Phytophthora diseases – problematic in the nursery and beyond

Nurseries represent a high risk for the spread of *Phytophthora* potentially resulting in outbreaks of root diseases in home gardens, orchards, wild flower farms and natural ecosystems. Some nursery plants, especially susceptible Australian native species, may be infected with more than one species of *Phytophthora*. Recent serious outbreaks of *Phytophthora* diseases in natural woodland ecosystems in Europe and North America have been linked to internationally traded nursery plants.

The name *Phytophthora* is derived from the Greek words meaning 'plant destroyer'. *Phytophthora* species cause devastating losses in a variety of tree, ornamental and crop plant species as well as in native ecosystems. One species, *P. cinnamomi,* has had a particularly high impact on the sclerophyll forests and heathlands of southwestern and southern Australia. Although *Phytophthora* has fungal like characteristics it is not a fungus and is closely related to algae and protozoans. This means that diseases caused by *Phytophthora* cannot be managed in the same way as diseases caused by fungi. *Phytophthora* and *Pythium* species are commonly referred to as water moulds as both are favoured by free water in the soil or on the foliage. As water status and temperature have a large impact on *Phytophthora* diseases, severity will vary greatly from year to year depending on climatic conditions.

Fig. 1. Phytophthora diseases in ornamental horticulture and in a natural ecosystem a) native flower crop (photo by Leif Forsberg) b) *P. cinnamomi* in *Xanthorrhoea* sp. (photo by Andre Drenth).

There are more than 100 species of Phytophthora which have been identified and new species or variants of existing species are emerging continuously. Of the some one hundred species described worldwide, around twenty are currently described as causing disease in Australia (Table 1). All species are plant pathogens that attack various parts of the plant including roots, crowns, stems, buds, flowers, fruit and leaves. In contrast, most *Pythium*

species tend to be good saprophytes and opportunistic pathogens; *Phytophthora* is a poor saprophyte.

Phytophthora is a soil-borne organism and some species such as *P. palmivora* can also attack the aerial parts of plants causing cankers, foliage blights and fruit rots. Some species such as *P. cinnamomi* attack a wide range of plant species (> 3500) whereas others are confined to a single host species (e.g. *P. fragariae* var. *fragariae*). Other important species have a host range that lies between these two extremes. Some species can cause multiple diseases on the same host. Accurate identification of the species and a clear appreciation of its life cycle are essential for disease management.

Life cycle

The life cycles of *Phytophthora* species are all similar but the disease cycles of their host/pathogen systems are quite diverse. All species are soil-borne pathogens with poor saprophytic ability. They produce microscopic sac-like structures (sporangia) from which emerge from 8 to 32 small swimming spores (zoospores). In some species sporangia germinate directly to form a germ tube. Zoospores can swim for minutes or hours and are chemotactically and electrotactically attracted to susceptible plant roots. Two to three days after infecting the root the pathogen can again produce sporangia and produce a second generation of inoculum. This leads to a rapid build up of inoculum which may promote the disease to an epidemic level. The vegetative hyphae can also produce other types of spores. These are the chlamydospores (asexual) and oospores (sexual). These spores have thick walls and allow *Phytophthora* to survive for many months or even years in dry soil or decayed plant material.

Some species of *Phytophthora* are able to infect above-ground parts of the plant by special aerial sporangia. These sporangia are dislodged from plant parts by water, wind, rapid changes in humidity or by vertebrate, invertebrate or mechanical vectors. They are disseminated to neighbouring plants by water splash or spread longer distances by wind driven rain or contaminated vectors.

Zoospores can be spread to new host plants in surface floodwaters. In the nursery they can also be disseminated by splashing water drops and with irrigation water. The most important factor in the spread of *Phytophthora* is human activity either through the movement of infected nursery plants, infected plant material including seed and cuttings or the movement of infested soil or gravel. Animals can also spread *Phytophthora* through ingestion of diseased plant material or by spreading infested soil.

Symptoms

Phytophthora species are primary invaders that infect only healthy plant tissue or freshly wounded tissue. They do not infect tissue previously invaded by other

Fig. 2. Symptoms of phytophthora on riceflower (root rot – above) and crown and stem rots of foxtail palm (middle) and aloe vera (below) (photos by Leif Forsberg).

microorganisms. Symptoms of *Phytophthora* diseases are variable and often are not distinct from those resulting from other plant pathogens. For example *Cylindrocladium* root rot can easily be misdiagnosed as *Phytophthora* root rot. Confirming the presence of *Phytophthora* will require traditional laboratory culturing and/or molecular diagnosis.

