Forest Biosecurity Research Council

A Summary
of Research Findings
2005/2006

Members of the Forest Biosecurity Research Council:

NZ Forest Owners' Association, Ensis, Bio-Protection, Biosecurity New Zealand, Forest Health Research Collaborative, and the Radiata Pine Breeding Company.

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As this hard-working group knows well, I am a newcomer to the intricacies of forest health and forest health research. As a result, I was a some what reluctant starter for this role. I recently chaired my first FBRC meeting. Apparently it was the first such meeting to finish on time at which point it was noted:

> "Clearly, if these meetings are to finish on time, it requires a Chairman who knows nothing about forest health."

However (and in my defence) I have always been acutely aware of the importance of forest health issues and would note they feature significantly in the day to day considerations of a Forest Investment specialist. In the forest investment world, forest health is both a risk (when considering new acquisitions) and an opportunity (to improve growth and investment performance). I look forward to the learning experience, being the link with Forests Owners, bringing some Forest Investment perspective and perhaps being able to make our meetings run over time.

Foreword

– Ian Jolly (Chairman)

The Forest Biosecurity Research Council (FBRC) helps to protect New Zealand's forest resource from insect pests and diseases. An effective biosecurity system depends on scientific knowledge to underpin important risk assessment and management decisions. The FBRC provides a conduit between forest growers and scientists to ensure that research programmes are relevant to industry issues.

As a partnership between forest owners, research providers and Biosecurity New Zealand, the FBRC is uniquely placed to address priorities in a coordinated way. The Forest Owners' Association raises biosecurity and forest health issues affecting growers, while the FBRC coordinates funding support and knowledge to address those issues. Results are funded through levies contributed by forest owners, and through additional support from the Foundation for Research, Science and Technology (FRST).

This report summarises the FBRC research activities from 2005-2006, representing its third year of operation. Highlights include an assessment of survey methods for detecting insect pests and diseases in nurseries; and progress towards understanding *Nectria fuckeliana*, a flute canker disease affecting forests in the South Island. The Nectria programme includes research into fungicidal applications that may prove helpful in treating the disease.

A significant development for the FBRC this year was the inclusion of the Radiata Pine Breeding Company Ltd (RPBC) as part of our membership. Genetics has an important overlap

Another area of activity for the FBRC is to represent the forest industry on the governance board for the FRST-funded "Better Border Biosecurity" (or B^3). During the past year, B^3 and the FBRC contributed seed funding to support an initiative to find replacements for methyl bromide, a fumigant used for the treatment of exported forest products. This contribution, augmented by Smart Start funding from FRST, was used for a background study on quarantine treatments which highlighted the need for a significant research push. This realisation led to the formation of a group comprised of industry and government agencies known as STIMBR (Stakeholders in Methyl Bromide Reduction) dedicated to driving progress on this vital issue.

with forest health issues since susceptibility to diseases and insect attack often has a genetic component. This means that tree breeding is a potential solution for a number of forest health issues. Since most forest genetics research in *Pinus radiata* now comes under the RPBC umbrella it is an advantage to have their representative on our committee, ensuring that research programmes are complementary in approach.

An important function of the FBRC is to ensure that research programmes are adequately funded. This year the FBRC entered into the FIDA (Forest Industry Development Agenda) process. Three successful bids will make it possible to begin new research projects in the next financial year.

Finally, the FBRC experienced a change in administration this year when Jeremy Fleming stepped down as Chairman. Jeremy had a hugely positive influence during the formation of the FBRC, in terms of building key relationships and achieving maximum representation for forestry in biosecurity matters.

The FBRC will continue to ensure that the relatively small pool of specialised forest biosecurity researchers and limited funding streams available in New Zealand are focused towards the best interests of the forest industry and, ultimately, the nation.

FBRC Research Projects

This section of the report summarises projects co-funded by the FBRC. A brief summary of the project titles and funding contributors is given below.

