

NURSERY PAPERS

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ENDOPHYTES AND LATENT PATHOGENS – IMPLICATIONS FOR THE NURSERY INDUSTRY

Endophytes are fungi that reside in living plant tissue for all or part of their life cycle, without causing any apparent or detectable symptoms of disease.

Although generally benign, some have the ability to develop into aggressive pathogens and cause a range of symptoms including die-back, cankers or fruit rots, when trees or plants are stressed. These types of endophytes are usually referred to as latent pathogens.

Endophytic latent pathogens are an important biosecurity concern, since they can be moved undetected in plant material and once introduced into a new area, may move onto other hosts and cause disease epidemics.

In this Nursery Paper we examine endophytes in more detail and consider their potential future impact on the industry.

Summary

- Endophytic fungi live within plant tissues (roots, stems and/or leaves) without causing any obvious symptoms of disease, and can be beneficial to the plant.
- Some endophytic fungi need to be considered as opportunistic or latent pathogens in nursery, forestry or agricultural situations, with the ability to rapidly cause disease when plants are stressed.
- Some host/pathogen combinations show symptoms very soon (e.g. 2-3 days) after infection. Others may have a latent period of up to three years e.g. virus and viroid disease in trees.
- Most woody hosts will have latent pathogens residing asymptotically in their internal tissues. These are difficult to detect, and are being spread around the world with the global trade in living plants.
- The growing conditions in post-entry quarantine facilities are unlikely to favour disease expression of latent pathogens.

BACKGROUND

Endophytic fungi live within plant tissues (roots, stems and/or leaves) without causing any obvious symptoms of disease. For many endophytes their relationship within the plant is symbiotic.

The fungus lives in a protected environment where nutrients are readily available and it is able to eventually use host tissue for reproduction.

The benefits of such fungi to temperate grass hosts is well documented, and can include:

- enhanced plant growth
- improved nutrient uptake
- increased tolerance to heavy metals
- improved ability to tolerate abiotic stresses such as drought and salinity
- increased resistance to insects, plant pathogens and mammalian herbivores.

In trees, especially tropical rainforest trees, there may be hundreds of different kinds of endophytic fungi in one tree. There has been little research in this area, and the benefits of endophytes to the plant are poorly known.

Some endophytic fungi, especially those in the fungal family *Botryosphaeriaceae*, need to be considered as latent or opportunistic pathogens in agricultural, nursery and forestry situations.

They can be present in plant tissues for many years without manifesting symptoms of disease. These fungi have the ability to rapidly become aggressive pathogens causing disease when host plants are stressed.



THE RESEARCH

THE FAMILY *BOTRYOSPHAERIACEAE*

Some common endophytes belong to the fungal family *Botryosphaeriaceae* in the genera *Botryosphaeria*, *Diplodia*, *Fusicoccum*, *Neofusicoccum*, *Dothiorella*, *Lasiodiplodia*, and *Sphaeropsis*.

These fungi may be endophytic in virtually all tissues of woody plants.

While normally these fungi are benign, they do have the ability to become aggressive pathogens when plants are stressed or there is sub-optimal growth of trees or plants.

Within the broad definition of endophytes, these types of fungi are classified as latent pathogens.

STRESS FACTORS AND DISEASE EXPRESSION

The stress which ends the latent period of plant pathogens may be biotic or abiotic.

External stresses include under or over supply of water; mechanical or insect damage; diseases caused by other pathogens; interplant competition; or off-site planting.

Extreme or changing weather conditions may also stress plants, leading to latent pathogens causing twig, branch and main stem cankers, die-back of branches, collar rot, damping off, root cankers, blue-stain and death of an entire plant.

INFECTION AND SPREAD

Most woody hosts will have endophytes, including latent pathogens, residing asymptotically in their internal tissues. These are difficult to detect, and are being spread around the world with the global trade in living plants.

Many have a wide host range and some may move into native plants.



Branch dieback of Wollemi pine caused by a *Botryosphaeriaceae* fungus

It was originally thought that endophytic fungi could only infect through wounds. This undoubtedly occurs where cankers develop from wounds on stems or branches.

However, research indicates that fungi in the *Botryosphaeriaceae* can enter healthy plants directly through natural openings (stomata, lenticels) on healthy plants. This leads to endophytic colonisation by the fungi. Virtually all plant parts are able to host latent *Botryosphaeriaceae*.

Most of these latent pathogens produce slimy spore masses (conidia) in diseased tissue (dead leaves, twigs and branches). These spores are rain splash dispersed.

Another type of spore (ascospores) may also be produced in diseased tissue. The ascospores are ejected into the air and are wind dispersed. Ascospores can also be spread in water.

