Module 9
Postharvest Diseases

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Introduction

Apart from rind disorders, citrus is vulnerable to a number of postharvest diseases, which are caused by fungi.

Fungal organisms produce spores through which they propagate. Spores are adapted for dispersal, meaning that they are able to become airborne and, like some seeds, they can be spread by wind, water, or anything else that moves.

There are spores of different fungi all around us in the air. When spores settle down somewhere, they wait for the right conditions to start growing. Once the spores start growing and multiplying, feeding on the surface they are attached to, it becomes very difficult to stop the disease from developing.

There are many different fungi that can infect citrus fruit. Some of their spores can remain latent for up to 12 months, ready to propagate when the conditions are right. To control these fungal diseases, we need to create conditions in which the spores will not be able to propagate or infect fruit, and to minimise the spore load in the orchard and in the packhouse.

**definition**

**Propagation**

Propagation means the multiplication of organisms. In terms of fungal disease development, it refers to the process where fungal spores starts multiplying and thereby infecting and destroying the fruit.

**Latent**

Latent means present or existing, but in an underdeveloped, unexpressed or dormant form. In fungal disease development, it is used to refer to fungal spores that are there but not active, waiting for the right conditions.
**Postharvest Disease Groups**

Although there are about fourteen fungal postharvest diseases that we have to contend with, 80 to 90 percent of postharvest losses are caused by only about one quarter of these pathogens. These major postharvest diseases can be divided into two groups, being wound pathogens and latent pathogens.

The most economically important wound pathogens are:

- Green mould
- Blue mould
- Sour rot
- Trichoderma brown rot

Latent pathogens include:

- Diplodia stem-end rot
- Anthracnose rot
- Phomopsis stem-end rot
- Alternaria rot
- Brown rot, caused by Phytophthora

**Wound Pathogens**

**Green Mould**

Green mould infection takes place through wounds caused by insects and injuries to the fruit that occur during picking, transport and packing.

To prevent green mould, we therefore need to make sure that insects that cause wounds, such as fruit fly and false codling moth, are properly controlled, and that fruit is handled carefully during picking, transport and packing. Sanitation of the orchard and packhouse furthermore helps to keep the spore load down.

TBZ, SOPP and Imazalil, or combinations of these fungicides, can be used as treatments in the packhouse to control green mould.
Fungicides
TBZ – Thiabendazole
SOPP – Sodium ortho-phenylphenate

Blue Mould

Blue mould also infects fruit through wounds and injuries, just like green mould, but blue mould can spread from infected fruit to other fruit in a packed carton.

Blue mould is prevented and controlled in the same way as green mould.

Sour Rot

Sour rot is caused by a fungus that is present in the soil of all the citrus producing areas. The spores are spread to the fruit by dust and by water splashing up onto the low-hanging fruit when it rains. Fruit is infected through injuries that go through to the albedo, or the white part of the peel. The injuries can be caused by insects, such as false codling moth, fruit fly and fruit-sucking moths, and by snap picking fruit.

All citrus varieties, and especially soft citrus, are vulnerable to it, while over-mature fruit is also more susceptible.

The sour odour that develops in the advanced stages of the disease attracts vinegar flies, which can spread the fungus and cause other injured fruit to become infected.

Sour rot develops most quickly at temperatures above 27°C. It spreads in packed cartons from infected fruit to healthy fruit, and its development is stimulated by the presence of green mould spores.

To prevent infection pest control is very important. Good picking practices must be employed, so that injuries to fruit, such as those caused by snap picking, are avoided and fruit is not packed when it has been in contact with the soil.
Fruit must be picked before it becomes over-mature and it must be packed and refrigerated as soon as possible after picking. Packhouse sanitation is essential to prevent vinegar flies, which are attracted to sour rot, from spreading the disease.

Guazatine is the only fungicide that is registered for the control of sour rot, but SOPP also provides some protection.

**Trichoderma Brown Rot**

The trichoderma brown rot fungus is found in soil, and attacks the fruit of all citrus varieties. Initial infection requires an injury to the fruit, but in packed cartons the fungus spreads from infected fruit to healthy fruit.

Trichoderma causes cellulose to decompose and can grow on paper, cardboard and wood. It can therefore establish in wrappers, cartons, pallets and wooden bins, from where it can grow again and infect healthy fruit.

To prevent the fungus, injuries to fruit must be avoided and fruit that has been in contact with the soil must not be packed. Over-mature fruit must also be avoided. Wooden bins and lugs can be cleaned with steam.

Cooling fruit to below 10°C after packing effectively limits the development and spread of this rot. The fruit can also be treated with TBZ.

**Latent Pathogens**

**Diplodia Stem-End Rot**

The fungus that causes Diplodia stem-end rot (SER) sporulates on deadwood, including bark and twigs, and can survive from one season to the next.