Allocation of effort spent on each of the FBRC projects ($000)

Project	FBRC	FRST	Industry	FIDA	Total
Pitch Canker risk assessment	80	96			176
Understanding *Nectria fuckeliana*	96	163	47	110	416
Impact of *Cyclaneusma minus*	50	88			138
Causes of Physiological needle blight	40	59			99
Armillaria review	20	45			65
Efficacy of forest health surveys	76				76
Efficacy of nursery surveys	40				40
Beneficial organisms to enhance tree health	25	264	92	40	421
Bark beetle control	25	135	73		233
Total	**452**	**850**	**212**	**150**	**1664**

Government Support for Forest Biosecurity Research

The industry-funded FBRC projects described in this report are underpinned by substantial Government support from the Foundation for Research, Science and Technology (FRST). This additional funding provides benefit to the forest industry through comprehensive research programmes, the largest of which is maintained by Ensis Forest Biosecurity and Protection.

For a full summary of these programmes, see the Ensis Forest Biosecurity and Protection Annual Science Report 2005/2006 (available through Ensis).

Pitch Canker

Fusarium circinatum is the causal agent of the pine disease known as pitch canker, which is present in a variety of locations globally. Pitch canker infections are characterised by copious amounts of resin. The disease can result in mortality of the tree, but most commonly it suppresses growth.

To predict how pitch canker could behave, spread and be controlled if the fungus *F. circinatum* were introduced into New Zealand, an understanding of the disease dynamics of this pathogen worldwide is required. With FBRC support, post-doctoral fellow Rebecca Ganley has visited and worked with many research groups in countries affected by the disease. She is also investigating the effects of different levels of nitrogen on disease severity in *Pinus radiata* seedlings.

The behaviour of pitch canker varies considerably between countries, depending on the host tree species, climate, wound agents, host resistance and silvicultural practices. Based on the environmental conditions and epidemiology of pitch canker in countries visited, the following summarises the risk status for establishment of this disease in New Zealand:

- New Zealand's forests have wounds, wounding agents and vectors suitable for infection. However, in the absence of intricate insect-host systems (such as in California), wounding agents present are unlikely to play a significant role in disease establishment.

- The temperature and humidity levels in New Zealand would be sufficient for establishment of the disease in most areas. Pitch canker is likely to be more severe in regions that are coastal or frequently covered in fog. Colder or drier regions would be expected to have a low incidence and severity of disease. Moisture stress or drought can also increase the severity and incidence of pitch canker. It is unlikely that moisture stress will be a problem in New Zealand, as stands have low stock density and soil moisture levels are usually high.

- Nutrient levels can influence disease establishment. Preliminary greenhouse trials conducted overseas indicate that inoculating *P. radiata* seedlings with high levels of nitrogen results in increased disease severity. At this stage, it is unknown whether New Zealand's levels of nitrogen would facilitate disease establishment or severity. However, if pitch canker were to become established additional fertilisation would not be recommended.

- If *F. circinatum* were to be introduced into New Zealand, it could have devastating effects on the pine industry through mortality, growth suppression and stem deformation of the softwood species planted, specifically in *P. radiata*. Thus, continued vigilance and monitoring for this disease is essential for prevention or early detection of this pathogen in the forestry sector. Swift and stringent eradication procedures could easily prevent the establishment and spread of pitch canker to adjacent forestlands or nurseries.

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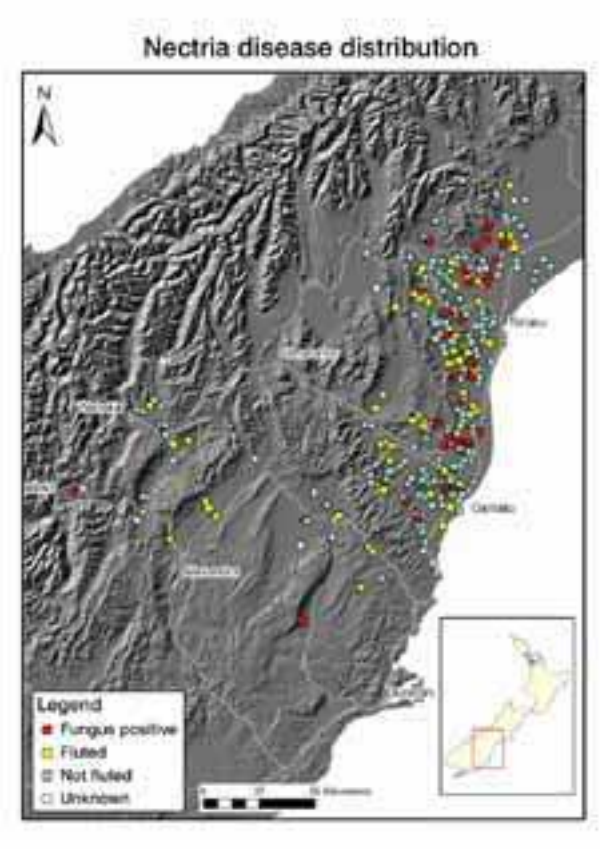
Nectria

