# Principles of Phytophthora root rot management in established orchards

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The duration of free water in the soil is the most important environmental factor in the development of Phytophthora root rot (Figure 1).

In 1974, a year of abnormally high rainfall, the avocado industry witnessed the collapse of over 50% of all avocado trees in eastern Australia as a result of root rot caused by Phytophthora cinnamomi. Already in 2008 we have had a number of extreme rainfall events. However, the situation since 1974 has changed somewhat; phosphonates are now available to help manage the disease.

Avocado root rot has always been associated with poorly drained soils or short term flooding and the disease was originally referred to as melanorhiza and was thought to be due to water injury. We now know that the presence of free water in the soil is critical for the dissemination of zoospores of Phytophthora and the infection of avocado feeder roots (Figure 2).

The primary symptom of Phytophthora infection is a rot of the feeder roots. Secondary symptoms (canopy decline, death of branches and whole tree) follow root damage. Secondary symptoms can be chronic or acute. Chronic symptoms include leaf chlorosis and abscission and death of primary leaf-bearing branches. With acute symptoms leaves wilt and turn brown and the trees die suddenly with leaves attached. Acute symptoms usually occur following a combination of prolonged soil flooding plus the presence of Phytophthora. Short periods of soil saturation have little impact on tree health unless *P. cinnamomi* is also present. With chronic disease, outward symptoms depend on the balance between feeder root death and feeder root replacement. This balance will be influenced by environmental factors such as temperature, sunlight and wind, all of which interact to affect the transpiration rate and the water demand on the tree.

With avocado the interaction between soil temperature and soil moisture will largely determine the severity of Phytophthora root rot.

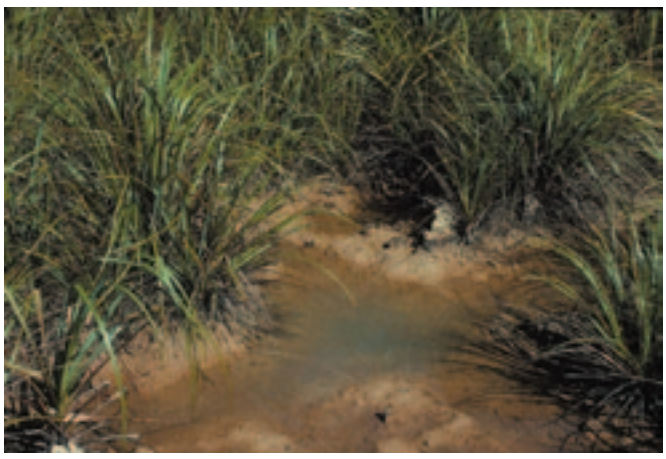

Figure 1: Pooling of water in pig wallows leads to a Phytophthora epidemic in a Queensland rainforest (above and right)

## Soil Temperature

*P. cinnamomi* grows slowly below 150C and above 300C. The optimum temperatures for infection are in the low 200Cs.

The avocado tree grows well between 210C and 330C. At higher temperatures (>280C) the tree can regenerate new roots and limit the damage caused by infection to the feeder roots.

When temperatures fall below 220C feeder root growth and replacement slow down considerably, but *P. cinnamomi* is still very active and the infection of new roots will far exceed the production of new roots and root rot will be severe. These lower temperatures occur in eastern Australia in late autumn/early winter when soils can remain saturated for a considerable time following prolonged late summer rains.

## Soil Moisture and Oxygen

Avocado roots and *P. cinnamomi* require oxygen but in the soil situation it is difficult to separate the effects of aeration and soil moisture.

A well aerated avocado soil will contain up to 16% oxygen. A saturated, poorly drained soil will have an oxygen content of 1-5%, a level which will damage or kill roots. *P. cinnamomi* requires an oxygen level of 2.5-16% to produce zoospores.

