Development of a bioherbicide to control gorse and broom in New Zealand: research update

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Abstract

Since 1991, Landcare Research has conducted a research programme towards developing the fungus *Fusarium tumidum* as a bioherbicide for gorse and broom. In this research update, we summarise progress made to date, with particular emphasis on recent work on host range testing, formulation, application and field efficacy.

Introduction

Gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*) are important weeds that compete with young trees in plantation forests in New Zealand potentially causing them to take longer to reach harvestable size and/ or reducing their yield. Our aim is to develop a bioherbicide (a formulated product where a living, plant-pathogenic micro-organism is the active ingredient) to inhibit the growth of these weeds. The advantage of this approach is that the bioherbicide can be applied to a weed in a directed manner, similar to a chemical herbicide, while providing a more environmentally acceptable alternative.

Our prototype bioherbicide is based on the fungus *Fusarium tumidum*, which occurs naturally in New Zealand and can often be found associated with diseased gorse and broom plants in the field. The fungus is a foliar pathogen, typically associated with dieback of shoots, stem and spine lesions on gorse and stem lesions on mature broom (Broadhurst and Johnston, 1994).

Selection of an appropriate fungus

In 1991–1992 a survey was conducted for pathogens that cause disease on gorse and broom in New Zealand (Johnston *et al.*, 1995). *Fusarium tumidum* was isolated from both weeds. Glasshouse trials showed that *F. tumidum* was more pathogenic towards gorse and broom than any of the other fungi collected during the survey, and had potential for development as a bioherbicide (Johnston and Parkes, 1994). As with many *Fusarium* species, *F. tumidum* produces secondary metabolites that are toxic to mammals (Morin *et al.*, in press).

However, toxin production varies considerably between different strains of *F. tumidum* and two isolates were found that produce very low levels of toxin while remaining highly pathogenic to both host plants (Morin *et al.*, in press). The research described here was based on the more pathogenic of these two isolates.

Optimum conditions for infection and disease development

Disease development is often constrained by environmental conditions that are unfavourable for pathogenic fungi. Consequently, the presence of *F. tumidum* on gorse or broom does not always result in serious disease outbreaks in the field. Experiments were performed to determine those conditions likely to limit disease epidemics and, thus, what constraints the fungus would need to overcome to be an effective bioherbicide (Morin *et al.*, 1998).

The most important constraint was found to be a requirement for available water during the early phases of the infection process. Long, continuous dew periods (24 h) after inoculation, or several shorter (12 h) dew periods, interrupted by 12-h dry periods, provide favourable conditions for infection (Morin *et al.*, 1998). Since long dew periods cannot be guaranteed in the field, it will be necessary to develop a formulation for *F. tumidum* that incorporates water-retaining adjuvants.

Mass production and storage of *F. tumidum* inoculum

The spores of *F. tumidum* are the active ingredient of our bioherbicide, and we have developed a method to produce sufficient spores in the laboratory to use in experiments and small-scale field trials. Spores of *F. tumidum* can be grown on solid substrate or in liquid medium. They can also be dried to produce a wettable powder, which can be stored and rehydrated later for use. A high proportion of the dried spores remain viable, and pathogenic, for up to three months when stored at room temperature, and for at least 12 months when stored at 8°C (Fröhlich *et al.*, 1998).

Host range testing

At the beginning of this study it was known that *F. tumidum* could infect three closely related legumes (Fabaceae): gorse, broom and lupin (*Lupinus* spp.) (Broadhurst and Johnston, 1994). Host range tests were conducted to determine whether non-target plants, likely to come into contact with the bioherbicide in the field, could also be susceptible to *F. tumidum*.

Five test-plant species were selected from each of the following four categories: trees grown commercially for timber in New Zealand, herbaceous plants (especially legumes) used as nitrogen-fixing cover-crops in plantation forests, commercially grown legumes and native legumes. These 20 plant species were exposed experimentally to *F. tumidum*. It was found that *F. tumidum* is capable of infecting, and damaging, a wide range of hosts under conditions ideal for the fungus (i.e. 24-h dew period after application) (unpublished data).

However, significant damage was limited to plant species in the same family as gorse and broom (e.g. tree lucerne (*Chamaecytisus palmensis*) and tree lupin (*Lupinus arboreus*)). Distantly related plants, such as *Pinus radiata*, were not damaged by the pathogen (unpublished data). The results from these host range tests will be used to prepare advice

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on the appropriate use of the bioherbicide.

Formulation, application and field trials

Landcare Research and Forest Research are collaborating to develop formulations that will allow *F. tumidum* to cause severe disease in the absence of an extended dew period. Early experiments showed that emulsions of water in oil (invert emulsions) were better at protecting *F. tumidum* spores than nutrient solutions, humectants, granular formulations or oil emulsions.

Invert emulsions are highly viscous and difficult to apply using conventional spraying equipment. Consequently, staff at Forest Research took a standard invert emulsion recipe (available in the bioherbicide literature) and developed several improved mixtures that had better water retention properties but lower viscosity. Both the original invert formulation, and the improved versions, can only be applied with a twin fluid nozzle.

Three small-scale field trials have been conducted to date: in April 1998, November 1998 and April 2000. In these trials, *F. tumidum* spores formulated in water and a number of invert emulsions were applied to gorse (at several growth stages), broom and radiata pine. None of the invert emulsion recipes tested in trials one and two produced consistently high disease ratings, and invert emulsion formulants demonstrated some phytotoxicity towards gorse and *Pinus radiata* on their own (without spores) (Fröhlich *et al.*, 2000).

Recent experiments have been focussed on developing further formulations that will better enhance the activity of *F. tumidum* in the field. Results from the third field trial have not yet been subjected to statistical analysis but preliminary data from small gorse plants (two months old at treatment) appear promising (Figs. 1 and 2). Three of the four treatments comprising *F. tumidum* spores formulated in an invert emulsion resulted in disease ratings of 81–100 per cent necrosis and 62–87.5 per cent plant mortality.

Future research

Monitoring of the results of the third field trial will continue and research will proceed towards developing an effective formulation that is not phytotoxic, and which enhances the activity of *F. tumidum* in the field. The focus of research in 2000/2001 will be to develop an economically viable system to produce *F. tumidum* spores on a large scale.

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Fig1. Gorse plants, three months old, one month after treatment in the field with water (control plants),

Fig. 2. Gorse plants, three months old, one month after treatment in the field with formulated spores of *Fusarium tumidum*.

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