Potential of New Fungicides for Postharvest Disease Control of Florida Citrus

John Zhang and Patricia Swingle
Florida Department of Citrus
Citrus Research and Education Center
700 Experiment Station Road, Lake Alfred, FL 33850

The Impact of Postharvest Diseases on the Florida Citrus Industry

- Citrus diseases can cause significant losses for growers, packers, shippers, and consumers.
- Postharvest losses are usually greater than realized because of added cost of harvesting and handling.
- Postharvest decay is one of the most important factors affecting fresh citrus fruit market value.
- An effective postharvest decay control program is critical for the Florida fresh citrus industry.

Citrus Postharvest Disease Management System in Florida

Postharvest disease control in Florida is conducted by an integrated procedure using synthetic fungicides as the core component.

Currently Registered Fungicides for Citrus Postharvest Treatments

- Thiabendazole (TBZ)
- Imazalil
- Sodium o-phenylphenate (SOPP)

Problems Associated with Currently Registered Fungicides

- No effective alternatives available to the currently registered fungicides
- Increasingly restrictive regulations
- Health risk concerns
- Pathogen resistance development

Proposed timeline for EPA review of new postharvest fungicide products

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Active ingredient</th>
<th>Chemical class</th>
<th>EPA Review</th>
<th>Labeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penbotec (PH066)</td>
<td>Pyrimethanil</td>
<td>Pyrimidine</td>
<td>2003</td>
<td>2003</td>
</tr>
<tr>
<td>Abound</td>
<td>Azoxystrobin</td>
<td>Strobilurin</td>
<td>2004</td>
<td>2005</td>
</tr>
<tr>
<td>Scholar</td>
<td>Fludioxonil</td>
<td>Pyrrole</td>
<td>2004</td>
<td>2005</td>
</tr>
</tbody>
</table>
Evaluation of Abound and Scholar for Postharvest Disease Control of Florida Citrus

- The two compounds were tested against different pathogens in vitro.
- The two compounds were also tested in vivo using a dip method, and simulated commercial packingline application and drench systems.

Diplodia stem-end rot caused by Diplodia natalensis

Green mold caused by Penicillium digitatum

Evaluation of Abound and Scholar on Mycelial Growth of Penicillium digitatum and Diplodia natalensis in vitro

Materials and Methods

- D. natalensis D-11 and P. digitatum PD-9 were used in the tests.
- Scholar or Abound was incorporated into PDA at different concentrations.
- Fungal mycelial plugs were transferred onto fungicide amended medium, and incubated at 25C.
- Fungal colony diameters were recorded daily to determine the inhibitory activities of fungicides against the pathogens.

Effect of Scholar on mycelial growth of Diplodia natalensis and Penicillium digitatum

<table>
<thead>
<tr>
<th>Scholar (ppm)</th>
<th>D. natalensis</th>
<th>P. digitatum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>0.004</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>0.008</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>0.01</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>0.04</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>0.08</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Effect of Abound on the mycelial growth of
Diplodia natalensis in vitro

Abound conc. (ppm) % Inhibition

Effect of Abound on the mycelial growth of
Penicillium digitatum in vitro

Abound conc. (ppm) % Inhibition

Evaluation of Abound, Penbotec and Scholar for Decay Control Using a Simulated Commercial Drench Application System

Materials and Methods

• A simulated commercial drench system was used in all tests.
• Fruit were drenched for 3 min and drained for 4 min and then degreened with ethylene at about 10 ppm for 3 days.
• Treated fruit were incubated at 21°C, and decay incidence was recorded weekly.
Effect of Scholar on Diplodia stem-end rot by drenching application before degreening treatment of Ambersweet orange

Fungicides (ppm)

- Control
- Scholar, 250 ppm
- Scholar, 500 ppm

TBZ, 1,000 ppm
Imazalil, 1,000 ppm
Scholar, 1,200 ppm
Scholar, 1,000 ppm
Scholar, 750 ppm
Scholar, 500 ppm
Scholar, 250 ppm
Control

Effects of Abound and Scholar on Diplodia stem-end rot using drench application before degreening treatment of Fallglo tangerine fruit

Fungicides (ppm)

- Control
- Scholar, 500 ppm
- Scholar, 1,000 ppm
- Scholar, 1,200 ppm
- Imazalil, 1,000 ppm
- TBZ, 1,000 ppm

Penbotec, 500 ppm
Penbotec, 250 ppm
Imazalil, 500 ppm
TBZ, 500 ppm
Imazalil, 250 ppm
TBZ, 250 ppm

Evaluation of Abound, Penbotec and Scholar for Decay Control Using a Dip Application Method or a Simulated Commercial Packingline Drip System
Materials and Methods

- Decay was from natural infections or inoculations.
- For dip test, fruit were immersed in fungicide suspension for 1 min, 24 hrs after fruit inoculation.
- For packingline drip test, aqueous fungicides were applied on fruit by a non-recovery drip system with 15 to 20 sec. of contact time over running brushes.
- Fruit ethylene degreening was used for Diplodia stem-end rot evaluation.
- Treated fruit were incubated at 21°C, and decay incidence was recorded weekly.