The most common nursery disease is **root rot** (Fig. 2). Many nurserymen take the root system for granted because it cannot be observed directly, even though a healthy root system is essential for the normal functioning of the aerial parts of the plant. A healthy root system is necessary for the uptake of water and minerals, supplying growth hormones (cytokinins, gibberellins) and converting nitrogen into amino acids for protein synthesis. A healthy root system requires good drainage and root growth is sensitive to the oxygen concentration in the potting medium. Without a healthy root system, plants perform poorly or die.

Phytophthora can decay seed or seedlings before they emerge or cause damping-off of young plants. Infection generally starts at the root tip and rapidly involves all below ground parts and the plants fall over. When more mature, plants appear water stressed, chlorotic (yellow) and stunted. The plants may remain wilted even after constant watering. Roots are soft and watersoaked with a brown discolouration. There may be an absence of secondary and tertiary roots. In many hosts infection is confined to the fine feeder roots (avocado), in others (*Banksia*) it invades the larger roots and lower stem.

Fig. 3. Phytophthora pseudobulb rot of *Cattleya* orchid (above) and heart rot of bromeliad (below) (photos by Leif Forsberg).

Phytophthora is also of extreme importance in the post-nursery phase. Nurseries have an obligation to produce plants free of plant pathogens, not just free of symptoms. Root diseases often have cryptic infection and/or infestation can occur ahead of symptom expression; plants may not show obvious symptoms until after they leave the nursery. Such infections may kill a tree or shrub many years after the plants have left the nursery with great loss to growers and perhaps the environment. Planting diseased nursery stock may also infest a previously clean soil for the foreseeable future.

Other symptoms likely to occur in the nursery include **crown rot** (Fig. 2). This develops at or just below the potting mix level and the infection frequently moves into the lower stem to produce distinct **stem lesions** (Fig. 3).

Many species of *Phytophthora* can cause **cankers** on the stems of host plants. These are first evident as wet lesions on the bark surface. Bark discolouration, cracks and fissures and an exudation of a red sap will quickly develop. Several *Phytophthora* species cause **leaf blight and twig dieback** (Fig. 4). Leaf blight symptoms first appear as diffuse brown to dark-brown spots or blotches which rapidly turn black resulting in premature leaf fall. Shoot dieback symptoms include blackened shoots, with or without foliage attached (Fig. 3).

Disease management

It is of paramount importance that production nurseries produce *Phytophthora* free plants. This may be difficult and challenging for some nurseries due to the complex disease cycles of the pathogens with their

diverse spore forms, but it is achievable. Chemicals such as phosphonate and metalaxyl must not be used to achieve this objective. They will reduce disease and improve plant health but they will not eliminate the pathogen. They should only be used as a last resort to help prevent the spread of an existing infestation. If a *Phytophthora* problem persists in the nursery it indicates that there is a major contamination problem which requires urgent attention and not just the frequent applications of chemical. To quote the eminent ornamental and nursery pathologist, the late Professor Ken Baker, when advising growers about nursery pathogens, 'Don't fight 'em, eliminate 'em - temporary suppression with chemicals is not control'. This is particularly relevant when dealing with biosecurity threats.

Pathogen-free nurseries are the key to successful horticulture and managing major quarantine concerns. Careless nursery practices have often resulted in catastrophic losses in the field. Every precaution must be taken to exclude disease from the nursery using soundly proven methods. These include the use of clean potting medium, pathogen- free seed and vegetative material, irrigation water free of water mould pathogens and a strict hygiene system.

