OVERSOWN WHITE CLOVER SEED AND SEEDLING LOSS FROM INSECTS AND FUNGAL PATHOGENS

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SUMMARY

Two field experiments were carried out in South Island tussock grassland to determine the contribution of insects and soil-borne fungal pathogens to oversown white clover losses before and during germination and emergence. Seed sown into small plots, treated with insecticide or untreated, assessed for germination and survival of seedlings to the cotyledon stage, over a period of 19 weeks. In the second experiment seed was sown into fungicide-treated or untreated plots and survival to the cotyledon stage recorded for 14 weeks. Insecticide increased cotyledon seedling numbers by 32% but fungicide gave no such increase.

Keywords: white clover, oversowing, insect seedling pests, fungal pathogens

INTRODUCTION

Tussock grassland productivity and stock carrying capacity can be increased considerably by the introduction of exotic pasture species. It is normally recommended that legumes, commonly white clover, *Trifolium repens* L., are established first in order to raise soil fertility levels before grasses can be successfully introduced. Soils in these unmodified grasslands tend to have low pH, low fertility and be lacking in rhizobia. Therefore rhizobium-inoculated and lime pelleted seed is required and appropriate fertiliser should be distributed at the time of oversowing.

Barratt (1982; 1985), Barratt and Johnstone (1984) and Barratt *et al* (1992) have shown that native broad-nosed weevils (Coleoptera: Curculionidae) damage and destroy white clover seedlings at the cotyledon stage causing direct plant loss and indirect loss as a result of nodulation failure of sub-lethally damaged seedlings. Laboratory and field experiments have shown that sub-lethal damage to cotyledon seedlings can adversely affect nodulation, survival and dry matter production of white clover plants (Barratt 1980; 1985). On average 5% of sown seed survives to establish successfully in the presence of insects and the greater proportion of these losses occur before and during germination and emergence rather than once seedlings reach the cotyledon stage (Barratt *et al* 1992). The role of insects in this seed and early seedling mortality has not been determined.

Cullen (1971) found that the balance between competition from, and protection (from desiccation) afforded by, existing vegetation was critical for successful oversowing in the South Island. In the North Island, Madden (1952) discussed limitations to oversowing and listed competition, nutrition, invertebrates, soil/seed contact as among those that were particularly important. In Australia similar factors limit oversown pasture establishment, but ant harvesting of seed is also a major problem (Campbell and Swain 1973).

Falloon (1981; 1982) has shown that fungicide, particularly captan, applied to grass seed can improve establishment in lowland North Island pastures and Hall *et al* (1987) using fungicides in South Island tussock grassland achieved small increases in establishment and seedling weights of cocksfoot (*Dactylis glomerata* L.). Fungicide seed treatment of some forage legumes, including white clover has proved beneficial overseas (Kreitlow *et al* 1950).

This paper reports on two experiments which were designed to investigate whether insects or soil-borne fungus diseases such as *Phytophthora* and *Pythium* were responsible for white clover seed and early seedling losses.

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METHODS

The experiments were carried out on the East Otago Plateau between the Rock and Pillar Range and the Lammerlaw Range approximately 60 km NW of Dunedin. Twenty sites were located along the Old Dunstan Road at 1 km intervals from each other so that a range of altitude (850–1000 m a.s.l.), aspects, vegetation type and density, soil and other environmental variables could be proportionately represented. The soil type was a Teviot silt loam, and pH ranged from 4.5–5.0. Average annual rainfall was 650 mm. The sites were top-dressed with 300 kg/ha molybdate sulphur superphosphate in September before sowing.

A detailed vegetation composition analysis of the sites is given in Barratt and Patrick (1987) but cover on average over the 20 sites was 37% grasses, 22% herbaceous plants, 18% shrubs and sub-shrubs, 20% bare ground and dead matter and 3% sedges, rushes, ferns, lichens and mosses.

Experiment 1

Four 0.1 m² plots at each site were oversown by hand with 50 inoculated, lime pelleted 'Grasslands Huia' white clover seeds on 7 October 1985. Maximum germination in the laboratory was 88%. Two of the plots were sprayed, including a 50 cm buffer area around each plot, with parathion-methyl (Folidol M50), at a rate equivalent to 1.2 litres/ha, every 2 weeks from 7 October to 27 December to maintain insect-free areas. The other two plots at each site were left untreated. The sites were visited weekly for about 9 weeks and then at less frequent intervals until 21 February 1986. During each visit one pair of the plots (untreated and insecticide-treated) were searched for seedlings with fully expanded cotyledon leaves, and those found were counted and removed from the plots. The number of plants in the other pair of treated and unsprayed plots was counted only on 21 February 1986, having remained undisturbed until then.

