New recruits join the *Phytophthora* brown rot battle

Phytophthora brown rot developing on a lemon fruit.

Brown rot may not be a constant enemy in citrus production, but when it does invade it needs to be dealt with on all fronts. A recently completed study is presenting producers and exporters with fresh ammunition.

BROWN ROT OUTBREAKS ARE NOT regular occurrences in South African citrus. However, when they do occur, the disease usually causes significant economic losses, either in the orchard or while export consignments are in transit.

While losses due to brown rot can take place before citrus fruit is harvested, the biggest problem occurs when infected fruit make their way through the packing process and into a carton. During storage, the latent infection develops into decay and, more importantly, spreads to other fruit in the carton, causing them to develop brown rot. These brown-rot fruit are prone to being further infected with secondary decay pathogens such as *Penicillium* spp.

Leathery brown discoloration on a lemon fruit indicating Phytophthora brown rot.

It is well known that foliar applications of phosphonates provide excellent protection against brown rot of fruit, as well as root rot caused by *Phytophthora* spp, in the orchard. Phosphonates are easily absorbed by the leaves of citrus trees and, in addition to stopping the invading pathogens, they activate the tree's own defense mechanisms.

Regardless of the level of pre-harvest control, steps have to be taken during the packing process to reduce the risk of latent infections on fruit developing further during storage and transit.

Studies into postharvest treatments have, among others, focused on phosphonate dips alone or in

combination with heat treatments. Results indicated that postharvest dips with potassium phosphite are effective when done within four to 18 hours after picking, and even more effective when solutions are heated up. These findings led to this treatment being registered for use in the USA. However, certain export markets limit the phosphorous acid residues allowed on fruit, hence the treatment cannot be used extensively. These restrictions created the need for other options for postharvest control of brown rot.

The search for alternatives led to fludioxonil and azoxystrobin, two fungicides that have been investigated for their ability to control green mould – with positive results.

Studies in 2015 have shown that azoxystrobin, which has been registered in South Africa for postharvest use on citrus, gave very good curative and protective control of *Phytophthora* brown rot on Valencia or navel oranges. As these studies only looked at inoculating fruit with *P. citrophthora* either 15 hours before treatment (curative) or six hours after treatment (protective), there was no indication of the curative effect of azoxystrobin if inoculations are done 12 or even six hours before treatment. Neither could any data be found on the *in-vitro* sensitivity of *Phytophthora nicotianae* isolates to azoxystrobin.

Fludioxonil was recently registered for postharvest use on citrus in South Africa, specifically as a wax application aimed at sporulation control of *Penicillium* spp. As with azoxystrobin, very little is known about the *in-vitro* sensitivity of *P. nicotianae* isolates to fludioxonil. It is also unclear whether application in wax can have any curative effect on latent brown rot infections, or if it could protect healthy fruit against becoming infected from brown-rot-infected fruit during transit and storage.

To shed light on these unknowns, a two-year study was initiated by Citrus Research International (CRI) with support from the Postharvest Innovation Programme. The research was led by Dr Jan van Niekerk, from CRI. Working with him were two students, Elizabeth van der Merwe (MSc) and Micaela Tobias (BSc Hons), with Dr Cheryl Lennox from Stellenbosch University providing support.

The research was led by Dr Jan van Niekerk (top left), from CRI. Working with him was postdoctoral researcher, Dr Elodie Stempien, (top right) and two students, Elizabeth van der Merwe (MSc) and Micaela Tobias (BSc Hons) (below, right).

PROJECT INFORMATION

Project title: Evaluation of new postharvest fungicides for the control of *Phytophthora* brown rot on citrus
Principal investigator: Dr Jan van Niekerk
Duration: 01/04/2019 - 31/03/2021
PHI Programme and Industry Contributions: R568 938 and R568 938
Lead institution: Citrus Research International
Beneficiary: The South African citrus industry
Human resource development: 1 MSc student & 1 BSc (Hons) student
Focus area: Postharvest, fungicides, citrus, brown rot, *Phytophthora*

Study objectives and results

The researchers set out to evaluate the curative and protective efficacy of azoxystrobin, fludioxonil, and ammonium and potassium phosphite as aqueous dip treatments for the postharvest management of *Phytophthora* brown rot on lemons, oranges and mandarins.

Additionally, wax to which azoxystrobin and fludioxonil had been added, was evaluated for its ability to prevent the spread of brown rot in fruit cartons during transit.

Results indicated that the tested fungicides have good curative action. All three reduced brown rot incidence significantly when applied 12 hours after inoculation. Applications done 24 hours after inoculation still provided some curative action, but were not as effective as earlier applications.

