

ALLELOPATHIC EFFECTS OF *DANTHONIA RICHARDSONII* (CV. TARANNA) AND *PHALARIS AQUATICA* (CV. SIROLAN) ON *TRIFOLIUM SUBTERRANEUM* (CV. SEATON PARK)

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Summary In two laboratory experiments, it was shown that leachates from residues of *Danthonia richardsonii* Cashm. (cv. Taranna) and *Phalaris aquatica* L. (cv. Sirolan), reduce the germination and seedling growth of *Trifolium subterraneum* L. (cv. Seaton Park). This is the first report of allelopathic effects of this danthonia cultivar released for commercial sowings; field observations have confirmed these effects.

To ensure successful germination and seedling establishment of subterranean clover following autumn rains, prior management practices which reduce surface residues of danthonia would seem to be important.

INTRODUCTION

This paper reports experiments to compare allelopathic effects of shoot residues of *Danthonia richardsonii* (cv. Taranna) and *Phalaris aquatica* (cv. Sirolan) on the germination and early seedling growth of *Trifolium subterraneum* (cv. Seaton Park, hereafter called subclover).

Allelopathic interactions have been reported between weed residues and crop plants and, pasture residues and pasture plants. When plants are exposed to allelochemicals their growth and development are affected. Visible effects include: inhibited or retarded germination rate, seeds turning black or dark brown or swollen, reduced radicle and shoot extension, swelling of root tips, root discoloration, lack of root hairs, reduced dry weight and a lowering of reproductive capacity (McCalla and Haskins 1964, Chou and Patrick 1976). Generally, seedling growth is more sensitive to allelochemicals than seed germination, while radicle growth is more sensitive than shoot growth (Singh and Shekhar 1989).

The biological response of plants to allelochemicals is known to be concentration dependant with a response threshold (Connick *et al.* 1987, Einhellig 1989, Lovett 1979, 1989).

Danthonia richardsonii (cv. Taranna) is the first Australian native grass species to be domesticated for commercial use. Taranna is considered to have its greatest potential for aerial establishment into non-arable hill country, where existing grass cultivars have proved difficult to establish, although it is also suited to other pasture establishment methods. Taranna may also have

potential for use in soil erosion control and amenity areas such as recreational sites, as well as mining reclamation.

Phalaris aquatica cv. Sirolan was also used in these experiments for comparison since it has been shown to have allelopathic effects on subterranean clover (Halsall *et al.* 1995, Leigh *et al.* 1995).

Knowledge of possible allelopathic effects of *Danthonia richardsonii* cv. Taranna on subclover is important for pasture management since this legume species is most likely to be sown in a grass/legume mixture. Two potential pasture management problems could arise: establishment of subclover in a danthonia-dominant grass stand, and maintenance of the clover component in a mixed stand with danthonia.

Two experiments were carried out under laboratory conditions. Aqueous extracts of each grass were used to determine their effects on the germination and early growth of subclover.

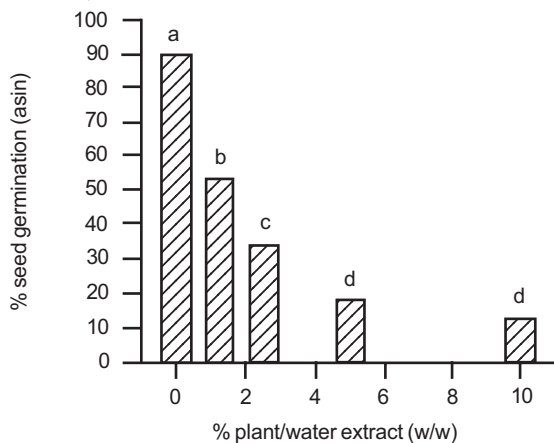
MATERIALS AND METHODS

General Green leaf and stem material from mature vegetative plants of phalaris (cv. Sirolan) and danthonia (cv. Taranna) were collected from established chemical-free pastures. The plant material was cut into 15 cm lengths and oven dried at 50°C for 48 hours. The dried samples were then finely chopped using a plant grinder and combined with deionised water in conical flasks at a ratio of 1:10 or 10% (plant:water w/w). The flasks were sealed, wrapped in alfoil and incubated in the dark at 30°C for 72 hours to allow elution of shoot compounds. The liquid was then filtered and used to make up extract concentrations using deionised water of 5, 2.5 and 1.25%.

