PHYTOPHTHORA

Phytophthora nicotianae var. *parasitica* (Dastur) Waterhouse
P. citrophthora (Smith and Smith) Leonian.

1 PATHOLOGICAL PROFILE

1.1 Distribution and status

Phytophthora is a soil- and water-borne fungus which causes feeder root rot and collar rot of citrus trees as well as brown rot of fruit. It is distributed worldwide. In southern Africa the two species most commonly found on citrus are *P. parasitica* and *P. citrophthora*. *Phytophthora* forms part of the citrus root rot complex.

1.2 Description

The fungus grows as mycelial mats which produce pearshaped spore-bearing structures called sporangia. Under free-water conditions these sporangia release large numbers of biflagellate motile zoospores. These zoospores are the main means of distribution of the fungus. Unlike *P. citrophthora*, *P. parasitica* also produces abundant chlamydospores, in addition *P. parasitica* produces oospores, which are produced only on rare occasions by *P. citrophthora*. Unfavourable periods are survived as chlamydospores or oospores.

1.3 Symptoms

Disease symptoms can be divided into two groups, i.e. collar rot and feeder root rot, depending on the way in which the pathogen manifests itself. **Collar rot** is easier to detect and includes the following:

- Exudation of gum (gummosis) on the rootstock in the case of susceptible cultivars. Gummosis can be found on the scions of trees planted too deep and/or which have been injured by cultivation or during the removal of watershoots. Pickers' shoes can also carry the pathogen onto the framework branches during harvesting.

- As a result of the infiltration of gum, the wood beneath the bark becomes darkly stained and subsequently dries out, causing the bark to crack.

- The cracking of the bark causes a girdling effect, which in turn affects the foliage. The leaves exhibit typical starvation symptoms (similar to nitrogen deficiency), turn pale green and develop yellow veins. Completely girdled trees eventually die.

- If a lesion has ceased to expand or the fungus has died as a result of fungicide applications, the affected area becomes surrounded by callus tissue.

- On susceptible rootstocks, lesions may be found either on the rootstock or on both the rootstock and scion. Lesions usually only occur on the scions of trees budded on resistant rootstocks.

- Young trees are often killed as a result of the girdling effect whereas older trees are usually only partially girdled. The injury then causes a decline of the canopy resulting in defoliation and twig die-back in the corresponding sector of the canopy.

Phytophthora feeder root rot usually produces less clearly defined symptoms than collar root and is consequently often overlooked in the orchard. Feeder root rot causes greater losses to the southern African citrus industry than collar rot. Symptoms include :

- The infected outer cortical tissue of feeder roots dies and disintegrates, leaving only the inner vascular wood (sloughing).

- Slow decline characterised by defoliation, a yellowing of the remaining foliage and twig die-back.
- In severe cases branches may die back when a significant portion of the root system is infected.

- Out-of-season and particularly early spring flowering.

- A decline in yield and fruit size.

1.4 Transmission

Phytophthora is spread through irrigation water, run-off water from adjacent orchards, tillage equipment, and the movement of workers and animals. It is also spread from the nursery to

the orchard through the use of infected nursery stock.

1.5 Seasonal occurrence

Phytophthora is endemic in many of the citrus orchards of southern Africa, especially the older orchards that were established prior to the commencement of the Citrus Improvement Programme (CIP). Severe outbreaks are associated with prolonged wet periods caused either by rainfall or over irrigation.

These fungi are more active during the summer months in the subtropical areas and during the winter in the Mediterranean rainfall regions. The latter occurs even though the temperatures are sub-optimal for the fungi during winter.

2 MANAGEMENT ASPECTS

2.1 Disease assessment

Assessment of the role played by *Phytophthora* in tree decline is often very difficult because the disease is part of the root rot complex. Infection by *Phytophthora* usually also occurs several years before death or die-back of the tree.

There are several laboratory techniques for detecting *Phytophthora*. *Phytophthora* is an extremely poor saprophyte, cannot compete with the diverse population of micro-organisms in the soil and therefore cannot survive on dead roots. Growers should therefore not wait until tree die-back occurs, but should sample healthy orchards annually to monitor for the presence of *Phytophthora*. Soil samples should be collected in the same manner described for nematodes. (Consult the part on the Diagnostic Centre in Chapter 5).

Nitrogen deficiencies or girdling as a result of the use of non-biodegradable ties to stake trees, can induce leaf symptoms similar to those of collar rot. Application of insecticides, such as monocrotophos or Citrimet and phosphorous acid under dry or very hot conditions can also induce gumming and even girdle the tree, resulting in leaves becoming pale green, with yellow veins. A positive diagnosis of the presence of *Phytophthora* by a laboratory such as the Diagnostic Centre is therefore important.