Research into *Nectria fuckeliana* forms a large part of the FBRC programme, receiving additional support from FRST and the Nectria Focus Group. Progress has been made over the past year on a number of fronts, providing information to assist with management and containment strategies for the disease in *Pinus radiata*.

Nectria Disease Distribution



Distribution

Ongoing delimiting surveys involving over 280 forest owners have determined the distribution of the disease. There was almost no expansion of the range of Nectria. The most recent record was made at Orari Gorge Station, WSW of Ashburton, and the disease remains confined to the lower half of the South Island. The current known infected area is shown on the map above. These surveys are now being expanded to determine the limit of spread.

New findings on Nectria epidemiology

It is believed that the disease is initiated by the entrance of *N. fuckeliana* spores through pruning wounds. The infection then spreads upwards and downwards from the entry point, killing cambium cells and resulting in the flute canker symptom. New findings over the past year, however, have raised questions about how this infection actually develops.

A DNA-based identification system to detect the presence of *N. fuckeliana* within woody tissue was used to test pruned and un-pruned trees. The purpose of this research was to determine if there is a relationship between pruning and the presence of *N. fuckeliana*. Unexpectedly, *N. fuckeliana* was detected in both pruned and un-pruned trees from the three forests that were surveyed.

The identification of fungus in wood cores from un-pruned trees indicates that the fungus has entered though another wound of some kind, or infection occurs via a different mechanism. This result shows that current understanding of the infection process of this fungus is not complete and other studies of the epidemiology of the pathogen are being conducted. As the results of other studies are analysed, it is hoped that the mode of infection will become apparent.

It should be emphasised that these results are preliminary and future investigation is planned. The identification of *N. fuckeliana* in the wood cores does not necessarily constitute a disease outbreak in the affected forests. The majority of the trees sampled showed none of the symptomatic traits associated with *N. fuckeliana* infection (i.e. fluting or fruiting bodies).

Key findings on spore dispersal

- A cluster of fruit bodies probably remains active for many months.
- Moisture is required for spore release and dispersal. Rain dispersed fungi generally result in patchy distribution and spread of the disease is slow.
- *N. fuckeliana* grows best at warm temperatures, but growth and spore germination can occur at a wide range of temperatures.
- Infected *P. radiata* shows active resistance response. Study of early disease development is in progress.

Susceptibility of other conifers

Five species of "other" conifers were inoculated in 2005 with *N. fuckeliana* in a small pilot trial to determine whether stem cankers develop. Inoculations of *P. radiata* were carried out for comparison. Preliminary results are as follows:

- There were no external symptoms on either *Sequoia sempervirens* or *Larix decidua*.
- *Cupressus macrocarpa* developed symptoms from over 30% of the inoculation points.
- *Pseudotsuga menziesii* (douglas fir) did not develop external or internal symptoms.
- Minor lesions developed on 16% of *Pinus ponderosa*.
- *P. radiata* developed a higher percentage of symptoms, and which were more severe, than those for *P. ponderosa* or *C. macrocarpa*.

These results give an early indication that *P. menziesii* may not be susceptible to disease caused by *N. fuckeliana*, and that the other species may be affected to some degree. However these results are drawn from a small sample and very early in the expected disease development cycle for this pathogen. Monitoring of this trial will continue.

