Kenya Avocado Industry Support Programme (KAISP)

Technical Note 1: *Phytophthora cinnamomi*

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All images courtesy of RA Fullerton, Plant & Food Research.

Phytophthora cinnamomi is one of the world's most destructive plant pathogens. It is commonly referred to as a fungus, but technically it belongs to a different group known as Oomycetes or 'water moulds' as they require free water for reproduction, dispersal and infection.

Distribution and host range

The pathogen is distributed world-wide and has an extremely wide host range (over 1000 species), from soft herbaceous species to large woody trees. It is a major problem globally in avocado both in nurseries and in orchards.

Symptoms

P. cinnamomi is a root-infecting pathogen causing the disease commonly known as **phytophthora root rot**. It infects at the tips of feeder roots and spreads back along the root system killing increasingly larger roots as it travels, finally destroying most of the root system. The effect on the plant is to stop water and nutrient supply to the canopy. The first signs of the disease are leaf wilting and dieback of one or two branches on the tree. The disease progresses over time with more branches losing leaves and dying back. Often only one or two branches or just half a tree will show symptoms while the other half remains healthy. Eventually however, the whole tree dies unless curative management intervenes.

The disease is favoured by wet soil conditions particularly in sites of poor drainage where water is ponded as surface or subsurface water.

Within an orchard it is common to see a pattern of tree death in the path of runoff water. However, the disease can occur at random in orchards as a result of being introduced as infected plants from the nursery.

Life cycle

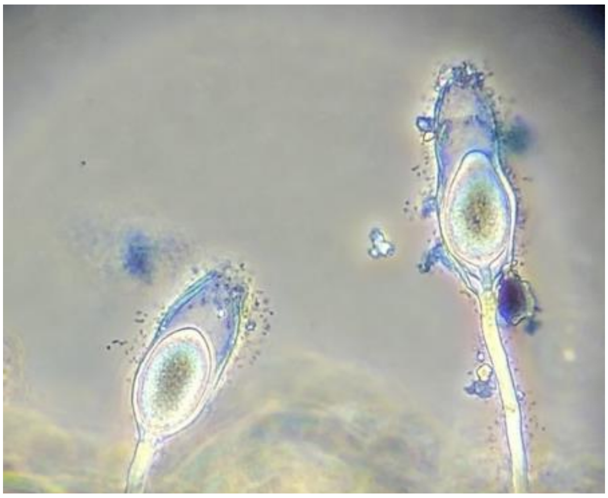
Figure 1. New sporangia forming

The hyphae of *P. cinnamomi* initially colonise the outer tissues of the roots. In saturated soil conditions the hyphae extend from the infected root tissue and form microscopic balloon-like structures called sporangia. The sporangia are, in effect, small 'bags' of multi-nucleate cytoplasm contained by a thin wall.

Figure 1 shows new sporangia forming inside the walls of previously discharged sporangia.

In culture, the hyphae are quite distinctive and characterised by numerous hyphal swellings (Figure 2) and short irregular branches (coralloid hyphae) (Figure 3).

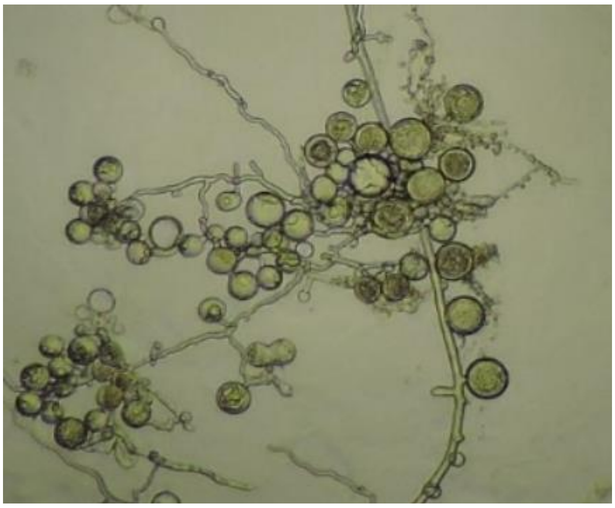

Figure 2. Typical hyphal swellings in culture

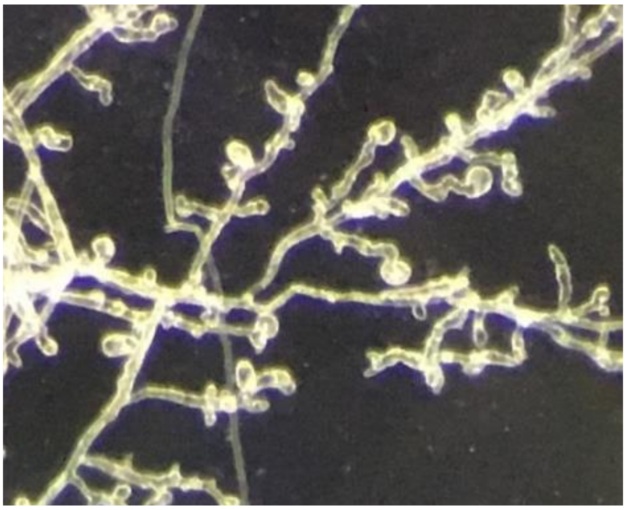

Figure 3. Coralloid hyphae in culture

The sporangia can germinate in water in two ways:

1. Zoospore release

Under cool conditions (normally below 20°C) the cytoplasm condenses around the nuclei to form motile spores called zoospores. The tip of the sporangium opens and the zoospores squeeze out and rapidly disperse into the water film. The zoospores swim in the water film and are attracted to the young root tips. Within a few minutes the zoospores settle on the root surface to form rounded 'cysts'. The cysts then germinate to a germ tube which penetrates the young root to establish infection. Thereafter the pathogen grows back along the root killing the tissue as it grows.

