**Figure 1.** Grapefruit decay is seen on some HLB-affected trees in Florida groves.

# New decay control options on the horizon for Florida citrus

**By Mark A. Ritenour and Jiuxu Zhang**

Preventing decay of fresh fruit has always been critical for a successful citrus industry. Prior to citrus greening (huanglongbing or HLB) in Florida, effective decay control practices were well established. These practices fueled Florida's robust fresh domestic and export citrus sales, allowing shipping durations of 21 days or more. Since the establishment of HLB in Florida, postharvest fruit decay pressure has increased, especially diplodia stem-end rot (diplodia SER) caused by *Lasiodiplodia theobromae*.

Some fruit on trees heavily affected by HLB can even be observed with various stages of decay while still hanging on the trees (Figure 1). HLB-induced tree stress promotes the diplodia fungus colonizing in the fruit button to grow into the fruit flesh before harvest,

which causes decay. Efforts to develop new preharvest and postharvest methods to combat HLB-induced fruit decay started during the 2019–20 season with funding through the Florida Citrus Packers and a U.S. Department of Agriculture Technical Assistance for Specialty Crops grant (TASC-2019-02). The project concluded in June 2023. Potential new tools developed from the project to reduce postharvest decay are summarized below.

> Miravis Prime (21.4% fludioxonil plus 12.8% pydiflumetofen) and Headline (pyraclostrobin) were identified as the best of those tested at reducing postharvest diplodia SER.

## PREHARVEST CHEMICALS

Over four seasons, 15 different commercial products were evaluated over 12 field experiments. Promising materials were tested over multiple seasons. Chemicals tested included: thiophanate-methyl, fludioxonil, azoxystrobin, pyraclostrobin, trifloxystrobin, difenoconazole, propiconazole, mefentrifluconazole, cyprodinil, pydiflumetofen, fluopyram, thiabendazole, 2,4-D, essential oils and various combination mixtures of these.

All materials were sprayed on red grapefruit two or 14 days before harvest, and the fruit degreened for up to five days with 5 parts per million (ppm) ethylene at 85 degrees with high (≥90%) relative humidity and then incubated at 75 degrees with high humidity for up to three weeks before decay evaluation. In most cases, the fruit were not washed or waxed. However, in the 2022–23 season, researchers focused on the best performing treatments, and after degreening, the fruit were washed, waxed and stored at 50 degrees to better simulate commercial handling practices.

Miravis Prime (21.4% fludioxonil

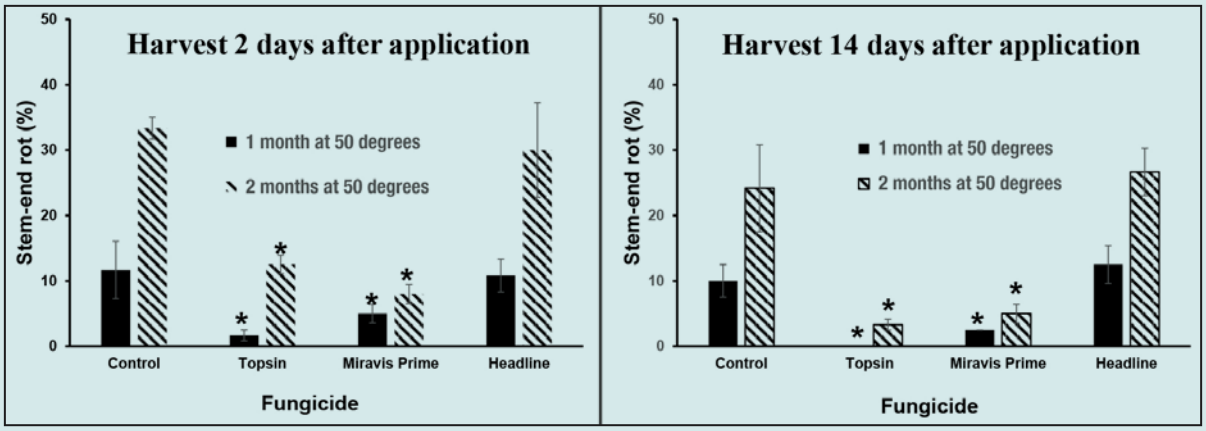


**Figure 2.** Effects of preharvest fungicides on postharvest diplodia stem-end rot incidences on red grapefruit from two harvests and after degreening, washing, waxing and storage (50 degrees) for one or two months during the 2022–23 season. The asterisk (*) indicates significant difference at the same harvest time compared to the unsprayed control.