Experiment 1 aimed to quantify the effects of differing concentrations of danthonia and phalaris residue extracts on subterranean clover germination.

Treatments used deionised water and extracts of danthonia and phalaris residues at plant:water ratios of 10, 5, 2.5, 1.25 and 0% applied to 20 subterranean clover seeds in petri dishes at 4 mL per dish. Each treatment was replicated four times. Seeds were germinated at 30°C for five days after which germination levels were recorded.

A. Analysis of variance. $LSD=9.2$ ($P<0.05$).



B. Regression relationship. u danthonia n phalaris.
 $y = 38.33 - 22.57 \times \log(x)$ ($r^2=0.77$).

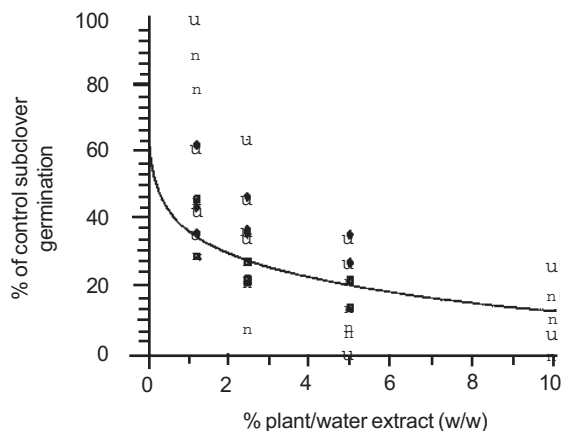


Figure 1. Effect of danthonia and phalaris extracts on subclover germination (data for both species combined).

Raw data was expressed as a proportion of the control value and arcsine transformed. Analysis of variance (ANOVA) was used to assess any significance of treatment differences. Relationships between extract concentration and germination percentage relative to the controls were modelled by regression.

Experiment 2 investigated the effects of aqueous extracts of danthonia and phalaris residues at various plant:water ratios on early seedling growth of subterranean clover.

Twenty seeds of subterranean clover were placed in petri dishes with double filter papers and 4 mL of distilled water. Seeds were germinated at 30°C for four days

after which 4 mL of each extract concentration of danthonia and phalaris were added to the germinated seeds. Each treatment was replicated four times. Seedlings were allowed to grow for a further four days after which total seedling length was measured.

The significance of treatment differences in seedling growth was assessed using ANOVA. The relationship between extract concentration and seedling growth was modelled by linear regression.

RESULTS

Experiment 1 The mean germination of subclover was significantly affected by extract concentration ($P<0.001$), however differences between phalaris and danthonia extracts were not significant. Figures 1A and 1B therefore combine the germination data for each concentration of extract for both danthonia and phalaris and show the significance of treatment differences (Figure 1A) and the regression relationship between extract concentration and subclover germination rate ($P<0.05$, Figure 1B).

Experiment 2 There was a significant difference between the effect of concentrations of danthonia and phalaris extracts on seedling length of subclover ($P<0.01$, Figure 2A). The associated linear regressions were highly significant, the regression equations accounting for 88 and 79% of the variance of danthonia ($P<0.001$) and phalaris extracts ($P<0.001$) respectively, danthonia extract having the most adverse effect at the highest concentration (Figure 2B). At lower extract concentrations, early growth of subclover seedlings was very similar but was significantly higher than growth of seedlings exposed to higher concentrations.

DISCUSSION

Phalaris and danthonia extracts behave similarly in inhibiting subclover germination at all concentrations (Experiment 1). Generally, only the highest concentration was sufficiently potent to inhibit germination totally. This is consistent with the findings of Leigh *et al.* (1995). The initial very rapid decline in germination at low extract concentrations (Figure 1B) is possibly due to the method used to prepare the plant:water extract, where dried material was finely ground prior to elution of allelochemicals. This method would perhaps provide a more rapid release of allelochemicals than would occur in the field, however, results are still meaningful because of the use of phalaris as a comparator species. Despite a significant relationship between extract concentration and germination level, more accurate results would be obtained with higher subclover seed numbers for germination and increased replication.