Diplodia spores, as is the case with Phomopsis and Anthracnose spores, are washed down during rainfall onto the dead calyx tissue or onto the rind or under the calyx. The calyx is the button, or stem-end, of the fruit.
Here the spores remain latent until conditions are favourable for infections to develop, such as during degreening, when the fruit ages, or when the calyx dies and abscises. This area then becomes an entry point to the fruit where the infection develops internally as well as externally.

To prevent this disease, trees must be kept free of deadwood, fruit should be picked before they become over-mature, and 2,4-D can be applied in the packhouse to maintain a living green calyx on the fruit. TBZ is effective for controlling Diplodia SER. Refrigerating the fruit as soon as it is packed also helps to control the disease.

**Anthracnose Rot**

Anthracnose rot is common in citrus orchards and all citrus types, especially soft citrus. Spores are produced on dry twigs and dead tissue in the tree, from where they spread to young fruitlets by wind, rain and insects.

The fungus penetrates the rind through injuries or insect punctures, and remains latent until conditions are favourable for it to grow. These favourable conditions occur when fruit is over-mature or injured. Young fruit can sometimes be attacked while still on the tree, by fungus growing into the fruit from deadwood.

To prevent the development of Anthracnose rot, it is important that production practices promote tree vigour and fruit quality, and that deadwood is removed from trees. Fruit must be harvested at optimum maturity and should not be kept in storage for lengthy periods.

The fungus is controlled by packhouse treatments with TBZ, Imazalil and Prochloraz.

**Phomopsis Stem-End Rot**

The first sign of the Phomopsis stem-end rot is softness around the stem-end of the fruit, with no initial discolouration. Thereafter, a very slight off-colour and eventually a tan to brown and almost black colour develop.

The infected tissue shrivels a little, causing a shoulder or ridge to form between decayed and healthy tissue. The pulp becomes mushy, but there is no discoloration. An unpleasant, rancid odour develops.
Phomopsis has a lifecycle and mode of infection similar to Diplodia, in that it remains latent in the button tissue, and infects the fruit when the calyx abscises. Further infection develops after the harvest when loosening of the calyx results in natural openings, through which the fungus then penetrates.

Phomopsis stem-end rot may be prevented by cultural practices that promote vigorous trees and fruit with high vitality, by avoiding an accumulation of dry twigs in the tree, and avoiding conditions that will lead to abscission of the button such as injuries, over-maturity, degreening of fruit with ethylene, high temperatures during transit of packed fruit, and long storage.

**Alternaria Rot**

Alternaria rot in citrus appears in different forms. This fungus causes navel-end rot in navels, stylar-end rot in lemons, mandarin hybrids and some other orange varieties, stem-end rot in all citrus varieties, and internal black rot in most citrus varieties.

The spores of the fungus infect the flower tissue and by the time the fruit is mature, the fungus is established in the button tissue and on the stylar scar, out of reach of fungicides. It may also develop from injuries in the rind, caused by insects or mechanical practices.

Mature fruit and fruit with low vitality as a result of unfavourable weather conditions, such as low temperatures over a long period or frost, dry, hot winds, low humidity or extreme heat, are more vulnerable to Alternaria rot, as is fruit with signs of sunburn.

Control measures include production practices that promote tree vigour and the removal of fruit that shows signs of sunburn and splitting at the stylar-end. The use of 2,4-D in the packhouse is essential to delay the abscission of the calyx.
**Phytophthora Brown Rot**

Phytophthora brown rot can be devastating, especially during seasons of high and frequent rainfall during harvesting, when fruit is more likely to get into contact with wet soil.

**This disease cannot be controlled by any registered postharvest fungicide, and prevention is therefore the only cure.**

When fruit comes into contact with wet soil, or if rainwater splashes up onto low-hanging fruit, Phytophthora spores, which are present in the soil, get onto the fruit and penetrate the rind within three hours at temperatures between 12°C and 20°C.

Fruit must be prevented from coming into contact with soil, and pickers must be warned never to pick up fruit that has been in contact with the soil and place it with the fruit destined for the packhouse. Trees must be skirted so that the branches will not bear fruit that hang low enough for rainwater to splash onto it.

**Conclusion**

Infection by most postharvest diseases can be prevented by:

- Production practices that promote tree vigour and fruit quality
- Not packing over-mature fruit
- Deadwood removal and skirting
- Regular removal of fallen fruit
- Handling fruit with care during picking and transport
- Washing fruit in sanitised water when it enters the packhouse
- Treating fruit with the prescribed dosages of fungicides, ensuring sufficient residues, as soon as possible but no longer than 48 hours after picking
- Not packing fruit with low vitality
- Storing fruit at 4.5°C as soon as possible after packing
- Not storing fruit for long periods
- Regular packhouse sanitation
**Production Practices**

An effective pre-harvest pest control programme is essential in controlling postharvest diseases. For more information on pre-harvest pest control, please refer to module 11 of this series, and consult volume III of the CRI Production Guidelines.

