conditions (Figure 2). Less than 2% of the total herbage yield was contributed by sown legumes under warm and wet conditions but under warm and dry conditions it was higher. The percentage of herbage contributed by the three medic species was <1.6% of total herbage yield. Barrel medic, murex medic and subterranean clover made no contribution to herbage yield under cool and wet conditions.

Discussion

These experiments have revealed a low level of legume establishment from oversowing into existing pasture in

Figure 1 The average response of seedling number per unit area of eleven legume species to different sowing seasons.

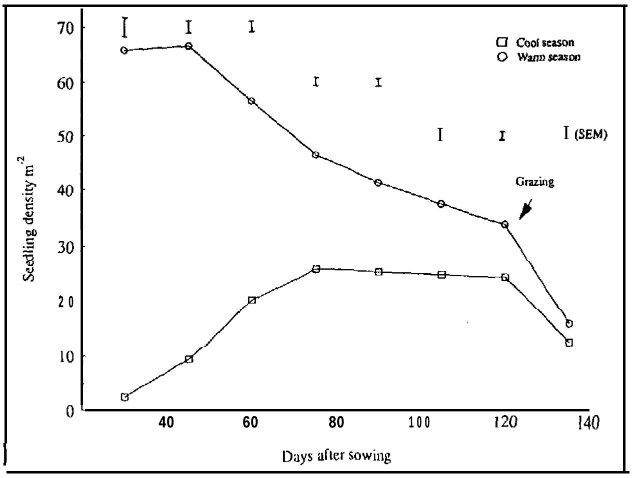


Table 1 Responses of seedling number per unit area (plants/m*) over time in cool and warm seasons and wet and dry soil conditions.

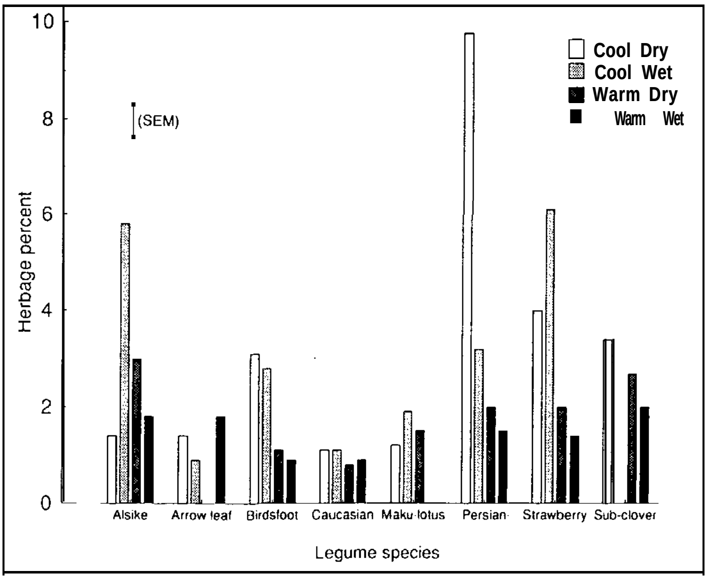
Species	Cool-Dry 30'	Cool-Dry 75'	Cool-Dry 120	Cool-Wet 30'	Cool-Wet 75'	Cool-Wet 120'	Warm-Dry 30'	Warm-Dry 75'	Warm-Dry 120	Warm-Wet 30'	Warm-Wet 75'	Warm-Wet 120'
Annual legumes												
Subterranean clover	0	23	23	0	1	1	152	75	54	106	53	46
Arrow leaf clover	2	45	43	2	12	12	0	0	0	27	34	27
Persian clover	0	35	34	0	18	17	27	36	27	33	22	15
Barrel medic	7	29	29	0	1	1	149	86	64	112	76	53
Murex medic	3	22	21	0	2	2	84	63	44	91	54	42
Perennial legumes												
Alsike clover	0	36	34	11	26	23	41	36	21	37	27	20
Birdsfoot trefoil	2	67	62	16	53	47	99	59	51	55	37	31
Caucasian clover	0	30	27	0	10	9	42	56	37	12	26	16
Lucerne	0	19	16	1	8	6	108	69	47	69	44	33
Maku lotus	0	17	16	0	27	24	55	49	29	29	19	10
Strawberry clover	2	43	41	0	15	15	49	44	26	55	31	25
SEM	7.7"	5.0"	4.1"	7.7"	5.0"	4.1"	7.7"	5.0"	4.1"	7.7"	5.0"	4.1.

[1] Days after sowing
** Significantly different at 5% probability level

drought-prone hill country in the Hawkes Bay. By 30 days after over-sowing, less than 15% of the sown seed had produced a surviving seedling and after 120 days even the most productive species contributed less than 10% of total pasture yield. One year after oversowing, only strawberry clover and birdsfoot trefoil were evident in the pasture. Poor success from oversowing legume species into existing dryland hill pastures has previously been reported (Charlton & Brock 1980; Lowther & Patrick 1992) and often contrasts with the per-formance of mature plants of the species established into a clean seedbed or by transplanting (Woodman *et* al. 1992).

The rate of germination was clearly temperature dependent (Figure 1) and some species such as subterranean clover were more sensitive to cold temperature than others (Table 1) (Campbell *et al.* 1987). There was no effect of soil moisture on seedling density but it was possible that the high frequency of rainfall after oversowing was beneficial to germination (Campbell et al. 1987). The soil was generally moist, even for the dry soil condition from May to November 1992. Barker *et al.* (1988) analysed oversowing experiments and found Grasslands Tahora white clover (*Trifolium repens*) germination was insensitive to rainfall in the week before or the 3 weeks after sowing, but was significantly increased by high rainfall 1 or 2 weeks after sowing.

Figure 2 The percentage contribution to herbage yield of eight oversown legume species under different sowing seasons and soil conditions. Measurements were made after six and eight months for the cool and warm treatments, respectively.



The poor establishment from oversowing resulted from the loss of plants or potential plants, during both the germination and establishment phases. The greatest loss of plants resulted from the non-appearance of seedlings for approximately 80% of the seed sown.

Lowther & Patrick (1992) reported similar poor germination from oversown legume species. Although some of the poor germination of the oversown legumes seed was undoubtedly the result of the interaction between the seed properties of the different species and temperature, and possibly moisture, the cause of failure of most of the seed to germinate was not identified. Fruitful areas for further research would be to identify seed properties that improve the germination of oversown legume seed and to identify the reasons why such a large proportion of seed fails to germinate successfully.

As would be expected, seedling vigour and competition from the regrowth of the existing pasture species influenced the longer-term establishment of the seedlings that emerged (Campbell *et al.* 1987). The competition was more severe for species oversown under warm conditions, largely negating the greater initial emergence of seedlings.

The low contribution of legume species to total herbage yield, e.g., persian clover 9.8%, strawberry clover 6.1%, subterranean clover 2.7%, emphasised the importance of improving the establishment rate from oversowing into dryland hill pastures if legume species are to make a useful contribution to pasture productivity.

In conclusion, the usefulness of new pasture legumes for dryland hill country will depend on their having characteristics enabling establishment by oversowing, and also on the development of improved oversowing techniques.

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