

Pre-pack-house drench

- The CRI factsheets list all the recommended fungicide options for the pre-pack-house drench and must be consulted. The factsheets are available to members on the CRI website.
- Importantly, adequate waterflow will thoroughly drench the fruit in all the bins – drenches must deliver at least 250 ℓ drench mixture/bin/min.
- Pre-suspend fungicides in warm water and add to the tank while agitating, using the order SC > EC > SL. Then fill the tank to the correct level.
- Exposure time is 1–3 minutes.
- Replace the mixture after 150 bins (1 000 ℓ tank), 200 bins (2 000 ℓ tank), or 300 bins (3 000 ℓ tank).
- **Constant agitation**
 - The system must be in operation for at least 15 minutes before use.
 - Never let the fungicide mixture stand still, as the chemicals will settle out and be unavailable for fruit treatment.

Fungicide dip tank and in-line drench

- The fungicide of choice for use in the aqueous applications is imazalil sulphate for all markets. No market restrictions are predicted for the immediate future, although CRI is investigating alternatives.
- The imazalil sulphate concentration should be managed continuously by means of titration and maintained at 500 ppm.
- The pH level of the imazalil solution should be kept stable to ensure consistency in terms of residue loading.
 - Recommended automatic dosing system for pH:
 - ◻ pH 3 will result in lower residue levels (around 1 ppm) but can still give excellent curative control if the exposure time is 60–90 seconds, and fruit is treated within 24 hours of infection.
 - ◻ pH 6 will result in higher residue levels (around 2–3 ppm), but the exposure

time needs to be limited to 45 seconds to prevent MRL exceedance.

- The CRI factsheets list all possible options for the fungicide bath or in-line drench and need to be consulted.
- If not replaced daily, the fungicide solution should be pasteurised every evening by increasing the temperature to no less than 60°C, keeping it there for 20 minutes, and then letting the solution cool down overnight.

Wax application

- Fruit should be dry before entering the wax applicator – wet fruit will hamper the efficacy of this treatment.
- It is highly recommended to apply imazalil in the dip tank and thereafter in the wax. The wax application will ensure good protective control and sporulation inhibition of green mould, while the aqueous application provides excellent curative control.
- Wax containers/tanks containing fungicides should be gently agitated continuously (i.e., 24 hours a day, seven days a week) to ensure that thiabendazole and imazalil stay in solution and do not precipitate. Precipitated chemicals will result in MRL exceedance from wax lower down in the container, while the top layers will not have enough residue to give the desired protection. Containers should also be tightly sealed to prevent wax formulation from deteriorating.
 - Plus:
 - ◻ Do not use air bubbles as an agitation measure. They break down the wax formulation through liberation of the volatiles and oxidation of the solvent system.
 - ◻ Do not over-agitate the wax, as this also eliminates the volatiles that are an integral part of the wax during film formation after application.
- Fruit must be totally and uniformly covered in wax; if not, contact your wax suppliers for support.

- Protect the wax applicator against wind from the drying tunnel to prevent wax drying on the last brushes and hardening of the bristles. Hardened bristles hamper effective wax application and pose injury to the fruit rind.

Cold chain

- Promptly place fruit in cold storage.
- Maintaining the cold chain will reduce the incidence of green mould infections and physiological rind disorders.
- Never break the cold chain.

Sanitation

- Pack house sanitation helps keep inoculum (spore) levels as close to zero as possible.
- Remove all fruit from the floor, including any waste fruit in bins.
 - Plus
 - ◻ Remove any waste fruit from the pack house and discard it in closed containers as soon as possible.
 - ◻ Do not allow fruit destined for processing to be anywhere near your pack house.
- Sanitation is an effective way of preventing fungicide resistance from developing.

Remember

Fresh citrus fruit is a perishable, high-risk commodity. The fruit is alive and, therefore, respiring. Thus, the shelf life and quality must be maintained. The packed export crop must be moved from the pack house into the cold chain as soon as possible, thereby reducing the risk of loss of quality and waste.



