'Jarrah dieback': a threat to horticulture

K Sivasithamparam

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Most Western Australians have heard of the dieback disease which is now devastating the State's jarrah forests.

It has cost the timber industry millions of dollars already, and is likely to cost much more in the future.

But it also poses a problem for nurserymen, and those orchardists who want to grow susceptible species such as the avocado.

Forestry researchers have been studying the problem for some time, in an effort to counter the spread of the disease. Their work has contributed greatly to our knowledge of the fungus responsible.

The Department of Agriculture's plant pathologists also have subjected the fungus to close study. The outcome is a series of recommendations to nurserymen and orchardists.

Dr. K. Sivasithamparam and Olga M. Goss of the Department's Plant Research Division summarise present knowledge, and their own research findings:

*Phytophthora cinnamomi* (the 'dieback' fungus) is a soil-borne plant pathogen with a world-wide distribution and extensive host range (more than 950 plant species). It has come into prominence in Western Australia as the causal organism of jarrah dieback, but it is also of particular importance to horticulture in this State. Plant pathologists believe it was introduced into the State from elsewhere.

The fungus is threatening the emerging avocado industry and the culture in Western Australia of susceptible ornamental trees and shrubs. Banksias and other plants of the same family are particularly susceptible to this disease. Thus the culture in nurseries of these species, as well as others which may either be susceptible hosts or tolerant 'carriers', has to be carried out with great care to prevent the spread of this fungus to new sites or areas.

Photograph: Cliff Winfield,
Forests Department, Como.
The disease organism has been carried down the slope to the irrigation dam below.

The complicated life cycle of the dieback fungus, Phytophthora cinnamomi.

Vegetative phase of the fungus
The body of the fungus (mycelium) is made up of very small tubular threads (hyphae) which usually do not have any internal division walls. Development of this phase is mainly within or on living or dead tissue. It produces bunches of grape-like cells (vesicles). Temperature range for growth is: minimum 5°, optimum 24-28° and maximum 32-34° C. Infection by all forms of this fungus is promoted at 20-30° C.

Asexual Reproductive Phase
(a) The fungus produces chlamydospores which are rounded cells with thick walls and a basal cross wall. These structures cannot move about on their own. The chlamydospore acts as a resting spore. Plant pathologists suspect it to be the form involved in the spread of the fungus from one area to another in soil clods and on root pieces. When the soil is sufficiently wet and warm (above about 15° C), the chlamydospores germinate to form mycelia and sporangia (see below).

(b) The fungus also produces zoospores which are tiny swimming spores with two whip-like tails which help them to move in water. They are produced in special sacs called sporangia which are formed in moist, relatively warm soils (above 15° C). Normally the zoospores do not remain mobile for more than six hours. If in this period they come into contact with a root they immediately become thick-walled spores. Within a short period each spore germinates to produce a hypha which infects the host. If the zoospore does not contact a root it still becomes a thick-walled spore, then germinates...
to form a new sporangium which in time will release a small number of zoospores. Zoospores are killed by copper, chlorine and other toxic substances such as leachates from the bark of some hardwoods. Sporangial production is prolific at 22 to 28°C. Colonies of the fungus cultured in the laboratory produce sporangia readily when incubated at 22°C in the presence of soil-inhabiting bacteria. Mass release of zoospores occurs if the cultures are stored at 4°C for half an hour and then returned to room temperature (26°C).

Zoospores are strongly attracted to the root exudates of certain plants. They have been known to move up to 2 to 3 cm in wet soils. They are frequently passively carried in moving water and therefore disease spread down a slope can be very fast.

Sexual Reproductive Phase
Spherical sexual spores called oospores are produced by the joining together of a ‘male’ cell (antheridium) with a ‘female’ cell (oogonium). The mating only occurs between different strains of the fungus (known as A¹ and A² or + and −). As it is rare to find both strains in the same area in Western Australia, oospore formation is likely to be uncommon here. Under laboratory conditions they can be produced without the pairing of different strains. Oospores have thicker walls than chlamydospores and may live longer in the soil.

Growth and Survival
Chlamydospore formation is favoured by the drying out of the soil. These spores are known to remain viable in soil for 8 to 10 months. Low organic matter content and the consequent low activity of antagonistic bacteria in the soil, increase their chances of survival. However, they do not survive in gravel in the absence of organic matter.

It appears that the roots infested by the fungus may protect it against severe soil dryness. Outside the roots, survival depends on the drying rate of the soil and can be as low as two weeks in freely drying sites.

For survival in natural situations moisture appears to be more important than temperature, though continuous high temperature can inactivate the fungus. Temperature however appears to be the controlling factor in the “bloom” or massive production of zoospores in the field in spring.

With most infected hosts, the growth of the fungus and production of spores may result in the spread of the disease. But Banksias provide a special case. It is known that Banksia spp. that are infected stimulate a massive production of hyphae and spores. This still occurs even after the death of the host. Thus Banksias provide an excellent “food base” for the fungus and become a source of mass spread.

