

# Inoculum management in citrus nurseries – why pathogen exclusion underpins healthy nurseries

Diseases move very quickly in nursery environments and inoculum management is essential to prevent major production losses or sale of diseased stock.

**Nursery success hinges on one critical principal: start clean, stay clean.**

## What is inoculum?

The greatest threat to young citrus trees isn't always visible, it can be microscopic. Inoculum (a.k.a. the pathogen) that causes root and foliage diseases can quietly infiltrate a nursery, spread rapidly, and leave a trail of damage that's hard and sometimes impossible to reverse.

Inoculum is any part of a pathogen that can disperse and cause a new infection. It's hard to manage because it is usually until it is too late. It may be fungal spores, pieces of mycelium or bacteria. It is usually produced in very large numbers so they spread easily and can be very hard to eradicate.

Once they gain entry, control options are limited. One common choice is the use of fungicides which may suppress symptoms but not eliminate the cause. And when infected plants leave the nursery, the damage continues thereby hurting your customers, your reputation, and your business.

## Where to start

1. Know your enemy – Understanding the biology and behaviour of key citrus pathogens helps you anticipate and prevent outbreaks (inoculum pathways).
2. Run a tight ship – Rigorous hygiene, movement controls, and clean propagation material are your best defence.
3. Protect your brand – Selling infected or latent-disease plants may result in crop failures for growers, damaging trust and your bottom line.

## Inoculum Pathways and Management Options

- **Wind:** Shield your plants with protective structures such as greenhouses, polytunnels, or windbreaks, both natural and artificial.
- **Pathways:** Swap bare soil for concrete or gravel paths. These surfaces trap less dust, reducing the risk of inoculum hitching a ride.
- **Water:** Only use water that's been filtered, treated, and checked for ideal pH and salinity levels.
- **Potting mix:** Use pasteurised mix or use quality product from accredited sources.
- **Plant material:** Use certified plant material, Auscitrus budwood and seed are the gold standard.
- **Equipment:** Dedicate machinery to nursery use only and enforce sanitising measures for anything brought in from outside.
- **People:** Remember that hands, shoes, and clothing can all transfer pathogens.
- **Plant Health:** Healthy plants are less susceptible to disease than stressed (water, nutrition) plants.

## Additional strategies

- **Grow Resistant Varieties** if possible
- **Disposal of Infected Plants:** Discard infected plants hygienically; avoid stockpiling them on-site, do not mulch infected material.
- **Prevent physical damage** and manage pests that create entry points for pathogens.
- **Manage Leaf Wetness:** Avoid overhead irrigation at night and limit overhead irrigation during periods conducive to pathogen infection and spread. Ensure leaves dry quickly by improving ventilation and spacing plants.
- **Manage Soil/Potting Mix Wetness:** Avoid over-wet potting mix that facilitates diseases like *Phytophthora* and *Pythium*
- **Optimize Growing Conditions:** Provide ideal nutrient regimes, irrigation, growing media, adequate spacing to ensure adequate aeration and preventing leaf to leaf contact where possible.
- **Regular Monitoring:** Check plants frequently, especially during high-risk periods. Address signs of disease promptly.

## Citrus Nursery Diseases

Citrus is susceptible to several diseases in the nursery that can halt production, compromise other stock and affect sales. They can be 'below ground' (soil or potting mix) pathogens, or 'above ground' (stem, leaf and twig) pathogens. Examples of 'below ground' diseases include the major water- and soilborne pathogens *Phytophthora* and *Pythium* and 'above ground' diseases include the more citrus specific foliar diseases such as **Citrus Black Spot (CBS)**, **Citrus Scab** and **'Emperor' Brown Spot (EBS)** (see following page). *Rhizoctonia*, another root/below ground pathogen, may be an occasional problem.

### Below ground pathogens

*Phytophthora* is arguably the primary pathogen affecting citrus seedling production and plants in nursery systems in general. Almost all plants species can be affected. It is spread in soil or growing media, water, infected plant material and on contaminated equipment. Symptoms are usually root and crown rots (Fig. 1B, 1C) and can include root rot and death, necrosis at the crown, leaf chlorosis and a general failure to thrive and eventually plant death. Aerial *Phytophthora* diseases can also occur when inoculum is splashed from the soil to foliage.

