Biopesticides and their Modes of Action

Debbie Palumbo-Sanders
Technical Services Specialist
dpalumbo-sanders@bioworksinc.com

Tri-State Greenhouse IPM Workshop
January 17, 18, 19 2018
According to the U.S. EPA, biopesticides include naturally occurring substances that control pests (biochemical pesticides), microorganisms that control pests (microbial pesticides), and pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants) or PIPs.
1. Short REIs (Most are 4 hours)
2. Zero day pre-harvest intervals (PHI)
3. Generally safer to plants
4. Low risk to environment
5. Quicker to market at lower overall cost
   - 3 years and $5 million to develop vs. 10 years and $200 million
6. Complex modes of action
FIFRA: any substance intended to preventing, destroying, repelling, or mitigating a pest, and/or intended for use as a plant regulator, defoliant, or desiccant.

Intent is expressed through the product’s claim.
Laboratory Testing

Rhizoctonia

Rhizoctonia

Rhizoctonia
Greenhouse Testing

Un  CaCl  Fung  T382

APS/Dr. Hoitink
Background

1. *Bacillus* spp.
2. Over 100 *Bacillus*-based biopesticides registered
   - Majority are Bt (insecticide)
   - *B. amyloliquefaciens* (6)
   - *B. subtilis* (12)
3. Target foliar as well as some soil-borne diseases
Biofungicides: Bacterial-Based Products

Mode of Action

Responsible  |  Economical  |  Proven
Background

2. The most frequently isolated soil fungus from all temperate and tropical soils
3. Marketed as biopesticides, biofertilizers, growth enhancers and biostimulants
4. Biocontrol isolates target root diseases

*Trichoderma harzianum*

www.omicsonline.org
RootShield Plus Modes of Action

1. **Competitive exclusion** - growth around the root system
   - Competition with fungal pathogens for space on the plant’s roots
   - Competition with fungal pathogens for food
Biofungicides: Fungal-Based Products

RootShield Plus Modes of Action

1. Competitive exclusion - growth around the root system
   - Competition with fungal pathogens for space on the plant’s roots
   - Competition with fungal pathogens for food
2. Mycoparasitism - seeks out and eats other fungi
3. Metabolite production to inhibit microbe growth

RootShield attacking a hyphal strand of *Rhizoctonia* using enzymes to degrade the cell wall of the pathogen.
RootShield Plus Modes of Action

1. Competitive exclusion - growth around the root system
   - Competition with fungal pathogens for space on the plant’s roots
   - Competition with fungal pathogens for food
2. Mycoparasitism - seeks out and eats other fungi
3. Metabolite production to inhibit microbe growth
Potassium bicarbonate (MilStop) Modes of Action

1. Increases pH on leaf surfaces, which is detrimental to fungal spores
2. Increases osmotic potential and dries out fungal spores
3. Inhibits mycelial growth by destabilizing and destroying cell membranes

SEM of MilStop Treated and Untreated Powdery Mildew Spores
Background

1. Living spores of entomopathogenic fungi
2. From four fungal genera:
   - Beauveria
   - Isaria
   - Metarhizium
   - Paecilomyces
3. Contact insecticides, so full coverage is essential
4. Mortality is not immediate, takes 3-7 days
BotaniGard Mode of Action

0-6 hours

12-48 hours

96-120 hours
BotaniGard Mode of Action

Sporulation is not a measure of efficacy
Background

1. An extract of neem seeds
   - Family of complex secondary compounds in seed extracts (limonoid terpenes)
   - Most potent of the neem-derived insecticides
   - Is not neem oil
2. Largely function as insect growth regulators for immature insects
3. Takes 3 to 7 days until effects on insects are evident
Background

1. Horticultural oils include vegetable as well as mineral oil products
2. Pests are killed by direct contact so thorough coverage is necessary
3. Non-selective, but residues short-lasting and beneficials can reenter
4. Most effective against soft-bodied insects
1. Niche competition
2. Release of antagonistic metabolites
3. Predation and parasitism
4. Induced host resistance and increased plant vigor
5. Alteration of the soil or host plant environment
6. Disruption of fundamental biological functions, development and structures of target organisms
   - Directly inhibit biochemical processes
   - Interfere with developmental pathways of pathogens
   - Compromise the physical integrity of pests and pathogens
Biopesticides are NOT a chemical

Need to change your mindset

• Be PROACTIVE
  – Start from the beginning
    • With biologicals it is a numbers game. When the pest/disease pressure is too high biologicals are outnumbered
• Do not expect to use them the same way as with chemistries
  – Contact is crucial
  – Non-systemic, non-translaminar
• Do not expect the same kind of results
  – Pests don’t drop dead immediately
• Shelf life
  – Appropriate storage conditions are critical for their viability
  – They are living organisms
BotaniGard®
Tank Mix Compatibility

All products tested for compatibility and reported in this document have been evaluated for impact on Beauveria bassiana strain GHA, spores and physical compatibility only. Tests were not carried out to evaluate impact on the partner product integrity or for plant phytotoxicity. Compatibility has been tested at normal tank mix dilutions, not in concentrated stock tank dilutions (such as for injecting at 1:100). Physical compatibility can be impacted by your water quality, tank residues, or the addition of other materials in the spray tank.

- Always maintain constant agitation in your spray tank.
- Read and follow label directions for all tank mix materials.
- Make applications of tank mix solutions as soon as possible after mixing.