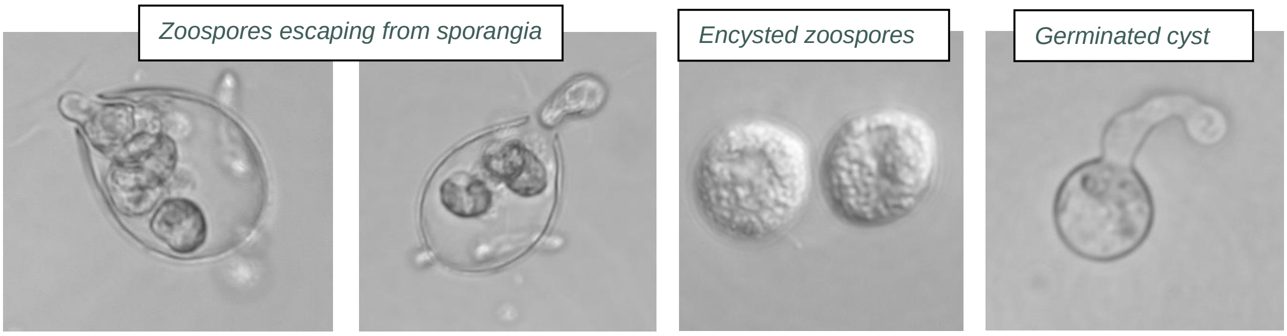

Figure 4. Release of zoospores

2. Germination to form hyphae

Under warmer conditions the sporangia germinate directly as hyphae which can then infect nearby host tissue.

Figure 5. Hyphal germination of sporangium

In terms of epidemiology, germination to form zoospores is a much more efficient means of reproduction as there is a 15-20 times increase in inoculum compared with hyphal germination of single sporangium.

Sporangia and zoospores are very fragile and require free water for zoospores to develop, disperse, germinate and infect. They do not survive drying.

However, the pathogen can survive dry and hot conditions in two ways:

1. Formation of chlamydospores

These are vegetative thick-walled resting spores that form in the hyphae inside diseased plant tissues and can survive for up to 6 years in plant debris and soil. They germinate under favourable (wet) conditions to form sporangia and zoospores which can infect nearby roots.

2. Formation of oospores

Oospores are sexual reproductive structures formed within diseased root material. They are thick walled and, like chlamydospores, are resistant to adverse climatic conditions. They typically germinate via sporangia and zoospores under wet conditions.

Dispersal

Spread of the pathogen (and hence the disease) can occur via movement of surface water, ground water, streams, irrigation, movement of infested soil, infested potting mix, soil splash in nurseries, and movement of infected nursery stock.

Prevention and Control

1. Phytophthora-free planting material

One of the most common means of spread of the disease and introducing it to new areas is the use of young plants already carrying infection from the nursery. Such plants will often die within the first year or two. The pathogen can be readily spread to a high proportion of plants within a nursery by the use of contaminated potting mix and rain splash from plant to plant or from the soil surface to the pots.

The adoption of a Phytophthora-free nursery production system is essential to ensure the disease is not spread to new areas. Essential elements of the Phytophthora-free nursery protocol include:

- Steam pasteurisation of potting mix
- Strict hygiene to prevent recontamination of potting mix
- Plants in the nursery kept out of contact with soil (on a raised gravel pad or on raised benches on a gravel or concrete floor
- Ensuring pots are well-drained and not overwatered
- Regular laboratory monitoring for Phytophthora in nursery plants to ensure the nursery remains disease free.

2. Disease-free planting sites

Ideally new seedlings should be planted into ‘new’ ground (i.e. that does not have existing avocado). Areas that have plants showing symptoms of Phytophthora should be avoided for new plantings.

3. Chemical control

Two options exist for chemical control of Phytophthora.

Metalaxyl: This chemical is normally sold under the trade name Ridomil®. It is most commonly sold as a mixture with mancozeb as Ridomil Gold® and various other trade names. In avocado, metalaxyl is normally spread over the soil surface. While it is quite effective, it is not suitable for long-term soil use. The chemical itself is prone to resistance by the pathogen. In addition, prolonged use as a soil treatment can lead to a condition known as 'enhanced degradation' in which other soil microorganisms begin to use it as a food source and break it down so rapidly that it does not have time to work against Phytophthora.

Phosphonate: This chemical is most commonly used in the form of potassium phosphite (phosphorus acid (H_3PO_3) neutralised with potassium hydroxide). Note; this is not the same as phosphoric acid (H_3PO_4). A closely related chemical, fosetyl aluminium (sold,as Aliette) acts in a similar way.

These chemicals can be applied to the soil, to the foliage or, more commonly with avocado, as a trunk injection. It is readily translocated to the roots where it acts primarily by boosting the resistance of the root system to the pathogen. Plants with quite advanced symptoms of Phytophthora can be 'rescued' by trunk injections of potassium phosphite.

Both of these compounds are specific to species of Phytophthora and closely related organisms and will not control diseases caused by true fungi.

Neither of these options can be applied to organic orchards.

4. Cultural control

Cultural practices which enhance soil organic matter and maintain high soil base saturation (particularly calcium and magnesium) are considered to create soil conditions that are less conducive to Phytophthora infection. The effect is likely to be low in sites that are poorly drained or in which there is a high incidence of the disease.

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