Azoxystrobin and potassium phosphite furthermore provided very good protection against infection if inoculations were done up to 48 hours after application on all three fruit types; fludioxonil did not fare as well.

Interestingly, the protective ability of all three fungicides was better the longer the fungicides remained on the fruit before inoculation.

In terms of preventing the development and spread of latent infection during transit, only azoxystrobin-amended wax significantly reduced brown rot from spreading to healthy fruit when in contact.

The data obtained from this study can add additional value to the already registered postharvest azoxystrobin and fludioxonil fungicides, as well as the pre-harvest registered potassium and ammonium phosphite.

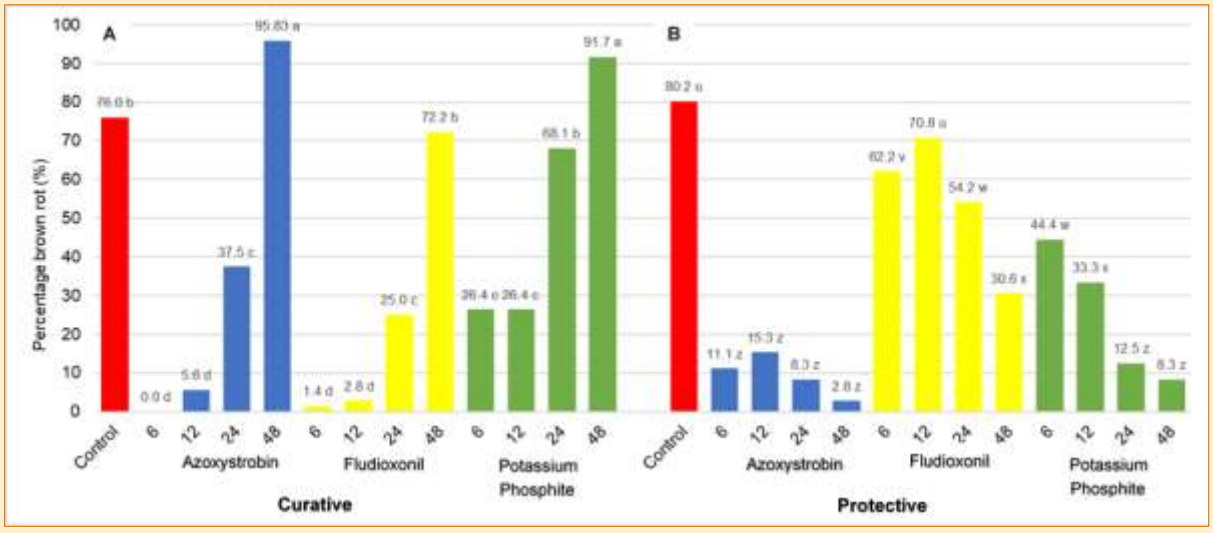

Figure 1: *The graph shows the mean percentage brown rot that developed on lemons, when the fruit was treated curatively (A) with azoxystrobin, fludioxonil or potassium phosphite 6, 12, 24 or 48 hours after inoculation with P. nicotianae zoospores, and protectively (B) when fruit was treated with either azoxystrobin, fludioxonil or potassium phosphite 6, 12, 24 or 48 hours before inoculation with* P. nicotianae zoospores.