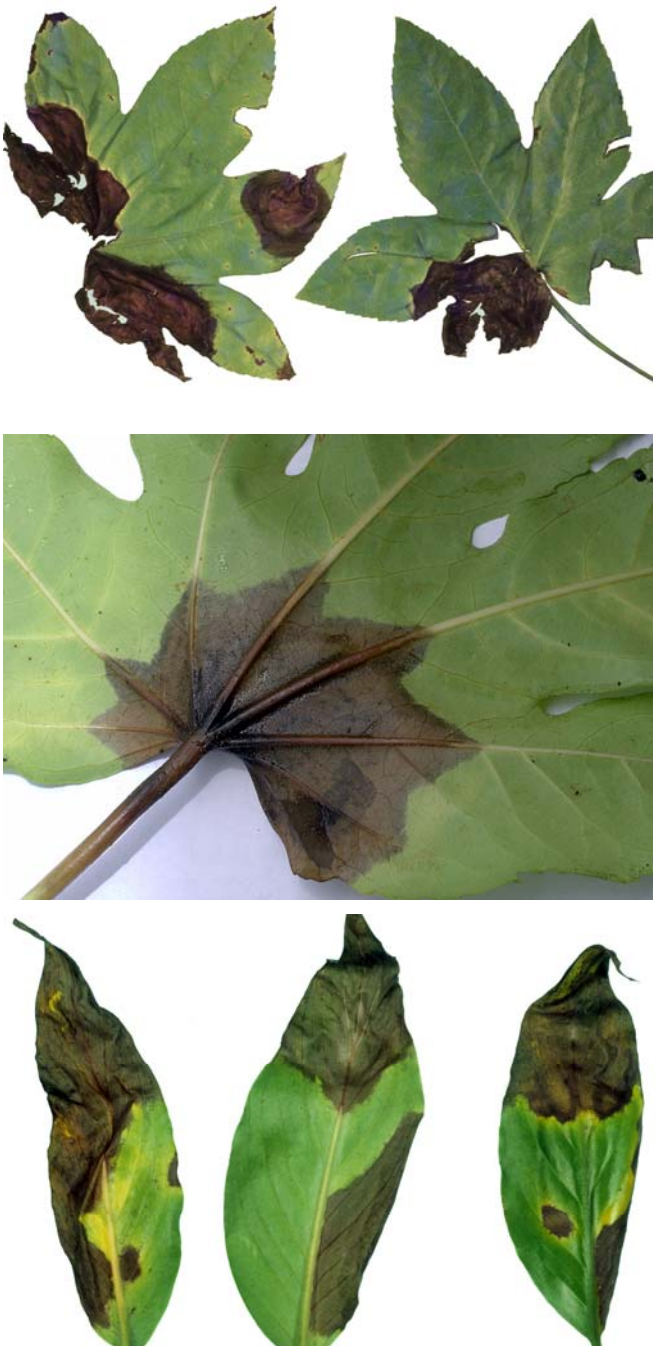

Fig. 4. Phytophthora leaf blight symptoms of *Aralia* (above and middle) and *Spathphyllum* (below). Photos by Leif Forsberg.

- The production nursery should have secure perimeter fencing with controlled access points for machines and vehicles which are decontaminated prior to entry.
- Staff and visitors must walk through two foot baths at the entrance to the growing area. The first foot bath should contain Farmcleanse® (a detergent and decontaminant which kills spores), the second a copper fungicide powder (kills germinating spores and provides residual activity). Provision of disposable shoes is a suitable alternative.
- Do not transfer plants from one nursery to another unless they can be safely quarantined.
- A potting medium with good drainage and aeration which is disinfested with steam (100° C for 30 minutes) or pasteurised with aerated steam (60° C for 30 minutes, steam is then turned off and air continues to be blown through to cool the media to assist colonisation by beneficial organisms) is required. If it is not possible to sterilize or pasteurise the potting mix make sure all components of the mix are pathogen free. The mix should permit free drainage and adequate aeration (15% of air space after watering). Composted hardwood bark and sawdust in the mix help suppress *Phytophthora.*
- Ideally container grown plants should be held on steel mesh benches at a height of at least 1m above the nursery floor. This minimizes water splash which may contain spores. Zoospores are negatively geotropic (swim upward against gravity) resulting in a high concentration of zoospores just below a surface film which is ideal for dissemination by the rain splash mechanism. The nursery floor should be of bitumen, concrete, gravel or crushed rock and this can regularly be treated with copper fungicides or chlorinated water.

- If benches are unavailable place plants on well drained gravel, never on polythene sheets as there will be pooling of water which favours *Phytophthora*.
- Irrigation water should come from a clean reticulated water supply or from deep wells or bores free of surface run-off. Water from rivers, canals and dams is often contaminated with *Phytophthora* and must be disinfested with chlorine. The pH of the water should be adjusted to below 7.0 and after chlorination should result in a minimum chlorine level of 2 micrograms per litre. Manual chlorination is best carried out in an open tank to allow the chlorine to dissipate. In-line filtration (5µm pore size cartridge), chlorine injection and ultraviolet irradiation have also been used to treat water.
- Control the moisture level in the potting medium. Saturated soils will predispose plants to infection.
- The practice of carrying over nursery stock should be avoided as this allows pathogens to persist and even increase in the nursery.
- Diseased plants must be immediately culled and disposed of safely. Keep the whole nursery free of dead plant material.
- All implements used in the nursery must be regularly washed free of soil and decontaminated.
- Some *Phytophthora* species (eg. *P. nicotianae*) can survive in dust. Therefore control dust around the nursery by sealing with bitumen or concrete.
- Remove alternative hosts growing near the nursery. This is important for *Phytophthora* species that produce deciduous sporangia and infect aerial plant parts.
- Regularly monitor the crop for pests and diseases. This includes examining the young roots for discolouration or rot. If a diseased plant is detected, fast and accurate identification of the causal agent is essential. Remedial action can then be implemented. A complete appreciation of the disease cycle of the host/pathogen system will be invaluable in developing the appropriate remedial action.