Organic matter incorporation into the soil often results in the death of mycelia and the abortion of sporangia. This is considered to be a result of microbial antagonism. However, fresh organic matter can act as a food source for the fungus, facilitating its sporulation and spread. Some soils have the capacity to inhibit or interfere with the growth of the pathogen. “Resistance” of at least some tree species to Phytophthora cinnamomi is due to a reduction in activity of the fungus caused by microbial activity in the soil around the roots.

Spread of the Fungus to New Areas
The main method of introducing Phytophthora cinnamomi to a new area is by chlamydospores in infested soil or zoospores in water. The infested soil may be:

- the potting mix in which the plant is growing either at propagation or during subsequent growth.
- loam or sand brought into the garden.
- unsealed surface soil on which is dumped bulk potting materials such as peat or sawdust.
- the clods, mud or dust introduced on vehicle tyres, footwear, garden implements.
- the dust on seed or propagation material, particularly if collected from ground infested with the organism.

The contaminated water may be from—

- run-off from an infested site, or
- that used for irrigation.

The nursery is the first link in the chain of preventing a spread of this important pathogen. If care is not taken with hygiene methods, there is risk of spread both during
production of plants and then in the subsequent planting out of plants in gardens throughout the State. Spread of disease from these gardens, parklands, recreation areas and orchards may follow. Even plants not susceptible to the disease may act as carriers of the fungus.

Prevention and Control of the Disease

In the nursery

The main areas of importance in preventing disease development in the Nursery are:

- Clean cuttings (i.e. freedom from soil contamination and use of heat treatment).
- Clean seed (i.e. freedom from soil contamination).
- Clean potting mix. Use inert material such as peat, perlite, sawdust, pine bark and deep sand, sterilised before use.
- New or cleaned and sterilised containers.
- Holding plants in well drained areas and preferably on benches (away from contact with soil).
- Water obtained from deep bores, mains, or which has been decontaminated by chlorination, filtration or exposure to ultra violet light.
- Use of a chemical drench such as Ridomil* at the rate of 4 g/m², or Fongarid* at the rate of 8 g/m² as a further safeguard.

Details of the methods recommended are already published in “Guidelines for Nursery Hygiene” by Olga M. Goss and D. Harrison, obtainable free of charge from the Department of Agriculture.

In the orchard/vineyard

- Avocados:
  When a new area is to be planted the grower should ensure that the site is not already affected with the disease and that the trees purchased come from a registered avocado nursery. If he plans to produce his own trees, the seed should be soaked in hot water (50° C) for 30 minutes and then grown in a free-draining sterilised potting mix.
  Work in the United States of America has indicated that the rootstocks “Duke 6 and 7” are tolerant of the disease, so that use of these stocks should be considered.
  For both new and older plantings the following points will assist in keeping trees healthy:
  - Increase levels of composted organic matter in the soil to encourage antagonistic organisms.
  - Use an organic mulch on the surface around the trees.
  - Ensure that drainage is good and do not overwater.
  *Subject to registration in W.A. for this purpose. Also see note at the end of article.

A young Banksia burdettii from a nursery, affected by the dieback fungus. Note the apex shoot starting to die.

- Ensure that water used for irrigation is clean (as recommended in the nursery situation).

- If disease does develop in any area, drench with Ridomil*.
  Work done in the Eastern States indicates that Ridomil* should be used at the rate of 20 g per m². However, in some instances, particularly when levels of organic matter are low, phytotoxicity can result when the chemical is used at this rate and therefore care must be taken to test the particular site.

- Other Fruit Trees and Grapevines
  Although fruit trees, particularly peaches, and some grapevine rootstocks are susceptible to Phytophthora cinnamomi, no real problems have been recorded in this State so far. A problem is likely to develop only where drainage is inadequate. Therefore close attention should be given to—
  - Ensuring good drainage.
  - Avoiding overwatering.

The use of as much organic matter as possible in the orchard/vineyard, balanced with adequate phosphorus and potash, if required, will tend to develop soil antagonism against the fungus.

In the home garden

- Do not dig up plants from the bush and plant them in the garden.
- Do not add loam or soil from infected areas, which has not been sterilised, to the garden.
- Buy plants from a nursery known to be adopting good hygiene methods or grow from seed or cuttings being sure to use a sterilised potting mix.
- Do not irrigate from a dam or creek unless the water has been chlorinated or filtered.
- If Phytophthora cinnamomi is detected, treat lightly infected plants with a chemical such as Fongarid® at the rate of 20 g per m² (see note below).
- Remove dead and dying plants and treat the area with formalin before replanting.
- Ensure good drainage and do not overwater.
- Increase levels of composted organic matter in the soil and if possible use an organic mulch.
- Plant varieties which are more tolerant of the disease in areas known to be infested. A list of these varieties is available from the Forests Department.

NOTE:
*Care must be taken with the use of Ridomil and Fongarid on native species as little is known about their individual reaction to these chemicals. Some, like Grevilleas, are known to be sensitive especially when grown in containers.