2.2 Control options

2.2.1 Cultural

a) **Soil**

Avoid soils with a clay plus silt content of above 30%, especially where poor drainage and hard pans are encountered. In high rainfall areas with heavy soils, trees should be planted on ridges to drain water away from the trunks.

Deep ploughing to at least 60 cm and allowing the soil to dry out before planting will eliminate *Phytophthora* to a large extent. High density plantings which will be replaced sooner than is currently the case will enable more frequent use of this method of controlling *Phytophthora*. (Consult the chapter on soil preparation in Volume I of these guidelines).

b) ***Phytophthora*-free nursery trees**

It is extremely difficult to rid infected trees of *Phytophthora*. A preventive approach should be followed by only planting trees that have been certified by the CIP as being *Phytophthora*-free. (Consult the chapter on the Citrus Improvement Programme in Volume I of these guidelines).

These certified trees must be taken direct from the nursery to the orchard and must not be stored before planting in any location where it may possibly become infected with *Phytophthora*. *Phytophthora nicotianae* (*parasitica*) has 600 other hosts, many of which are commonly found near farm houses, e.g., Bougainvilleas, granadillas, paw-paws and Poinsettia.

c) **Planting depth**

Ensure that trees are not planted too deep. Most scion cultivars are more susceptible to *Phytophthora* than the rootstock. Once the soil has settled, the bud union should be at least 20 cm above the soil surface. (Consult the chapter on planting and care of young trees in Volume I of these guidelines).

d) **Irrigation**

Over irrigation leads to anaerobic conditions which pre-dispose the roots to *Phytophthora*

infection. Spores are released every time free water is present. Irrigation should be scheduled in such a way that water is applied as seldom as possible but without stressing the tree. This should be based on an acceptable method of irrigation scheduling. Aspects such as root depth, root distribution and the soil water holding capacity should be taken into account when planning irrigation schedule. (Consult the chapter on irrigation in Volume II of these guidelines).

Stems should be kept as dry as possible by placing micro-jets as far away from the stems as is practical. It is necessary to move micro-jets further away from the stems as trees become older. A micro-jet standing right next to the stem spraying onto the stem of a mature tree will result in the accumulation of a large amount of water beneath the base of the trunk, increasing the chances of collar rot. Where flood irrigation is used, key-hole basins could be used to drain water away from the stems.

Irrigation could also predispose feeder roots to *Phytophthora* infections once the water stress is alleviated. This is as a result of root exudates leaking from the microscopic cracks, caused by drought, which attracts *Phytophthora* zoospores once free water is present.

e) **Trunk injuries**

Injuries to the trunk should be avoided as far as possible as these are prime infection sites for *Phytophthora.*

These injuries are usually caused mechanically by cultivation, breaking off of suckers or damaging of the green stems of young trees with herbicides such as paraquat. Strong wind can also cause trunk injuries to develop at the soil level in young trees. Trees in windy areas should therefore be staked.

f) **Tolerant rootstocks**

Citrus rootstocks vary considerably in their susceptibility to *Phytophthora* infection. Choosing a rootstock is a task which can only be done after thorough evaluation, taking into consideration factors such as compatibility with the scion, soil type, clay content, pH and prevalence of diseases such as blight, tristeza and soil pathogens. These factors are discussed in more detail in Volume I in the chapter on rootstock choice. The relative susceptibility of the different rootstocks to *Phytophthora* is given in Table 7.1. However, this is a generalisation and could differ under certain conditions and for different selections budded on the same rootstock. Trifoliate and trifoliate hybrids are susceptible to feeder rootrot under certain conditions of cultivation, but not to *Phytophthora* collar rot.

Table 7.1. Relative susceptibility to *Phytophthora* of different citrus rootstocks used in South Africa

Rootstock	Degree of susceptibility to *Phytophthora*
Sweet orange	Highly susceptible
Rough lemon	Highly susceptible
Volckameri lemon	Highly Susceptible
Sun Chu Sha mandarin	Susceptible
Cleopatra mandarin	Susceptible
Troyer citrange	Intermediate
Carrizo citrange	Intermediate
X639 hybrid	Intermediate
Minneola x Trifoliate	Intermediate
Swingle citrumelo	Tolerant
Sour orange	Tolerant
Benton citrange	Tolerant
C35 citrange	Tolerant
Rusk citrange	Tolerant
Trifoliate	Tolerant
Yuma citrange	Intermediate
C32 citrange	Intermediate

2.2.2 Biological

Antagonists

Two fungal antagonists, *Trichoderma*

harzianum and *Fusarium oxysporum,* are currently under investigation. These antagonists are incorporated in nursery growing media and when the nursery trees are planted in the field, the roots continue to grow in a soil environment which suppresses *Phytophthora.*

Producers are warned to use only registered biocontrol agents from reliable distributors in order to prevent contamination of orchards or nurseries with citrus pathogens.