Fig. 5. Crop hygiene is extremely important for preventing phytophthora. Use of dual footbaths (above) for entry into nursery and raised benches (middle) help keep the nursery clean. Plants growing on the ground with significant amounts of organic matter (below) will increase risk of *Phytophthora* infection. Photos by Leif Forsberg and Tony Cooke.

Phytophthora biosecurity threats

Plant diseases caused by *Phytophthora* remain an ever increasing threat to agriculture and natural ecosystems. New species or variants of existing species continue to be found. International trade in nursery plants and ornamentals has increased significantly and this increases the risk of these pathogens being brought into Australia. Biosecurity threats include *P. ramorum* which is causing serious and widespread

damage in nurseries and woodland systems of Europe and North America, *P. pinifolia* which attacks needles of *Pinus radiata* in South America resulting in tree death, *P. kernoviae* which produces bleeding cankers, leaf blight and dieback of rhododendron, magnolia and beech in a number of countries including New Zealand, *P. mengei* which infects the trunks of avocado trees in California and Mexico, *P. fragariae* var. *fragariae* which causes red stele root disease of strawberry; new strains of *P. infestans,* the pathogen that caused the Irish potato famine in the 19th century and other strains of *P. capsici* which attack capsicum, chilli and cucurbits.

Should any of these or other *Phytophthora* pathogens enter Australia, early detection will be essential for their eradication. Confirming the presence of these pathogens will require culturing and/or molecular diagnostics. Current molecular detection tests for the genus *Phytophthora* are specific to several key species rather than the entire genus. Of the 100+ species currently identified, only 27 have been tested using molecular techniques hence the continual need for traditional methods.

Table 1. Some horticulturally important species of *Phytophthora* in Australia. Other species of *Phytophthora* have been found in forests but not yet in horticultural cultivation or nurseries. These include *P. heveae*, *P. katsurae, P. meadii* and *P. boehmeriae*.

Species	Host	Disease
P. cactorum	> 200 host species including apple, pear, maple, walnut and strawberry	Root and crown rot, fruit rot, cankers, blights and wilts
P. cambivora	~ 30 host species including chestnut, almond, apple and rhododendron	Root and crown rot
P. capsici	~ 50 host species including custard apple and vanilla	Root rot and fruit rot
P. cinnamomi	> 3,000 host species including avocado, pineapple, chestnut, rhododendron, pear and a wide range of Australian native plants	Root and crown rot
P. citricola	~ 100 host species including citrus, kiwifruit, azalea, rhododendron, apple and peach	Root and crown rot, cankers and blights
P. citrophthora	> 100 host species including citrus and a wide range of temperate fruit	Root rot, crown rot and blights
P. cryptogea *P. drechsleri*	> 150 host species including many Australian native plants	Root and crown rot
P. erythroseptica	Few vegetables including tomato and potato	Root rot
P. hibernalis	< 10 host species including citrus	Fruit rot and blight of leaves and twigs
P. infestans	> 50 host species including potato and tomato	Blight
P. megasperma	> 50 host species including asparagus and Australian native plants	Root and crown rot
P. nicotianae/ *P. parasitica*	> 400 host species including tomato, pineapple, citrus, papaya, strawberry, orchids, palms, passionfruit and a range of Australian native plants	Root and crown rot, fruit rot and blight
P. palmivora	> 200 host species including papaya, orchids, durian and cocoa	Root rot, fruit rot, cankers and blights
P. syringae	~ 30 host species including pear, almond and lilac	Crown rot, cankers and fruit rot

This document was prepared by Ken Pegg, Leif Forsberg, Tony Cooke and Lindy Coates (Agri-science Queensland, Department of Agriculture, Fisheries and Forestry, Ecosciences Precinct, GPO Box 267, Brisbane QLD 4001) as part of NY11001 Plant health, biosecurity, risk management and capacity building for the nursery industry. Thanks go to Andrew Manners and John Duff for providing comments on earlier versions of this factsheet.