Colour plates and identification key



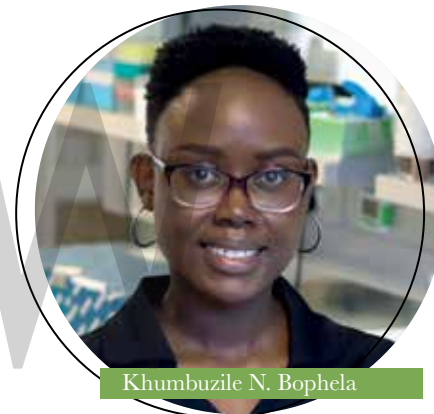
CRI-PhytRisk



South Africa is the world's second-largest exporter of citrus fruit (CGA, 2025). By Jacquie E. van der Waals, Jason McNeil, Khumbuzile N. Bophela, Teresa A. Coutinho and Jan M. van Niekerk



Jacquie E. van der Waals



Khumbuzile N. Bophela

HIDDEN SOURCES OF *Phytophthora* inoculum in South African citrus nurseries

Sustainable citrus production depends on a steady supply of healthy nursery trees for new orchards and replanting. Unfortunately, citrus nurseries can become reservoirs for soil- and water-borne pathogens, especially *Phytophthora* species such as *P. nicotianae* and *P. citrophthora*.

These oomycetes cause fibrous root rot, damping-off and seedling death, leading to serious losses in nurseries and poor establishment in orchards later.

Despite strict sanitation and application of oomycete-specific fungicides, occasional outbreaks of root rot still occur. This suggests that *Phytophthora* inoculum persists within nursery systems despite compliance with Citrus Improvement Scheme (CIS) nursery guidelines. The aim of this study was, therefore, to identify sources of *Phytophthora* inoculum in 12 commercial CIS-accredited citrus nurseries across the major production regions: Letsitele and Malelane (Limpopo and Mpumalanga), Sundays River Valley (Eastern Cape) and Citrusdal (Western Cape).

Materials and methods

After assessing standard operating practices at each nursery, a strategy was designed to sample potential contamination sites. These included:

- soil from dirt roads around tunnels and from walkways inside tunnels/netting structures
- unused potting media (from surface and deeper in the pile)
- potting media in use
- irrigation water sampled after flocculation, filtration or sterilisation

- surfaces sampled with sterile cotton swabs: wheelbarrows, tractor wheels, filled and empty seedling trays, worker boots and gloves, cement benches, shade netting, footbaths, and moss or plant debris in or around pots.

Soil samples were baited with citrus leaf discs on flooded slurries, then plated onto selective media. Putative *Phytophthora* isolates were purified, morphologically identified, and identities confirmed by Polymerase Chain Reaction (PCR) and sequencing of two Internal Transcribed Spacer regions. DNA was extracted directly from swab samples and subsequently screened with ITS primers to detect *Phytophthora* gDNA.

Results and discussion

All nurseries surveyed tested positive for *Phytophthora* inoculum in at least one sampled site. Notably, no oomycete-like organisms were isolated from any of the 110 water samples, confirming that the chlorination, flocculation, and filtration systems used in these nurseries are effective at eradicating oomycete species.

Phytophthora was recovered from soil on dirt roads surrounding tunnels (average 44% of samples positive across nurseries) and from tunnel walkways (41% positive). Inoculum was also present in potting media before use (17%), and in use (24%) at more than half of the nurseries sampled, despite nursery managers considering these media to be sterile due to composting, on-site treatment, or certified purchase.

Swabbing revealed even more contamination points. *Phytophthora* DNA was frequently amplified from:

- tractor wheels and wheelbarrows (movement of soil between areas)
- boots and gloves
- cement benches used to raise pots off the ground
- moss and plant debris in or around pots
- shade netting structures
- filled seedling trays and discarded used trays
- footbaths (even where disinfectant was used).

These results show that *Phytophthora* survives and spreads at multiple steps in the nursery. Equipment, vehicles, worker clothing and footwear, benches, trays and even mossy debris act as bridges that carry inoculum from contaminated soil or old media into fresh potting mix and onto healthy roots.

Why does the pathogen keep coming back? Poor drainage and runoff allow build-up near production areas. Surrounding soil likely re-contaminates treated media over time. Composting temperatures, or durations in some cases, appear insufficient to kill resilient *Phytophthora* propagules. Disinfectant



Teresa A. Coutinho



Jan van Niekerk

footbaths and vehicle dips lose efficacy if not refreshed often enough. High plant density, frequent irrigation and warm conditions inside tunnels create an ideal environment for any surviving inoculum to multiply. The good news is that the tested samples of treated irrigation water were free from oomycetes, highlighting the value of the water-treatment and in-line spore trapping protocols already in place.