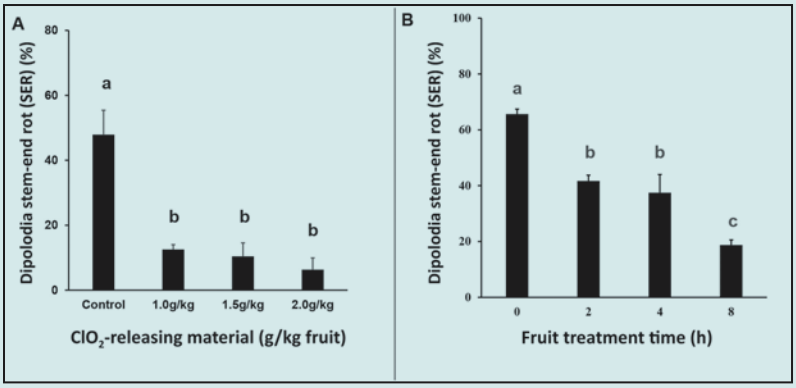


**Figure 3.** Effects of postharvest $ClO_2$ treatments on diplodia stem-end rot (SER) incidence at different application rates (A: 8-hour exposure) and exposure durations (B: 1 gram per kilogram) on naturally infected red grapefruit. Bars with different letters are significantly different.

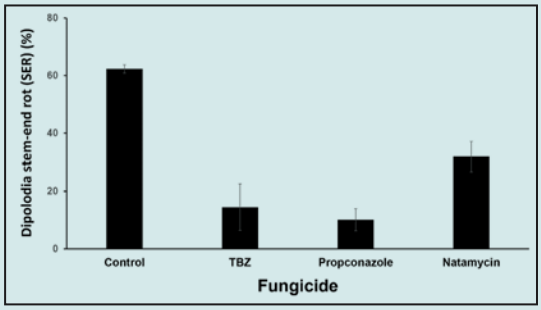


**Figure 4.** Effects of postharvest fungicides on diplodia stem-end rot (SER) incidences using dip treatment method and diplodia naturally infected red grapefruit.

> New $ClO_2$ gas-releasing products are now available for treatment of fresh produce.

plus 12.8% pydiflumetofen) and Headline (pyraclostrobin) were identified as the best of those tested at reducing postharvest diplodia SER. Topsin (thiophanate-methyl) was always included as a "best case" control method, even though efforts to obtain a citrus label were abandoned by the registrant in 2009. While Headline is registered for citrus preharvest and continued to significantly reduce postharvest decay last season in incubation tests, there was no significant reduction when the fruit were washed, waxed and cold-stored for up to two months (Figure 2). On the other hand, Miravis Prime continued to significantly reduce diplodia SER in all tests and appears to be a good candidate as a reliable tool for reducing postharvest diplodia SER. However, while Miravis Prime is labeled for lemon and lime, it is not currently registered for use on other citrus species. The potential for such registration is being explored.

## POSTHARVEST CHLORINE DIOXIDE GAS

Chlorine dioxide ($ClO_2$) has long been used to sanitize water, including water used in fresh produce packinghouse operations. However, new $ClO_2$ gas-releasing products are now available that are easy to use, release $ClO_2$ gas over different lengths of time and are registered for treatment of fresh produce. We tested 1, 1.5 and 2 grams of $ClO_2$-releasing materials (ICA-TriNova) per kilogram grapefruit, placed in sachets within sealed plastic containers (42.5 liters) containing the fruit and incubated at 70 to 75 degrees for eight hours (Figure 3A), or treated with 1 gram $ClO_2$ per kilogram fruit for two, four or eight hours (Figure 3B) before degreening the fruit.

Afterwards, fruit were evaluated for decay, peel injury and diplodia SER decay after storage for up to three weeks at 72 to 75 degrees. As little as 1 gram $ClO_2$ per kilogram fruit reduced diplodia SER incidence by 74%, with no significant benefit from treating with higher concentrations (Figure 3A). Only two hours of $ClO_2$ at the lowest dose reduced decay 36%, increasing to

71% after eight hours (Figure 3B, page 18). Fruit absorbed about 93% of the $ClO_2$ gas during the eight-hour treatment, which caused no peel injury or changes in fruit weight loss, firmness, total soluble solid or acid content. While the results show great promise, further work is needed to develop these treatments on a commercial scale.

## NEW POSTHARVEST FUNGICIDES FOR FLORIDA CITRUS

Two relatively new postharvest fungicides (propiconazole and natamycin) were evaluated over three separate experiments for their effectiveness against diplodia SER under Florida conditions. Control fruit were dipped in water, and thiabendazole (TBZ) was included as an industry standard for diplodia SER control. Fruit were dipped for 1 minute in the solutions, and all fungicides were at 0.1% (1,000 ppm) aqueous concentration. The fruit were then degreened for three days and then incubated at 75 degrees for up to three weeks.

Both propiconazole and natamycin significantly reduced diplodia SER incidences compared to the water control, but propiconazole was more effective than natamycin, and similar to TBZ under the test conditions (Figure 4, page 18). Therefore, propiconazole could be a good postharvest fungicide for use in Florida citrus for managing not only sour rot and green mold, but also diplodia SER.

## LOOKING TO THE FUTURE

Space limitation prevents additional results from the project being reported here, but the current results demonstrate at least one new postharvest fungicide effective against diplodia SER, plus a preharvest fungicide that can provide good postharvest decay control if the label can be expanded to include grapefruit, mandarins and oranges. In addition, the use of $ClO_2$ is promising, but needs refinement and validation treating large commercial loads.

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