*Entry and spread:* Contaminated tools, water, soil.

*Consequences:* Failed orchard establishment, plant death, introduction of *Phytophthora* to orchards.

*Pythium* is a less commonly found pathogen in citrus seedlings but is a particular problem in seedlings of any species in nurseries (Fig. 1A). In this scenario it is usually referred to as 'damping off'. It is spread similarly to *Phytophthora* above but is noted for its ability to spread very quickly through trays of seedlings and closely situated plants. Symptoms include root and stem rot and damping off or collapse of entire seedlings.

*Entry and spread:* As above.

*Consequences:* Loss of very young seedlings.

Both diseases can be largely prevented by incorporating a suite of nursery hygiene practices including water treatment, raising bench heights, eliminating uncovered soil from growout areas (weedmat/gravel/cement) in conjunction with judicious fungicide treatments.

*Rhizoctonia* is a secondary pathogen and not considered a major pathogen of citrus. It is opportunistic under favorable conditions as a wound pathogen.

### More Information

<https://nurseryproductionfms.com.au/pest-management-plan-soilborne-root-pathogens/>



**Fig. 1:** L) *Pythium* damping off of young seedlings (Image: DPI Qld). Centre) *Phytophthora* root rot (Image: Leif Forsberg). Right) Citrus tap root rot (lemon) (Image: Grow Help Team, DPI Qld).

## Above ground pathogens

Aerial diseases can also move through the nursery, causing leaf spots, stem issues, leaf drop and failure to thrive and can make stock unsaleable quite quickly. Citrus specific foliar, stem and twig diseases include **CBS**, **EBS** and **Citrus Scab**. All three diseases also affect fruit. EBS and Citrus Scab are the most common in nurseries.

Lesions of **EBS** develop on young leaves and flush. Infection causes leaf yellowing and necrosis and, if severe, extensive leaf drop (Fig. 2A). Young flush is particularly susceptible. Spores are produced on the lesion and infection spreads rapidly from plant to plant. Not only are these plants a source of inoculum if transferred to an orchard but affected leaves are unsightly and unsaleable for cosmetic reasons. Early detection and removal of inoculum is an important component of disease management.

*Entry and spread:* On infected material, wind and rain/irrigation splash.

*Consequences:* Failure to thrive if severity induces leaf loss, orchard establishment with infected plants.

**Scab** also develops on leaves, petioles and stems. Symptoms begin as pustules transitioning to scab-like lesions (Fig. 2B). The scabs are raised, may coalesce and become rough and cracked in appearance. Infection can be severe and cause leaf distortion. Spores are produced on the scab, providing an ongoing source of inoculum for infection of new growth and neighboring plants. Early detection and removal of inoculum is an important component of disease management.

*Entry and spread:* As above.

*Consequences:* Movement of infected material to orchards.

**CBS** is less common in nurseries but is a major citrus fruit disease and older stock should be monitored for leaf spots. Spores are produced in black fruiting bodies in the centre of the spots and spread through splash (rain/irrigation) to nearby plants. Symptoms are latent and often not seen until long after infection. Utilising budwood from regions where the disease is prevalent poses a risk for entry into the nursery and spread between regions.

*Entry and spread:* As above

*Consequences:* Movement of infected material to orchards.

## More information

The NIASA program provides comprehensive guidelines that provide industry 'Best Management Practices' for including crop hygiene (root disease prevention, and disease, pest and weed control), crop, site and water management and general nursery procedures (e.g. media preparation, <https://nurseryproductionfms.com.au/niasa-accreditation>). The site also hosts extensive fact sheets for technical aspects of nursery production and pest, disease and weed management (<https://nurseryproductionfms.com.au/technical-information/>).

The Australian Plant Production Standard (APPS) also has a lot of useful resources and factsheets about best management practices and biosecurity practices (<https://nurseryproductionfms.com.au/about-us/>).



Fig. 2: Top) Severe symptoms of EBS on new citrus flush prior to leaf drop (Image: Tony Cooke). Bottom) Citrus Scab on leaf and petiole material (Image: Kathy Grice).