It is important to note that this data is merely a snapshot of the situation in nurseries. Nonetheless, the results highlight several practical steps for disease management, all of which are outlined in the CIS nursery management guidelines:

- Test potting media batches (new and in use) regularly for the presence of *Phytophthora*.
- Improve composting: ensure high enough temperatures and turning for long enough to eliminate oospores and chlamydospores.
- Clean and sanitise wheelbarrows, trays, benches, tractor wheels and shade nets more thoroughly and regularly.
- Replace footbath and dip solutions regularly to maintain effectiveness.
- Minimise standing water, excessive wetness, and runoff around potting areas.
- Keep walkways and surrounding roads free of plant debris and avoid bringing soil into tunnels on boots or tyres.
- Consider routine testing of high-risk surfaces with swabs or baiting to find hidden reservoirs early.

The results from this survey emphasise that successful *Phytophthora* management in citrus nurseries requires a systems approach – not just one or two control measures. 🍋

Acknowledgements:
We thank the nursery owners and staff who allowed sampling on their premises, and Christopher Liakos for valuable laboratory support.



HARVEST GUIDELINES to retain fruit quality



Natasha Jackson

Don't let harvest mishaps turn high expectations into a costly nightmare. By Natasha Jackson (Citrus Research International)

When not to harvest - the five absolute red flags

Even when maturity indices are satisfactory, the following harvest conditions dramatically increase rind disorders and decay:

1. Fruit still wet from rain, irrigation, or dew.
2. Excessively high soil moisture levels, resulting in turgid oil glands.
3. The fruit is too green (especially lemons and early navels).
4. Within 10–14 days after a cold front.
5. Ambient relative humidity >70 %.

If we ignore these guidelines, oleocellosis, peteca, or pitting symptoms could develop (Figures 1–3).

How to measure the ideal harvesting conditions

1. **Measuring fruit turgidity – the penetrometer is your best friend.** The single most powerful tool for predicting oleo is the rind oil-release pressure penetrometer (Figure 5):
- Use the 8 mm probe for mandarins/soft citrus and the 6 mm one for oranges/lemons.
 - Test 20–25 fruit per orchard on the shaded side.
 - Safe harvest threshold: >3.0 kg. Readings below 3 kg indicate that the risk of oil glands bursting at the slightest touch is high – severe oleocellosis is thus inevitable.

At the end of the 2025 South African citrus season the numbers were nothing short of spectacular. Export volumes exceeded the estimated 171 million cartons by 22%, internal quality was superb, sizing was excellent, and global demand strong – initially.

Yet every seasoned grower knows that citrus is much like rugby. You only score when the ball is grounded over the line. Too many packing seasons have been negatively affected by entirely preventable harvesting and handling errors in the last few metres.

This article consolidates the latest CRI harvest guidelines and reminds the industry how to safeguard the hard-earned quality in orchards.

When is fruit ready to be harvested?

Maturity indexing is imperative (Table 1). Harvest decisions must be driven by weekly maturity-index tests and objective standards. Fruit should only be harvested for export once specific minimums have consistently been met according to the Perishable Products Export Control Board (PPECB) standards, or stricter minimum market requirements.

Table 1. In maturity indexing, external colour must meet market requirements, using approved CRI colour plates

Variety/cultivar type	Juice (%)	Sugar: acid ratio	°Brix	Acid (%)
Alpha Seedless, Guscora, Delta Seedless and Midknights	≥48	≥7.5:1	≥9.5	≤0.7
Valencias	≥42	≥7.0:1	≥8.5	≤0.6
Navels and Late Navels	≥45	≥7.0:1	≥8.5–9.0	≤0.65
Navelates	≥42	≥8.0:1	≥10.0	≤0.65
Nova Mandarin	≤50	≤8:1	≤9.5	≤0.65
Mandarins	≤48	≤8:1	≤9	≤0.65
Late Mandarins	≤48	≤9:1	≤12	≤0.85
Lemons	≤36	N/A	N/A	N/A
Grapefruit	≤40	≤5.5:1	≤7.0	N/A
Pummelos	≤35	≤9.0:1	≤9	N/A

Citrus Research International Jacquie E. van der Waals* and Jan M. van Niekerk

Department of Plant and Soil Sciences, University of Pretoria
Jacquie E. van der Waals*, Jason McNeil and Khumbuzile N. Bophela

Department of Biochemistry, Genetics and Microbiology, University of Pretoria Teresa A. Coutinho

Department of Plant Pathology, Stellenbosch University Jan M. van Niekerk

*Corresponding author: jacquie@cri.co.za