**Postharvest Diseases**

<table>
<thead>
<tr>
<th>Name</th>
<th>Mode of infection</th>
<th>Prevention and control</th>
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</thead>
<tbody>
<tr>
<td><strong>Wound pathogens</strong></td>
<td></td>
<td></td>
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<tr>
<td>Green mould</td>
<td>➢ Infection through wounds caused by pest insects&lt;br&gt; ➢ Infection through injuries caused by handling (picking, packing, transport)</td>
<td>➢ Prevent injuries during picking, transport and packing&lt;br&gt; ➢ Control insects that cause wounds&lt;br&gt; ➢ Orchard sanitation&lt;br&gt; ➢ Packhouse treatments with TBZ, SOPP and Imazalil</td>
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<tr>
<td>Blue mould</td>
<td>➢ Same as green mould&lt;br&gt; ➢ Can spread from infected to healthy fruit</td>
<td>➢ Prevent injuries during picking, transport and packing&lt;br&gt; ➢ Control insects that cause wounds&lt;br&gt; ➢ Orchard sanitation&lt;br&gt; ➢ Packhouse treatments with TBZ, SOPP and Imazalil</td>
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<td>Sour rot</td>
<td>➢ Soil-borne pathogen&lt;br&gt; ➢ Infection through deep injuries (albedo) caused by insects, snap picking&lt;br&gt; ➢ Spread by vinegar flies&lt;br&gt; ➢ Over-mature fruit more susceptible</td>
<td>➢ Control insects that cause wounds&lt;br&gt; ➢ Prevent injuries to fruit&lt;br&gt; ➢ Prevent contact between fruit and soil  o Do not pick up fallen fruit and put with other fruit&lt;br&gt; o Skirt trees&lt;br&gt; ➢ Do not pack over-mature fruit&lt;br&gt; ➢ Pack and refrigerate fruit soon after picking&lt;br&gt; ➢ Packhouse sanitation to control vinegar fly&lt;br&gt; ➢ Packhouse treatment with Guazarine and SOPP</td>
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</tbody>
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Latent pathogens

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Symptoms</th>
<th>Control Measures</th>
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<tr>
<td>Diplodia stem-end rot</td>
<td>Sporulates on deadwood&lt;br&gt;Washed onto calyx, infects when calyx abscises</td>
<td>✓ Remove deadwood&lt;br&gt;✓ Pick fruit at optimum maturity&lt;br&gt;✓ Apply 2,4D to maintain calyx&lt;br&gt;✓ Refrigerate fruit after packing&lt;br&gt;✓ Packhouse treatment with TBZ</td>
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<td>Anthracnose rot</td>
<td>Sporulates on deadwood&lt;br&gt;Spreads to fruitlets&lt;br&gt;Infects when fruit is over-mature or injured</td>
<td>✓ Cultural practices for vigorous trees and fruit&lt;br&gt;✓ Remove deadwood&lt;br&gt;✓ Pick fruit at optimum maturity&lt;br&gt;✓ Do not keep fruit in storage for long periods&lt;br&gt;✓ Packhouse treatment with TBZ, Imazalil and Prochloraz</td>
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<td>Phomopsis stem-end rot</td>
<td>Sporulates on deadwood&lt;br&gt;Washed onto calyx, infects when calyx abscises / loosens</td>
<td>✓ Cultural practices for vigorous trees and fruit&lt;br&gt;✓ Remove deadwood&lt;br&gt;✓ Avoid fruit injuries, over-mature fruit, degreening, transport at high temperatures and long storage</td>
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<td>Alternaria rot</td>
<td>Infects flower tissue, establishes out of reach of fungicides&lt;br&gt;May develop from rind injuries (insects or mechanical)</td>
<td>✓ Cultural practices for vigorous trees&lt;br&gt;✓ Remove fruit with sunburn and split stylar-ends&lt;br&gt;✓ Apply 2,4D to maintain calyx</td>
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<td>Phytophthora brown rot</td>
<td>Soil-borne pathogen&lt;br&gt;Infects through soil contact</td>
<td>✓ Prevent contact between fruit and soil&lt;br&gt;✓ Control fungus in soil during pre-harvest pest control&lt;br&gt;✓ No postharvest control</td>
</tr>
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active learning

Watch the DVD clips, read through the learning material and do workplace research to gather the knowledge and information to complete the assignment(s) below.

Activity 9.1 – Worksheet

Answer the questions below in your workbook, in your own words and according to your understanding:
✓ What are pathogens?
✓ Name four wound pathogens.
✓ What are the symptoms of the following latent pathogens?
  • Diplodia stem-end rot
• Anthracnose rot
• Phomopsis stem-end rot
• Alternaria rot
• Phytophthora brown rot

Activity 9.2 – Worksheet

Complete this table by listing the pathogens that can be controlled by the action in the first column:

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