Microbial Treatment of Soil, Seed, and Plant: Can It Stop Chile Wilt?

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New Mexico State University.
Biology of Verticillium Wilt
(Verticillium dahliae)

• Soilborne fungal pathogen

• May survive over 16 years as sclerotia (survival structures) in soil

• Has a broad host range including crops and weeds

• Causes stunting, defoliation, vascular discoloration, wilting, and plant death
Verticillium wilt
Verticillium wilt

Fang, 2013
Verticillium wilt/Survival of pathogen in weeds

*Anoda cristada* (spurred anoda)

*Physalis wrightii* (Wright groundcherry)
Verticillium wilt/Survival of pathogen in weeds

Tall morningglory
<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Spurred anoda</th>
<th>Ground-cherry</th>
<th>Devil’s-claw</th>
<th>Tall Morning-glory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilt</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Vascular discoloration</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Pathway to Crop Losses – Verticillium wilt

Driving Forces
High soil moisture and temperature

Pathway to
Wilting
Stunting
Defoliation
Fruit turgor loss

Crop Losses
Biology of Phytophthora Blight (Phytophthora capsici)

• Soilborne fungal-like (oomycete) pathogen
• Survives for many years as oospores (survival structures) in soil/debris
• Has a broad host range including crops and weeds
• Causes root rot, crown, foliar blight, fruit rot, wilting, and plant death
Spread of *Phytophthora capsici*

Sporangia → Zoospores
Pathway to Crop Losses – Phytophthora blight

Driving Forces
- High moisture in soil and air
- Moving surface water
- Water splash

Root Rot
Crown Rot

Foliar Blight

Fruit Rot

Damping off

Post-harvest Fruit Rot

Crop Losses
<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Phytophthora Blight</th>
<th>Verticillium Wilt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilt</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Stunting</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Root Rot</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Defoliation</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Vascular necrosis</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Microorganisms (Bacteria and fungi)
Microbial and Plant Interactions

- Microbial interactions that reduce activities of pathogens
- Microbial interactions that boost crop’s response to pathogens
Microbial interactions that reduce activities of pathogens (antagonism)

- Antibiosis
- Competition
- Parasitism
Antibiosis
Antibiosis

Serenade

No Serenade
Competition
Competition
Parasitism

- \textit{Trichoderma stromaticum}
- Commercially used in Brazil (marketed as TRICOVAB) for control of cacao witches-broom
Parasitism
Parasitism
Microbial and Plant Interactions

- Microbial interactions that reduce activities of pathogens
- Microbial interactions that boost crop’s response to pathogens
Microbial interactions that boost crop’s response to pathogens

Mycorrhizae

Induced systemic Resistance (ISR)
VESICULAR-ARBUSCULAR MYCORRHIZA

endodermis
cortex

old arbuscule
point of entry
root hair
young arbuscule
extramatrical hypha
chlamydospore
vesicle
intramatrical hypha

ectomycorrhiza

endodermis
stele
cortex

Hartig net
fungal mantle

Source: The 5th Kingdom
Handout-B1 Glomeromycota

Source: The 5th Kingdom
Source: The 5th Kingdom
Efficacy of Microbial Products/ Laboratory Evaluation
Efficacy of Microbial Products
Growth chamber/Greenhouse Evaluation
Efficacy of Microbial Treatment

• Seed with Streptomyces-based (Micro108) and Bacillus-based (Kodiak) biofungicides +

• Transplant treatment with a Streptomyces-based biofungicide (Mycostop Mix @ 0.1% and 0.3%)

• No Seed treatment (Control) and Seed Treatment with Apron XL LS (chemical fungicide)

12 treatments
<table>
<thead>
<tr>
<th>No.</th>
<th>Treatment Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No seed treatment (Control)</td>
</tr>
<tr>
<td>2</td>
<td>Seed treatment with Streptomyces-based biofungicides (Micro108 at 8g/kg of seed)</td>
</tr>
<tr>
<td>3</td>
<td>Seed treatment with a Bacillus-based biofungicide (Kodiak at 85 mg/kg of seed)</td>
</tr>
<tr>
<td>4</td>
<td>Seed treatment with chemical fungicide (Apron XL LS at 0.42 ml/kg of seed)</td>
</tr>
<tr>
<td>5</td>
<td>No seed treatment + transplant treatment with Mycostop Mix (drenching with 100 ml of 0.1% suspension)</td>
</tr>
<tr>
<td>6</td>
<td>Seed treatment with Apron XL LS + transplant treatment with Mycostop Mix (drenching with 100 ml of 0.1% suspension)</td>
</tr>
<tr>
<td>7</td>
<td>Seed treatment with Micro 108 + transplant treatment with Mycostop Mix (drenching with 100 ml of 0.1% suspension)</td>
</tr>
<tr>
<td>8</td>
<td>Seed treatment with Kodiak + transplant treatment with Mycostop Mix (drenching with 100 ml of 0.1% suspension)</td>
</tr>
<tr>
<td>9</td>
<td>No seed treatment + transplant treatment with Mycostop Mix (drenching with 100 ml of 0.3% suspension)</td>
</tr>
<tr>
<td>10</td>
<td>Seed treatment with Apron XL LS + transplant treatment with Mycostop Mix (drenching with 100 ml of 0.3% suspension)</td>
</tr>
<tr>
<td>11</td>
<td>Seed treatment with Micro 108 + transplant treatment with Mycostop Mix (drenching with 100 ml of 0.3% suspension)</td>
</tr>
<tr>
<td>12</td>
<td>Seed treatment with Kodiak + transplant treatment with Mycostop Mix (drenching with 100 ml of 0.3% suspension)</td>
</tr>
</tbody>
</table>
Seed / Transplant Treatment - Phytophthora blight