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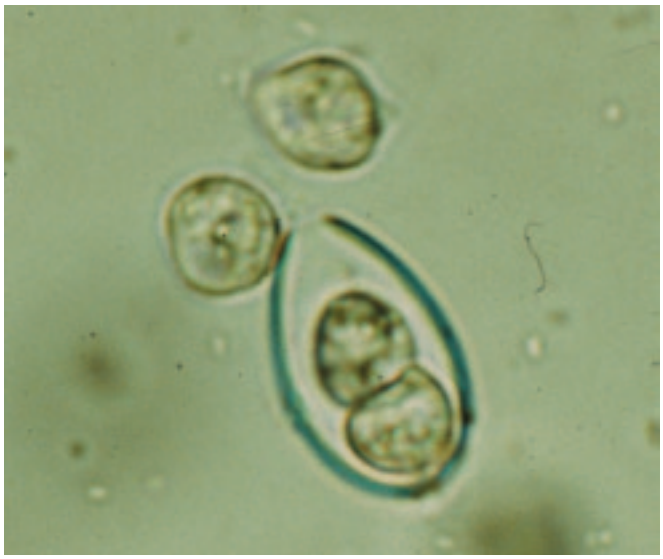

Figure 2: Phytophthora zoospore production and release

Phytophthora root rot should not be confused with root death caused by anaerobic conditions (anoxia). Within a few hours of flooding, soil microorganisms and roots use up most of the oxygen present in the soil, and chemicals such as carbon dioxide, nitrite and hydrogen sulphide accumulate. These chemicals, besides reducing Phytophthora activity, cause severe root damage.

In the absence of *P. cinnamomi*, if the soil is well drained and does not remain saturated for long (<2 days), a new flush of roots will regenerate which will replace the killed roots. However, the combination of short term flooding plus *P. cinnamomi* can cause severe root rot. This is because high soil moisture allows zoospores of the pathogen to be disseminated and infect the feeder roots.

## Phytophthora Population and Phosphonates

A healthy avocado tree produces a mass of vigorous, rapidly growing feeder roots which are an ideal 'food source' for Phytophthora. Such trees will have a higher population density of the pathogen in their root zone than a declining tree which has a reduced number of feeder roots.

Phosphonate applications do not eradicate this Phytophthora population or eliminate infection of feeder roots. They have little direct effect on the soil population of Phytophthora. This means that phosphonate treatments must be ongoing for the life of the orchard. Phosphonates operate in conjunction with physiological processes in the plant to increase the resistance of roots to infection. Phosphonate levels in roots must be maintained at or above critical levels (25-40mg/kg) during periods of high Phytophthora pressure.

## Control

The above factors, as well as several others affecting root rot, are complex and interrelated. There is no single solution to maintaining a healthy feeder root system and a number of different approaches must be used in an integrated manner.

**• Soil Selection**

Select soils which have rapid internal drainage, good aeration and be of sufficient depth to cope with extreme rainfall events such as cyclonic downpours, where up to 600mm of rain may fall in a few days. Avoid soils where surface water or water-filled pores are maintained in the root zone. In high risk areas improve drainage by using mounds and sub-surface drains.

**• Nursery Trees**

Plant disease-free nursery trees which have been approved by the Avocado Nursery Voluntary Accreditation Scheme (ANVAS). These nurseries prevent *P. cinnamomi* from infecting nursery trees by heat treatment (49-500C) of seed which has fallen to the ground, heat treatment of potting mix with steam (1000C for 30 mins) or with aerated steam (600C for 30 mins), use of clean water from bores or deep wells (or disinfest surface water with 0.5ppm chlorine or 20ppm copper sulphate) and good nursery hygiene.

**• Plant resistant rootstocks**

As the avocado originated in Central America and P. cinnamomi possibly in New Guinea, the host and pathogen do not have an evolutionary history and root rot is referred to as a new encounter disease. Conventional resistance is usually not available to this type of resistance. However, some rootstocks are more tolerant than others but infection still occurs. They can only be grown in infested soils if remedial treatments are applied (see Talking Avocados Volume 18 No. 1). Clones of recommended rootstocks are more resistant than seedlings. Avoid clonal or seedling rootstocks where scion overgrowth occurs (Figure 3). In such trees the graft union reduces carbohydrate flow to the roots and root growth and resistance to Phytophthora are reduced.