These latent pathogens are generally not spread by seed, although this does occur with mango.

THE LATENT PERIOD

The latent period is defined as the time interval between infection and the appearance of visible symptoms.

Many plant pathogens have a latent (symptomless) period before symptoms of disease appear. The exception are fungi which derive their energy from breaking down dead tissue.

Some host/pathogen combinations have a short latent period, with symptoms appearing 2-3 days after infection. Other pathogens may have a latent period of up to 3 years e.g. virus and viroid diseases in trees.

The latent period between infection and visible plant symptoms is important because the movement of infected but symptomless plants will unknowingly spread the pathogen.

For example, downy mildew of *Impatiens* can be spread over long distances through the movement of infected plants and cuttings prior to the appearance of visible symptoms.

Downy mildew symptoms typically do not become apparent until approximately 5-14 days after infection, depending on the age of the plant, temperature and humidity. Downy mildews are strongly influenced by environmental conditions.



MANAGEMENT

As latent pathogens are ubiquitous and can be present in most woody plants, it is important to maintain good vigour in such plants. Avoiding water stress is particularly important.

Disease incidence and severity is worse if plants are subjected to drought, waterlogging, temperature extremes, defoliation, damage by insects and other pathogens.

Wounding can be a prerequisite for infection. Avoid any mechanical or wind damage to plants. Only take cuttings for propagation and grafting from relatively young, vigorous and healthy mother stock plants.

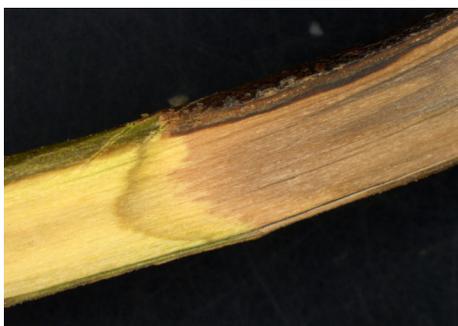
Protect pruning and grafting wounds, and any bark splits that occur with an appropriate fungicide. Seal the wounds with white plastic paint. Do not prune plants during wet weather and disinfect clippers regularly.

Dying and dead twigs and branches should be pruned back as far as possible to the main stem, and removed from the nursery. This will remove a source of primary infection.

IMPLICATIONS FOR THE NURSERY INDUSTRY

The nursery/plant trade actively moves seeds, seedlings, cuttings and plants of plantation trees and ornamentals internationally.

Many of these woody plants (especially those derived from cuttings, and budded or grafted trees) may have endophytes, including latent pathogens, residing asymptotically in their internal tissues.



Advancing margin of a blueberry stem infection caused by *Lasiodiplodia* sp.



Stem dieback of blueberry caused by *Lasiodiplodia* sp.

These hidden endophytes, especially the latent pathogens, are an important biosecurity concern, since they can be moved undetected in plant material. Once introduced into a new area these fungi may move onto other hosts and may cause disease epidemics.

The growing conditions in post-entry quarantine facilities are unlikely to favour disease expression of latent pathogens. Therefore many more 'new encounter' diseases can be expected to occur unless the global movement of live plants is better regulated, or a reliable technique is developed to detect endophytes of trees and woody ornamentals.

This document was prepared by Ken Pegg, Tony Cooke, Lindy Coates and Andrew Manners from Agri-Science Queensland, Department of Agriculture and Fisheries, and reviewed by Roger Shivas (DAF) as part of the 2017 project 'Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry'.

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EXAMPLES OF DIEBACK, CANKER AND FRUIT ROT caused by fungi in the family *Botryosphaeriaceae*. These fungi belong to many genera, which require molecular identification.



Necrotic graft union in avocado



Stem canker of grapevine caused by *Botryosphaeria* sp.



Stem dieback of *Leucospermum* sp. showing fungal fruiting bodies (black dots) on stem surface and discoloured vascular tissue



Stem-end rot of avocado fruit



Dieback of hoop pine seedlings caused by *Neofusicoccum ribis*; early symptoms on cotyledons of plants on the left and right and advanced dieback on middle plant

LINKS TO RESOURCES

Burgess TI, Crous CJ, Slippers B, Hantula J, Wingfield MJ. 2016 Tree invasions and biosecurity: ecoevolutionary dynamics of hitchhiking fungi. *AoB PLANTS* 8:plw076;doi:10.1093/aobpla/plw076.

Slippers B, Wingfield MJ. 2007 Botryosphaeriaceae as endophytes and latent pathogens of woody plants: diversity, ecology and impact. *Fungal Biology Reviews* 21: 90-106.

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