Transplant treatment with Mycostop

<table>
<thead>
<tr>
<th>Seed treatment</th>
<th>Apron XLS</th>
<th>Control</th>
<th>Kodiak</th>
<th>Mycostop</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUDPC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>100</td>
<td>120</td>
<td>150</td>
<td>140</td>
</tr>
<tr>
<td>0.1%</td>
<td>110</td>
<td>130</td>
<td>160</td>
<td>150</td>
</tr>
<tr>
<td>0.3%</td>
<td>120</td>
<td>140</td>
<td>170</td>
<td>160</td>
</tr>
</tbody>
</table>
Soil and Transplant Treatment - Phytophthora

![Bar chart showing AUDPC for different soil treatments: ACTINO, CONTRO, MYCOST, RIDOMI.](image)
Efficacy of Microbial Products
Field Evaluation
Microbial Seed/Soil/Plant Treatment

Field9

AUDPC

- FarMore+Tricho
- FarMore
- Untreated+Tricho

Treatment

FarMore+Tricho  FarMore  Untreated+Tricho
Microbial Seed/Soil/Plant Treatment

Field10

AUDPC

FarMore+Tricho  FarMore  Untreated+Tricho

FarMore+Tricho  FarMore  Untreated+Tricho

Treatment
Microbial Seed/Soil/Plant Treatment

Date

<table>
<thead>
<tr>
<th>Date</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8Aug013</td>
<td>Myco: 3, No Myco: 9</td>
</tr>
<tr>
<td>9Sept013</td>
<td>Myco: 9, No Myco: 12</td>
</tr>
</tbody>
</table>
Microbial Seed/Soil/Plant Treatment

Disease index (%)

Days after inoculation with pathogen

Garmendia et al. 2004
## Microbial Soil/Plant Treatment

<table>
<thead>
<tr>
<th>Treatment and rate/A (application time)</th>
<th>Marketable</th>
<th>AUDPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscodor 3.5 oz/ft^3 soil (8 days pre transplant)</td>
<td>3.3</td>
<td>59.0</td>
</tr>
<tr>
<td>Muscodor 1.9 oz/ft^3 soil (8 days pre-transplant)</td>
<td>2.1</td>
<td>33.3</td>
</tr>
<tr>
<td>Actinovate SP 6 oz/100 gallons seedling drench pre-transplant + 12 oz foliar (1-9)</td>
<td>3.4</td>
<td>54.6</td>
</tr>
<tr>
<td>Serenade ASO 2.0% drench at transplant</td>
<td>1.8</td>
<td>106.8</td>
</tr>
<tr>
<td>Serenade Max 2 lb + Kocide 2000 2 lb (1-9)</td>
<td>1.8</td>
<td>106.8</td>
</tr>
<tr>
<td><strong>Ridomil Gold EC 1 pt drench at transplant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil Gold Copper 2.5 lb (1,3,5,7)</td>
<td>3.0</td>
<td>70.1</td>
</tr>
<tr>
<td><strong>Ridomil Gold EC 1 pt drench at transplant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil Gold Copper 2.5 lb (3,7) alt Serenade Max 2 lb + Kocide 2000 DF 2 lb (1,5,9)</td>
<td>1.5</td>
<td>34.0</td>
</tr>
<tr>
<td><strong>Ridomil Gold EC 1 pt drench at transplant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ridomil Gold Copper 2.5 lb (3,7) alt Actinovate SP 12 oz(1,5,9)</td>
<td>1.9</td>
<td>30.4</td>
</tr>
<tr>
<td><strong>Ridomil Gold EC 1 pt drench at transplant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maestro 80DF 6 lb (3,7) alt Serenade Max 2 lb + Kocide 2000 2 lb (1,5,9)</td>
<td>3.4</td>
<td>36.3</td>
</tr>
<tr>
<td><strong>Ridomil Gold EC 1 pt drench at transplant</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maestro 80DF 6 lb (3,7) alt Actinovate SP 12 oz/A (1,5,9)</td>
<td>2.3</td>
<td>38.5</td>
</tr>
<tr>
<td><strong>Untreated control</strong></td>
<td>1.8</td>
<td>32.4</td>
</tr>
</tbody>
</table>

Miller et al. (2006)
Research Needs

- Combination of strategies
- Frequency of application