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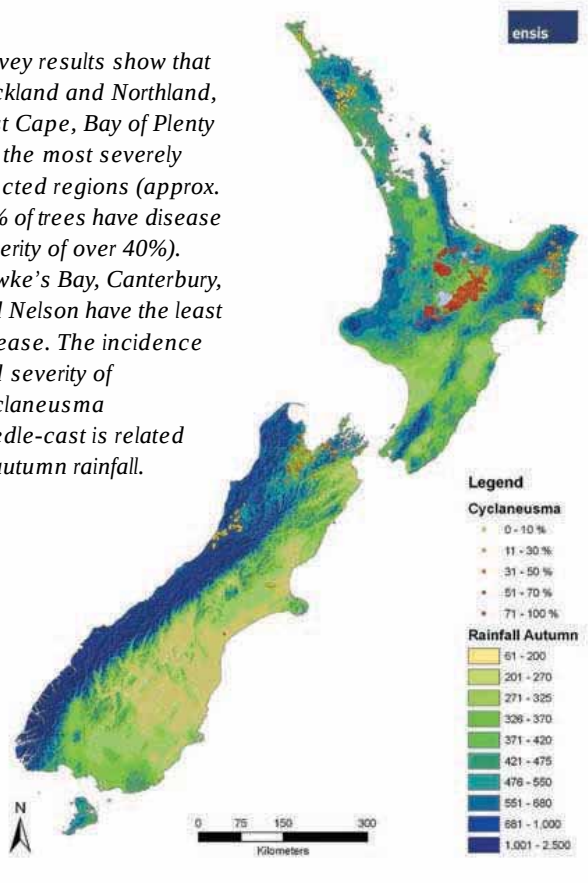
Many *Pinus radiata* plantations in New Zealand were aerially surveyed in October to November 2005 to assess the incidence and severity of Cyclaneusma needle-cast. The aim is to collect data that will determine the economic impact of Cyclaneusma needle-cast in New Zealand. These data can also be used to develop habitat preference models so disease-prone sites can be identified.

In 2005, disease was most severe in the central North Island and on the East Cape. Infection in Nelson and Westland was generally low. Gales took place just before Northland was surveyed, an area traditionally severely affected by the disease. Since most affected foliage had blown off, assessment in this region was difficult. A further year's data will be collected in order to develop the economic impact assessment.

Cyclaneusma Distribution

Survey results show that Auckland and Northland, East Cape, Bay of Plenty are the most severely affected regions (approx. 20% of trees have disease severity of over 40%). Hawke's Bay, Canterbury, and Nelson have the least disease. The incidence and severity of Cyclaneusma needle-cast is related to autumn rainfall.



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Physiological needle blight

Physiological Needle Blight (PNB) occurs in *Pinus radiata* plantations in late winter or early spring. The disorder affects trees of about 15 years and older, causing the foliage to turn red brown and to die, while remaining attached to the tree. The trees remain alive and new growth occurs in the months following the needle blight. In many cases, large areas within a plantation are affected, covering hundreds of trees across hillsides or through gullies.

Scientists believe that the primary cause of PNB is not fungal, although fungi may contribute to death of needles already stressed by environmental factors. Needle blight outbreaks have often been associated with high mid-winter rainfall and non-porous soils.

An FBRC-supported project investigated the hypothesis that PNB is caused by needle water stress. Factors of particular interest were:

- The effect of environmental conditions on water uptake and transfer from root to needles during winter and spring.
- The effect of tree age and branch height on needle water relations and branch water conductance.

The results of this study showed that water loss is greater in needles on 16-year-old trees than needles on 6-year-old trees. Resistance to water flow was also found to be higher in branches of older trees than in branches of younger trees.

This evidence tends to support the hypothesis the PNB results from a culmination of specific environmental conditions and age-related changes in tree physiology that result in water stress to the needles. More data will be gathered to test these results, and researchers will expand the study to consider the mechanism behind the needle water stress.

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This research was primarily carried out by Nick Gould - HortResearch

Armillaria Review

An extensive report completed this year by a number of authors summarises knowledge on Armillaria root disease in New Zealand forests and kiwifruit orchards. Armillaria root rot is caused by two species of fungi which occur naturally in native forests. When these forests were cleared, both species colonised the stumps of native trees and infection spread into the new pine trees through root contact.

Past research has shown that successful disease control in pine forests is achievable by removing stumps prior to planting. Because of the high cost and uncertain economic outcome, this method is rarely used in practice, and cheaper options are under investigation. Alternative methods include:

- The establishment of stands using robust planting material that is physiologically more resistant to infection.
- The planting of stock showing greater genetic resistance.
- Dipping root systems in a *Trichoderma*-based biological control product prior to planting.
- The treatment of stumps with competitive decay fungi to deny *Armillaria* an inoculum substrate and so reduce its ability to attack adjacent pine trees.