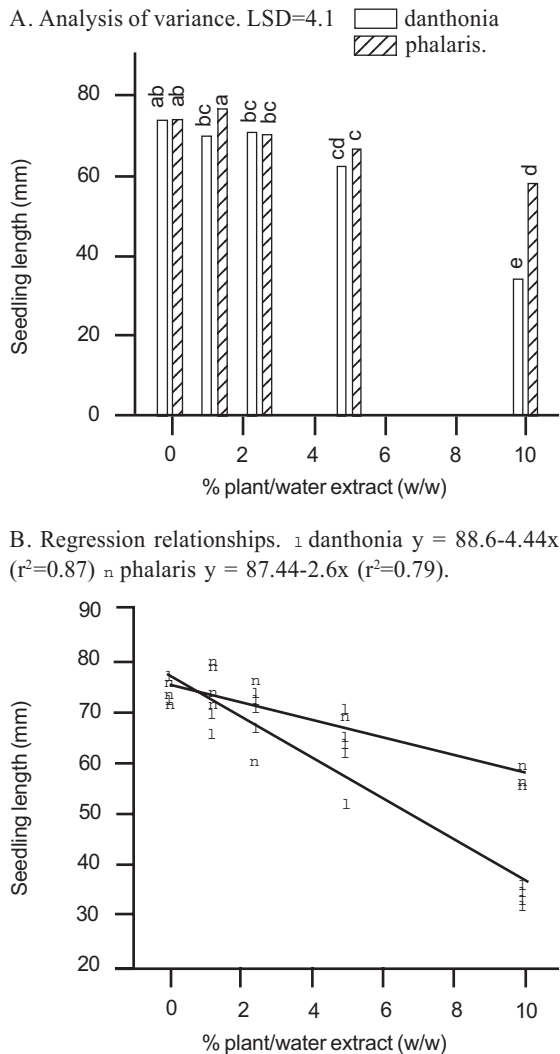


Figure 2. Effect of aqueous extracts of danthonia and phalaris shoots on seedling growth of subclover.

Early seedling growth of subclover was significantly inhibited by 10% concentrations of phalaris and danthonia extracts, danthonia being much more inhibitory than phalaris extract (Experiment 2, Figures 2A and 2B). The differences in extract inhibition decreased as the concentrations became weaker.

Danthonia therefore appears to have similar allelopathic effects on subclover to other introduced grass species such as phalaris and silver grass (*Vulpia* spp.) reported in the literature (Pratley and Ingrey 1990). Where the annual legume has to regenerate each year into perennial pastures containing these grasses, potential

establishment and production problems may arise leading to low legume content. This is supported by field observations by Keys (1996 personal communication). However, a field trial would allow validation of these results. Since the experiments reported here were carried out in the absence of soil, results are not confounded by chemicals produced as decomposition products from soil microorganisms or by 'the effects of plant pathogens' (e.g. *Pythium* spp.) 'which, in the field, could be favoured by increased humidity associated with retained residues' (Halsall *et al.* 1995).

To minimize allelopathic problems it would be beneficial to reduce surface grass residues before establishment of a pasture especially where surface seeding or direct drilling methods are used. Practices could include:

- heavy grazing in late summer and early autumn prior to subclover germination,
 - harrowing to encourage stubble decomposition and reduce stubble build-up in certain areas of the paddock such as stock camps,
 - cultivating the seed bed where residue levels are high,
 - stubble burning in a low intensity fire (a last resort).
- Further research is necessary to establish if danthonia residues affect other pasture and crop species, especially other legumes. It would also be valuable to assess the status of other native species being domesticated such as *Microleana* spp.

Allelochemicals, as secondary chemicals, are part of a plant's defence system (Edwards and Wratten 1980) against competing plants and herbivores. It may therefore be hypothesized that the closer a cultivar is to the native species from which it has been developed (by selection and breeding), the greater is the likelihood of allelopathic effects.

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