2.2.3 Soil solarisation

Control can be achieved by hydrothermal heating of the soil. This is accomplished by covering moist soil with 30 to 150 µm thick transparent polyethylene sheeting during the hottest months (January to February) for a period of nine weeks. However, this method largely depends on climatic conditions and will be ineffective in overcast weather.

2.2.4 Plant protection products

Chemical control methods are expensive and will only be economically feasible if all other factors contributing to the root rot complex are also attended to.

a) **Collar rot**

In the past, a copper paste was painted onto lesions to arrest collar rot. Being a contact fungicide, this did not control infections below the soil surface. Contact fungicides can be used preventively to protect potential infection sites which may arise during the execution of cultural practices such as weed control and the removal of watersprouts. The following are some of the copper oxychloride fungicides available:

Fungicide	Dosage per litre water
Cuprox	50 g
Cupravit	
Demildex	

Aliette, Phytex and neutralised Phytofos are systemic phosphonate fungicides which move both upwards and downwards in the tree and which control *Phytophthora* both above and below the soil surface. The entire surface of the trunk up to 35-40 cm above ground level must be painted. Registration of the above products for this purpose is as follows:

Fungicide	Dosage per litre water
Aliette WP	300 g
Phytofos	200 g + 200 g KOH or K_2CO_3
Phytex	Undiluted

b) **Root rot**

There are two groups of chemicals that can be used to control rootrot *viz* the phosphonates (Aliette, Phytex and Phytofos) and the acylalanines. (Ridomil). The phosphonates mainly control *Phytophthora* in the plant by slowing its growth and allowing the citrus tree to activate the phytoalexin scoparone whereas Ridomil controls *Phytophthora* both in the soil and in the roots.

Aliette WP, Phytex and Phytofos are registered as stem paints and as foliar sprays for root rot and collar rot control. The stem injection option with Aliette Ca was not popular in the citrus industry. This is due to injection holes not callousing over fast enough in the stems of older trees, leaving openings for secondary pathogens to gain entrance to the tissues. Stem injections with phosphonates were therefore abolished. The stem paints control *Phytophthora* root and collar rot whereas the foliar sprays not only control root and collar rot, but also brown rot.

The registered application rates for these products which should be applied during the rainy season, are as follows:

Fungicide	Stem paint	Foliar	Soil
Aliette WP	300 g/l	250 g/100 litres water every 6 weeks	
Phytex 200 SL*	Undiluted	1 ℓ/100 ℓ water every 2 months	-
Phytofos	200 g + 200 g KOH or K_2CO_3/ 100 ℓ	200 g + 200 g KOH or K_2CO_3/100 ℓ water every 2 months	-
Ridomil	-	-	2 x 40 g/m^2 (3 months between applicants.)

*Phytex is also available as a 400 SL formulation which is double the strength of Phytex 200 SL. More phosphonate options other than Phytex and Phytofos with different concentrations are becoming available. Producers should take careful note of the label instructions.

If diagnostic tests indicate that the soil is infected with *Phytophthora,* treatments should be carried out as follows:

- Start with a Ridomil application of 40 g/m^2 in spring and follow up with a second application of 40 g/m^2 three months later or two Aliette, Phytex or neutralised Phytofos treatments at two-monthly intervals.

- If follow-up tests show that *Phytophthora* is still present, treatment should be followed up with Aliette WP, Phytex or neutralised Phytofos during the following season. Trees should receive a light cover spray every six to eight weeks starting in September through to April or their trunks should be painted at the prescribed dosages every two months.

- Where *Phytophthora*-free trees are planted, but irrigated with infected water, the trees should be sprayed every six to eight weeks during spring, summer and autumn with Aliette, Phytex or neutralised Phytofos.

Phosphonate applications should not be conducted when trees are under heat or drought stress. Producers should take special care during the months of January, February and March. Day temperatures should not exceed 24°C and tensiometer readings should not exceed 20 kPa.

Fungicides should be used with caution when applied to the soil. The possibility exists that if used injudiciously, micro-organisms which degrade the fungicide could build up in the soil or resistance may develop.

Although not yet registered, results show that Phytex at dosages of between 5 ml (young plantings) and 18 litres/ha (trees older than 8 years) applied bi-monthly during the rainy season through drip irrigation systems, protects citrus trees against *Phytophthora*.