Options are limited for remedial treatment of infection in existing plantations, but silvicultural research is in progress seeking a suitable thinning regime that would minimise disease impact. Whatever control methods are finally used, a procedure is needed for identifying those stands with higher infestation in which disease management is economically viable. Two methods have been researched, one involving root collar inspection of a sample of trees within a stand, the other using visible mortality prior to first thinning as a guide to the distribution and intensity of chronic infection. The second option shows promise, but requires further development.

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Forest Health Surveys

The FOA surveillance system is presently being modified to provide improved information on both forest health condition and pest status. The system is also intended to be capable of detecting new pest organisms.

Whilst the efficacy of individual survey techniques is fairly well understood, combining and applying these techniques into a practical, cost-effective strategy is not a straightforward task. The FBRC is funding a project to estimate the variance in disease estimates through time by analysing aerial survey data of Dothistroma from Kaingaroa Forest and other disease incidence surveys (Nectria and Cylaneusma).

This information will allow the FOA to understand the reliability of forest health estimates based on various levels of survey intensity. That is, the trade-off between survey cost and the resulting reliability of inter-annual estimates of forest health.

Interim results from the first phase of the project suggest that the optimal sampling intensity may be around 0.5% of the forest area. Further analysis is required, however, including a comparison with the analytical result derived from an aerial survey.

In the second phase of the project, simulation models of the spread of generic invasive pests will be developed. These models will be used to determine what survey intensity is required to detect a new pest at a given rate of spread.

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Nursery Surveys

Surveys of forest nurseries are currently undertaken to provide a pre-lifting report on plant health and condition. A secondary function of these surveys is to detect incursions of new pests or diseases. The question for the industry is - how can these surveys be used most effectively and what do they accomplish?

The FBRC funded a study to determine the optimal method of pest detection survey and sampling in forest nurseries, and to recommend best practice for future nursery survey methods. In addition, a literature review of incursions in forest nurseries overseas was undertaken in order to determine the likelihood of pests or pathogens entering New Zealand via the forest nursery pathway.

To date no new-to- New Zealand records of pests or diseases of *Pinus radiata* have been made as a consequence of nursery surveys. Because of the lack of incursion detections over the years, the primary benefit of the surveys has been to provide forest owners with reassurance that the stock they are planting is healthy.

Pre-planting health assessments

It has been customary to undertake forest nursery surveys only once during the growing season, in the period leading up to lifting and dispatch of plants for field establishment. This study found that if a forest company requires an independent evaluation of plant health prior to lifting then a single survey undertaken during April –May is appropriate. Disorders such as *Phytophthora* root rot and Dothistroma needle blight are relevant to the forest company purchasing plants and the focus of reports should be on these diseases.

Discussion with experienced nursery staff about plant condition and survey specifications must be an important component of the evaluation. Surveyors need to place considerable reliance on nursery staff to provide the history of climatic and chemical effects on plant health. Without this input it may be impossible to separate symptoms caused by micro-organisms or insects and those caused by abiotic agents.

Most nursery managers practice a regular regime of insecticide and fungicide applications, or will monitor plant health regularly and implement treatments at early signs of infection. These practices may effectively suppress and/or disguise underlying disease, especially to an outside surveyor who visits the site only once and briefly. For this reason, considerable reliance is placed on the ability of nursery staff to detect symptoms and undertake treatments.

The study found that there is a high level of awareness among members of the New Zealand Forest Nursery Growers' Association of the symptoms of pitch canker and of other nursery problems. It is expected that nursery staff will recognise un-characteristic symptoms and send them to the Diagnostic Laboratory for diagnosis.

What risk do nurseries pose?

In other parts of the world, nurseries are strongly implicated in the spread of disease, both to other nurseries and to the wider environment. Seed, scions, whole plants and their growing medium have all been the source of documented incursions.

The only incursion record from New Zealand was the identification of pitch canker in asymptomatic *Pseudotsuga menziesii* scion material. That this incursion was discovered before the release of the plants from quarantine is an example of effective biosecurity. As there is high awareness in the forest industry of the nursery/pitch canker link, stringent regulations have been implemented covering the importation of *Pinus radiata* seed. As a result, the risk of an incursion of *Fusarium circinatum* through this pathway is negligible.