### Effect of Abound at different concentrations on green mold control using dip test method and inoculated Valencia orange

<table>
<thead>
<tr>
<th>Fungicides (ppm)</th>
<th>Green mold incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>A</td>
</tr>
<tr>
<td>Abound 37.5</td>
<td>B</td>
</tr>
<tr>
<td>Abound 75</td>
<td>B</td>
</tr>
<tr>
<td>Abound 125</td>
<td>B</td>
</tr>
<tr>
<td>Abound 225</td>
<td>B</td>
</tr>
<tr>
<td>Abound 375</td>
<td>B</td>
</tr>
<tr>
<td>Abound 750</td>
<td>B</td>
</tr>
<tr>
<td>Abound 1250</td>
<td>B</td>
</tr>
<tr>
<td>Abound 2250</td>
<td>B</td>
</tr>
<tr>
<td>Abound 3750</td>
<td>B</td>
</tr>
<tr>
<td>Imazalil 1250</td>
<td>C</td>
</tr>
</tbody>
</table>

### Effect of Penbotec on green mold on Valencia fruit using inoculation and dip test method

- Control
- Penbotec 1,000
- Penbotec 500
- Imazalil 500
- TBZ 500

### Effects of Scholar at different concentrations on green mold of Valencia fruit by packingline application

<table>
<thead>
<tr>
<th>Fungicides (ppm)</th>
<th>Green mold incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>A</td>
</tr>
<tr>
<td>Scholar 250</td>
<td>B</td>
</tr>
<tr>
<td>Scholar 500</td>
<td>B</td>
</tr>
<tr>
<td>Scholar 1,000</td>
<td>B</td>
</tr>
<tr>
<td>Scholar 2,000</td>
<td>B</td>
</tr>
<tr>
<td>TBZ 1,000</td>
<td>C</td>
</tr>
</tbody>
</table>

### Effects of Abound and Scholar on green mold of non-degreened Pineapple orange fruit using packingline application

- Control
- Scholar 1,250
- Abound 1,250
- Imazalil 1,000
Effects of Abound and Scholar on Diplodia stem-end rot of ethylene degreened Pineapple orange fruit

Diplodia stem-end rot (%)

<table>
<thead>
<tr>
<th>Fungicides (ppm)</th>
<th>Control</th>
<th>Abound 1,200</th>
<th>Scholar 1,200</th>
<th>TBZ 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

Effect of Scholar on Diplodia stem-end rot of degreened Valencia orange fruit

Diplodia stem-end rot (%)

<table>
<thead>
<tr>
<th>Fungicides (ppm)</th>
<th>Control</th>
<th>Scholar 1,000</th>
<th>Scholar 1,200</th>
<th>TBZ 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

Summary

- Currently registered fungicides are TBZ, Imazalil and SOPP. Three new fungicides Scholar, Abound and Penbotec are in process for EPA registration.
- Both Abound and Scholar
  - Actively suppressed the mycelial growth of green mold and stem-end rot pathogens in vitro.
  - Effectively controlled Diplodia stem-end rot using a simulated commercial drench system and packingline application.
  - Significantly reduced green mold using a simulated commercial packingline drip application and a dip test method.

Summary--continued

- Scholar
  - Showed better control of Diplodia stem-end rot compared to Abound.
  - Appears to be a promising alternative to TBZ for the control of stem-end rot and green mold on citrus.
- Penbotec
  - Showed excellent control of green mold using dip test.
  - Showed moderate activity against Diplodia stem-end rot in drench test.

Summary--continued

- New fungicides, Scholar, Abound and Penbotec should provide additional chemical tools to the citrus industry to effectively control postharvest diseases and manage fungicide resistance.
- More tests on new fungicides will be conducted.
- However, TBZ and Imazalil are still excellent chemicals for decay control as long as no obvious fungicide resistance problems develop in Florida packinghouses.

Effects of fungicides on different postharvest diseases of Florida citrus

<table>
<thead>
<tr>
<th>Stem-end Rot</th>
<th>Molds</th>
<th>Sour Rot</th>
<th>Anthracnose</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBZ</td>
<td>++++</td>
<td>++++</td>
<td>—</td>
</tr>
<tr>
<td>Imazalil</td>
<td>++++</td>
<td>++++</td>
<td>—</td>
</tr>
<tr>
<td>SOPP</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>
Thank You For Your Time