Experiment 2

In spring 1986, white clover seed germination and emergence to the cotyledon stage in the presence and absence of fungicide was assessed. At each of the 20 sites two 0.1 m² plots were oversown by hand with 50 inoculated, lime pelleted 'Grasslands Huia' white clover seeds on 9 October. One of the plots was sprayed every 2 weeks with captan (Captan 80) at 0.36 g/plot in 50 mls water. Because the sulphur content of captan could influence seedling survival and growth, the unsprayed plot was treated at the same time with an equivalent amount of sulphur in the form of calcium sulphate dihydrate (18% sulphur) at 0.21 g/plot in 50 mls water. Plots were examined for white clover seedlings at weekly intervals for 11 weeks and again on 18 January 1987. Seedlings with fully expanded cotyledon leaves were counted and removed on each occasion. In cool soil conditions it was considered that most fungal pathogens would affect seedlings during the early stages of germination rather than after seedlings had reached the cotyledon stage.

Rainfall data were obtained from automatic rainfall stations in the Logan Burn Reservoir catchment within the area encompassing the trial sites.

RESULTS AND DISCUSSION

White clover germination and emergence in both years occurred over a 3–4 month period with a peak 3–4 weeks after sowing (Fig. 1). Further flushes of germination occurred, which could be related to significant rainfall; for example after 13 weeks in 1985–86 and 8–9 weeks in 1986–87 (Fig. 2). Hard seed may have germinated after the period of these experiments.

Experiment 1

Despite quite high between-site variability because of the heterogeneity of the sites, more seedlings were found consistently in the insecticide treated plots compared with the untreated plots through the study period (Fig. 1). The total number of seedlings was about 32% higher in the insecticide treated plots ($P < 0.05$), but this total was still only about one third of the original seed sown (Table 1). Barratt *et al* (1992) found that when seedlings at the cotyledon stage were marked and assessed for survival, on average 60% survive when protected by insecticide compared with 28% of seedlings on untreated plots. This reconfirms the importance of losses occurring during germination and the early cotyledon stages.

Figure 1: Mean number of seedlings emerged to the cotyledon stage per plot in insecticide and untreated plots in 1985-6, and in fungicide and untreated plots in 1986-7 (95% confidence limits are shown).

Figure 2: Weekly rainfall (mm) totals for the period of the two experiments.

TABLE 1: Number of white clover seedlings (mean $\pm$ SE) per 0.1 m² plot (from 50 seeds sown in spring) which had germinated or survived by 21 February (Exp. 1) and 18 January (Exp. 2) in insecticide/fungicide treated and untreated plots. The range of values for each mean is shown in brackets.

Experiment 1				Experiment 2	
No. seedlings germinated		No. seedlings survived (undisturbed plots)		No. seedlings germinated	
Untreated	Parathion	Untreated	Parathion	Untreated	Fungicide
11.0 $\pm$ 1.2 (2-21)	16.3 $\pm$ 1.7 (8-36)	0.5 $\pm$ 0.3 (0-6)	1.0 $\pm$ 0.3 (0-5)	21.8 $\pm$ 3.0 (2-47)	20.4 $\pm$ 2.6 (0-39)

In the undisturbed plots there was no difference between the two treatments ($P>0.05$), but final plant numbers were very low in both insecticide treated and untreated plots (Table 1).

A possible explanation for the difference in final plant numbers between the disturbed and undisturbed plots is improved seed contact with the soil in the former. The process of searching the plots for seedlings at regular intervals may have assisted seed which was caught in the vegetation or deep litter to make better soil contact. In addition, seedlings in the undisturbed plots may have germinated and died due to desiccation, competition with resident plants, nodulation failure or inadequate nutrition etc., while seedlings in plots searched regularly would have been removed before these factors operated.

Experiment 2

Approximately 58% of seeds germinated successfully in Experiment 2 (Table 1). Much of the germination came 8-10 weeks after sowing (Fig. 1) following a flush of rainfall during weeks 8-9 (Fig. 2). There was no difference ($P>0.05$) between the two treatments although the range of values recorded from the 20 sites was large (Fig. 1; Table 1). The fungal pathogens that would be controlled by captan appear, therefore, not to cause white clover seedling mortality, although potentially, some fungal pathogens may have manifest their effects after seedlings were removed in this experiment.

CONCLUSIONS

The experiments have confirmed earlier findings that most oversown white clover seedling losses occur during germination and the early cotyledon stage of development. The experiments have drawn attention to possible factors which might limit white clover establishment other than competition/cover from existing vegetation, which is well documented. Fungal pathogens appear not to be a major factor and protection from insects at this stage gave only minor benefit.

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