As part of Tony Whiley's genetic improvement project we are continuing to recover, clone and test rootstocks from isolated surviving trees growing in poorly drained or flood prone soils where trees have been subjected to long term Phytophthora pressure (Figure 4). In Australia avocado trees were first sold from the Kamerunga State Nursery in 1914. Avocado root rot was first recognised by J.H. Simmonds in 1949, but pineapple root and heart rot which are caused by the same pathogen, were described by H. Tryon in 1887. This means that avocado seedling populations have been exposed to the pathogen for almost 100 years and rootstocks with greater tolerance to Phytophthora are likely to exist. Such rootstocks may have tolerance to poor soil aeration as well as Phytophthora root rot. Out of this selection program we have already identified one clonal rootstock

Figure 3: Trees with a scion overgrowth have reduced tolerance to Phytophthora root rot

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with significant root rot tolerance, and a seedling rootstock population which shows a consistent tolerance response to P. cinnamomi (Figure 5).

**• Irrigate carefully**

Soil moisture monitoring devices such as tensiometers or multi-sensor capacitance probe systems should be used to maintain soil water content below the saturation point but at an adequate level for good plant growth. Use high quality water as roots are more susceptible to root rot when stressed by salinity. Also roots infected by Phytophthora lose their ability to exclude salt and leaves develop necrotic margins.

**• Mulches**

Increase the organic matter content of the soil to enhance biological suppression of P. cinnamomi, and thus promote root health and tree performance. Phytophthora is a relatively poor saprophytic coloniser and has difficulty in surviving in soils rich in organic matter which supports an active and diverse microflora. Mulching under trees also stabilises soil temperatures and minimises soil moisture loss. Select a coarse mulch with a C:N ratio of 25:1-100:1 and avoid mulches such as sawdust (C:N ratio of 400-500:1) which cause severe nitrogen draw-down. Suitable materials include chipped avocado prunings, wheat and barley straw, sorghum and corn stubble, sugar cane tops, and composted or aged hardwood chips. Avoid mulching materials with a low C:N ratio (e.g. poultry manure 7:1) which promote excessive tree vigour and reduce soil carbon levels and thus the energy source for soil health and sustainability. Filter press (mill mud) (23:1) and peanut husks (12:1) also contribute a significant amount of nitrogen which increases vegetative vigour. Do not over-mulch as thick mulches can be too moisture retentive and thus exacerbate the root rot problem. Keep mulch away from the trunk to prevent canker development.

**• Calcium**

Apply gypsum under the canopy of each tree at 0.5–1.0 kg/m2. Reapply when the material is no longer visible on the soil surface. Gypsum supplies calcium, which promotes root growth, increases disease resistance in avocado roots and acts as a mild fungicide by suppressing the formation of Phytophthora spores. Use lime if pH correction is required.

**• Soil Nutrition**

Ideally, tree nutrition should be closely monitored with leaf analysis. Phosphorus, calcium and boron are particularly important for root growth and satisfactory levels of these elements must be maintained. Avoid large amounts of fertilizer or animal manures which may be high in ammonia and salts as these are toxic to feeder roots.

**• Fungicides**

Fungicides must be used with the other recommended practices. These systemic fungicides can be applied to the soil, injected into trees or used as foliar and bark sprays. Fungicide treatments do not eradicate the pathogen or eliminate disease and must be ongoing for the life of the orchard.

Many growers are reluctant to inject phosphonates because of the wounding that results from multiple and regular injections. However injections do minimise wastage and environmental contamination and give maximum persistence. Whether injected or sprayed, optimum timing of phosphonate applications requires knowledge of tree phenological activity to ensure the chemical is carried down into the roots

## Further Reading

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Figure 4: 'Hass' on a cloned rootstock which was propagated from an avocado tree surviving in a heavily Phytophthora infested site prone to waterlogging

Figure 5: 'Hass' on selected seedling rootstock (left) showing tolerance to Phytophthora root rot