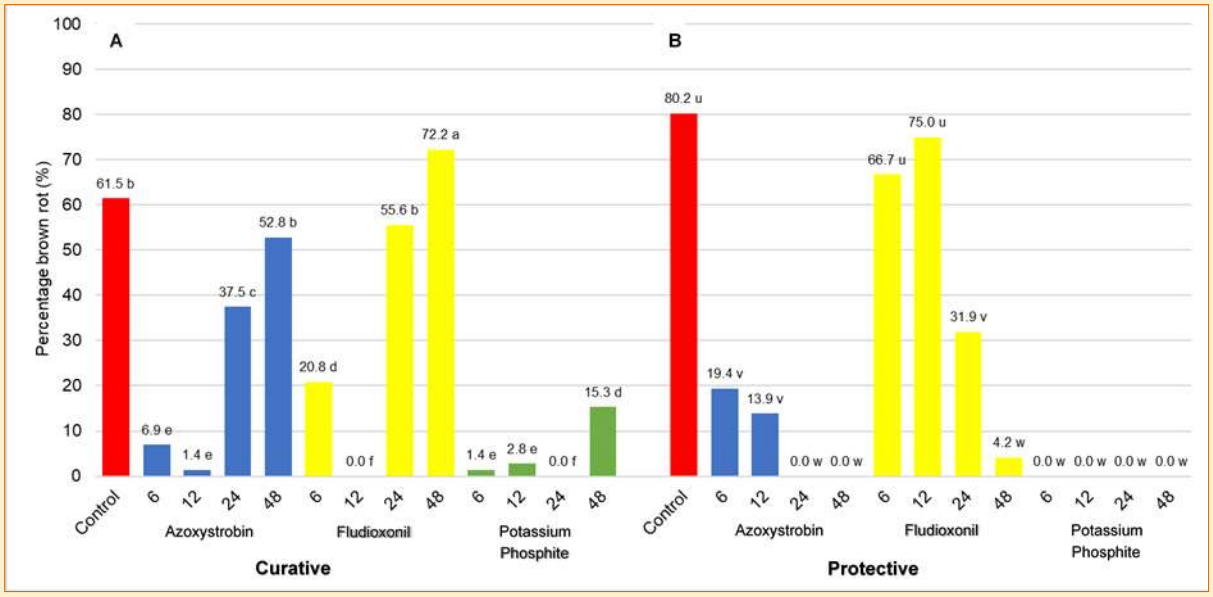

Figure 2. *The graph shows the mean percentage brown rot that developed on oranges when the fruit was treated curatively (A) with azoxystrobin, fludioxonil or potassium phosphite 6, 12, 24 or 48 hours after inoculation with P. nicotianae zoospores, and protectively (B) when fruit was treated with either azoxystrobin, fludioxonil or potassium phosphite 6, 12, 24 or 48 hours before inoculation with P. nicotianae zoospores.*

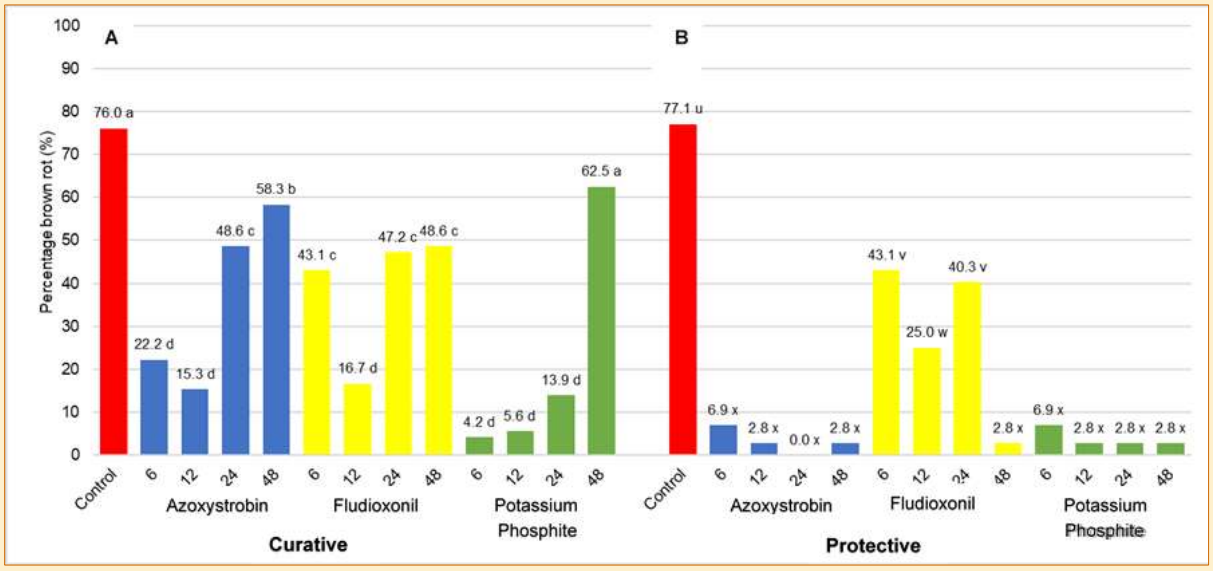

Figure 3. *The graph shows the mean percentage brown rot that developed on mandarins when the fruit was treated curatively (A) with azoxystrobin, fludioxonil or potassium phosphite 6, 12, 24 or 48 hours after inoculation with* P. nicotianae *zoospores, and protectively (B) when fruit was treated with either azoxystrobin, fludioxonil or potassium phosphite 6, 12, 24 or 48 hours before inoculation with* P. nicotianae *zoospores.*

Figure 4: These oranges show the Phytophthora *brown rot symptoms that developed after the fruit were treated curatively with azoxystrobin (from left to right) 6, 12, 24 and 48 hours after* P. nicotianae *zoospore inoculation.*