This study concluded that the systems currently in place in New Zealand to restrict or monitor plant material for forest nurseries appear to be working well. However there is clearly a need to maintain stringent control.

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Beneficial organisms to enhance tree health

The FBRC is providing additional support for selected FRST-funded projects to the National Centre for Advanced Bio-protection Technologies (Lincoln University). The purpose of this funding is to provide the forest industry with effective biological agents and natural products to control pests and diseases. Such alternatives are sought by forest managers to enhance productivity, reduce costs, and also, because of reduced chemical application, to improve the environmental sustainability of their growing practices as required by Forest Stewardship Council certification. The current research programme targets several key pests and diseases of *Pinus radiata* including bark beetles, Nectria flute canker and Armillaria root rot.

Bark beetle biocontrol

A newly described fungus, *Beauveria caledonica*, was identified as the primary natural pathogen of bark beetles (*Hylastes ater* and *Hylurgus ligniperda)* in New Zealand. Applications to newly harvested *P. radiata* stumps showed that inoculum can persist for several months on bark and soil surrounding the stump, but did not have a significant impact on beetle populations developing under the bark. Thus, the timing and formulation of biocontrol applications will need to target emerging adults.

Application trials have concentrated on identifying a formulation that will enhance the longevity of *B. caledonica* spores while attracting beetle adults to the fungal inoculum. An inert clay matrix coupled with ground pine cambium (which acts as an attractant) was found to work well, and this is currently being tested in pellet, granule and gel forms for persistence/survival on pine seedling roots and in potting soils.

Additionally, two lure and infect traps have been designed such that beetles attracted to the traps by chemical stimulants are infected by fungal spores incorporated into the trap's wall linings.

Bark beetles in general are considered a major threat to international pine forestry and have caused billions of dollars of damage in recent years (e.g., mountain pine beetle in Canada). Biological research for *Hylastes* and *Hylurgus* control may have significant spinoffs for control of other bark beetle species, should that prove necessary in New Zealand.

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Beneficial microorganisms to enhance *Pinus radiata* health and vigour

Several novel bio-protectant microbial formulations increased seedling growth in the forest nursery by 30 to 40% (compared to a 20% increase with ArborGuard), and reduced the need for fungicidal spray applications. Additionally, selected formulations also greatly increased root development and plant growth when applied to radiata pine cuttings (see photo below). To assess whether the microflora inhabiting pine seedlings can help or hinder biocontrol success, interactions between ectomycorrhizal species colonising *P. radiata* seedlings and bio-protectant microbial formulations are being investigated. These studies include detailed analysis of the identity of ecotmycorrhizal fungi (and of the genetic diversity in New Zealand Armillaria spp.), using advanced DNA technology developed by the research team.

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Radiata pine cuttings 3 months after setting showing beneficial effectives of selected microbial/natural product formulation vs control.

Nectria 'flute canker' wound protection

A number of fungi and bacteria have been identified as potential biocontrol agents for *Nectria fuckeliana*. In collaboration with City Forests Ltd (Dunedin), the best performing organisms have been incorporated into a field trial in the Tokoiti forest, established in mid-2006, in which their activity is being compared to that of a commercial wound-protectant (Garrison) and a new wound treatment formulation (Gelseal). The microbial treatments in this trial were selected on the basis of extraordinary antifungal activity in vitro. This trial will be assessed for development of 'fluting' initially in April 2007 and subsequently, as appropriate

Earlier field trials conducted by Lindsay Bulman (Ensis) showed that immediate fungicide application reduced, but did not eliminate fluting, and the cost- effectiveness of this treatment is still unclear. Delayed fungicide application was found to be ineffective.

1. Nectria flute canker symptoms; 2. Nectria wound protectant trial establishment (in winter); 3. Pruned tree showing stubs treated and untreated with trial formulations; 4. Trial trees.

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Armillaria disease

The Trichoderma product, ArborGuard, was optimised for use in the field by Bio-protection scientists working closely with PF Olsen and Company Ltd and Forenza Ltd. A single nursery-applied treatment can now result in over one third less mortality from Armillaria disease in forest plantations than untreated trees, 2 – 3 years after planting. This product demonstrates the potential benefit of biological treatments to manage forest health.

www.fbrc.org.nz

For more information on FBRC, membership details and science reports *and more*.

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