The use of phosphonate products through micro-irrigation systems are not recommended. Unlike drip systems, especially open hydroponic systems, where most of the irrigation water is taken up by the roots concentrated around the dripper in a fairly short period, the phosphonates applied through a micro system may be in contact with soil micro-organisms much longer, which could transform the phosphonates to phosphates. Instead of being a fungistat, the product then becomes an expensive fertilizer with no fungistatic properties.

If a young tree dies or grows poorly as a result of *Phytophthora* infection which originated in the nursery, it should be removed, the soil fumigated with methyl bromide at 100 g/m^2 and the site replanted one month later. If methyl bromide is not available, the tree should be removed together with the soil in which the roots are growing. The hole should be filled with surrounding topsoil and 1 m^2 treated with 40 g Ridomil.

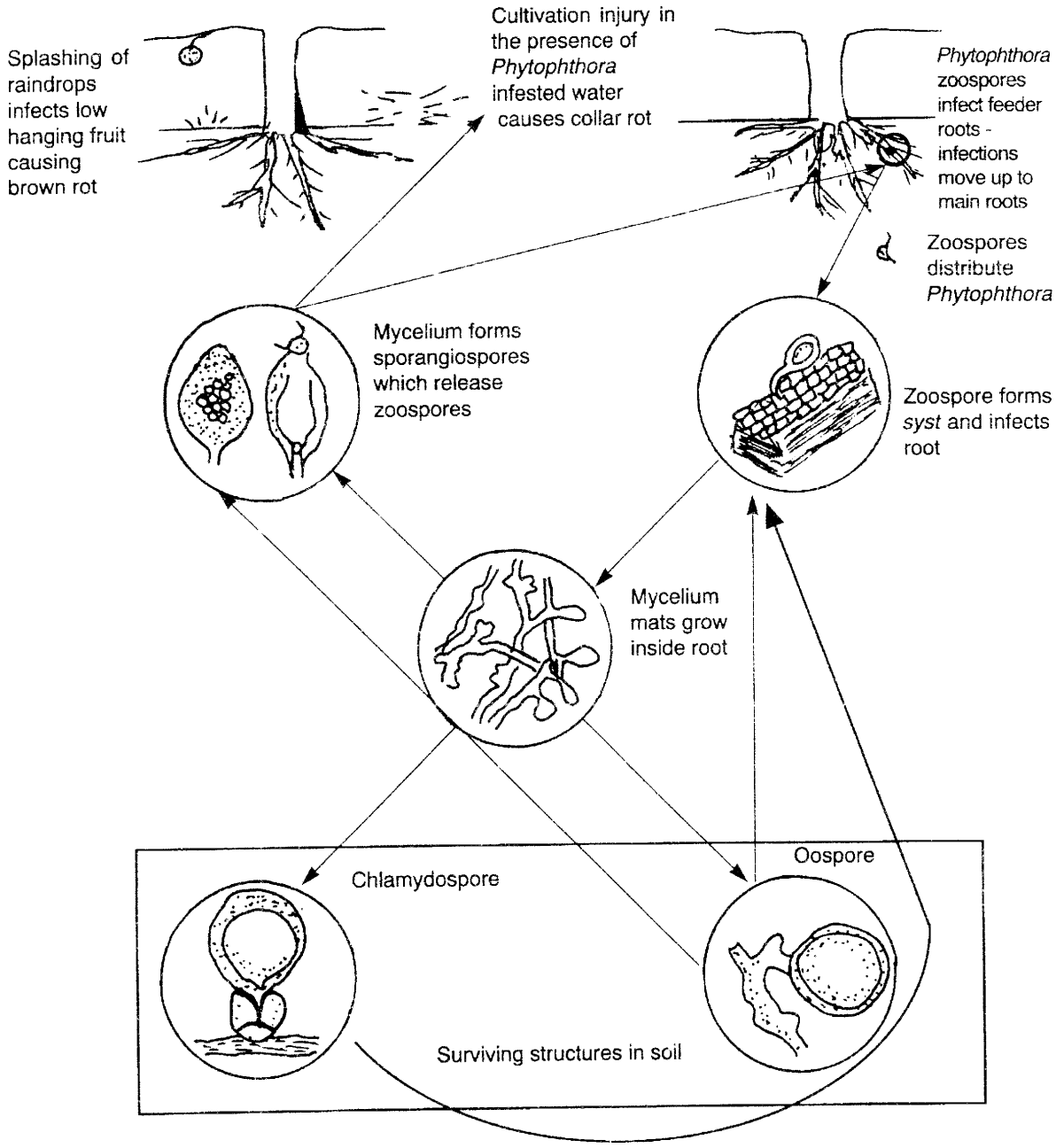

Figure 7.2. Simplified life cycle of *Phytophthora*.