All chemistries available have not been tested. As a general rule of thumb, for unlisted products, wait 4-5 days before or after a fungicide application to apply BotaniGard. Most insecticides will not harm BotaniGard. Ask your distributor for information regarding specific products.

* Compatibility with spores applies to BotaniGard® ES, and BotaniGard® 22WP.

### Adjuvants

<table>
<thead>
<tr>
<th>Brand Name</th>
<th>Active Ingredient</th>
<th>Maximum Tested Rate</th>
<th>Compatible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Choice® 2220</td>
<td>Alkylarlypolyoxylene glycols and isopropyl alcohol + sodium ethylene diamine tetraacetate</td>
<td>4 oz/100 gal</td>
<td>Yes</td>
</tr>
<tr>
<td>1st Choice® 4440</td>
<td>Cottonseed oil and adjuvant</td>
<td>1 gal/100 gal</td>
<td>Yes</td>
</tr>
<tr>
<td>1st Choice® 9300</td>
<td>Cottonseed oil and adjuvant</td>
<td>2 gal/100 gal</td>
<td>Yes</td>
</tr>
<tr>
<td>1st Choice® Spreader Sticker</td>
<td>Alkylarlypolyoxylene glycols and isopropyl alcohol</td>
<td>1 gal/100 gal</td>
<td>Yes</td>
</tr>
<tr>
<td>6E</td>
<td>Mineral oil</td>
<td>1 gal/100 gal</td>
<td>Yes, phyto concern</td>
</tr>
<tr>
<td>7N</td>
<td>Mineral oil</td>
<td>1 gal/100 gal</td>
<td>Yes, phyto concern</td>
</tr>
<tr>
<td>Activate® Plus</td>
<td>Alkylarlypolyoxylene glycols, free fatty acids &amp; isopropyl alcohol</td>
<td>2 qt/100 gal</td>
<td>Yes</td>
</tr>
<tr>
<td>Activator® 90</td>
<td>Alkylphenol ethoxylate, alcohol ethoxylate, tall oil fatty Acids</td>
<td>2 qt/100 gal</td>
<td>Yes</td>
</tr>
<tr>
<td>Agicide Activator®</td>
<td>Petroleum Oil &amp; polyl fatty acid esters</td>
<td>6 qt/100 gal</td>
<td>Yes</td>
</tr>
<tr>
<td>Agra Wet®</td>
<td>Ethoxylated soybean derived Surfactants</td>
<td>1 qt/100 gal</td>
<td>Yes</td>
</tr>
</tbody>
</table>
**Biological Control Agents**

Use only with high population of parasite. OK on parasitized whitefly pupae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Species</th>
<th>BioWorks Recommendation</th>
<th>Syngenta Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encarsia</td>
<td>formosa</td>
<td><strong>Use only with high population.</strong></td>
<td><strong>Expect reduction after application.</strong></td>
</tr>
</tbody>
</table>

*Resources were reviewed for the compatibility of the BotaniGard/Mycotrol active ingredient with BCAs and a summary of the findings is provided. Please refer to product label for proper application and your BCA supplier for further information.*
Dipping Plant Material

Responsible | Economical | Proven
Dipping Plant Material

Utilizing Dips

Clean Up Incoming Plant Material by Utilizing Dips

Bringing in outside plant material also brings in unwanted pests. Many cuttings and young plant material from domestic or offshore suppliers contain low level insect populations. Whiteflies, thrips, fungus gnats and aphids may arrive unnoticed until later in production when populations can suddenly explode. Incoming plant material may also carry root diseases that also require early prevention.

Dips are very successful when biological control agents (BCAs) are used. By dipping plant material, BCAs have a head start in keeping pest populations in check. By using the BioWorks products below, there is no risk of pesticide residues that will interfere with BCA feeding, growth or reproduction.

Dips are simply the use of biopesticides, alone or tank-mixed, in a spray or in a basin where the mixture sits for periods of time and then dunks plants for periods of time. The plants are then stuck or sprayed. Using dips, many cuttings or trees can be treated, resulting in the use of less overall volume of pest control products. (See Guidelines for Dipping and Dip Process below) Effective dips can significantly reduce the need for multiple applications of chemical pesticides later in the crop cycle. The bottom line is that dipping saves money and time for growers. BioWorks products have been effectively used in dips.

BotaniGard® 22WP (Do not use BotaniGard ES)
Nemastar®
Myconost® WP
WSDA Approved (Do not use Myconost ESO)
RootShield® WP
RootShield® PLUS® WP
OMRI Listed

For Unrooted Cuttings (URC) and Bare-root Plants: (Do not use this rate chart for plugs)

<table>
<thead>
<tr>
<th>Product</th>
<th>Metric Rate</th>
<th>US Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>BotaniGard® 22WP OR Myconost WP</td>
<td>2.5 grams/liter</td>
<td>0.5 oz/5 gallons</td>
</tr>
<tr>
<td>Nemastar®</td>
<td>1 million/liter</td>
<td>0.18 oz/5 gallons</td>
</tr>
<tr>
<td>ON-Gard®</td>
<td>2.5 ml/liter</td>
<td>0.8 oz/5 gallons</td>
</tr>
<tr>
<td>RootShield® WP OR RootShield® PLUS® WP</td>
<td>0.4 grams/liter</td>
<td>0.08 oz/5 gallons</td>
</tr>
</tbody>
</table>

Guidelines for Dipping

- Clean and disinfect the dipping tank and equipment before preparing a new dip suspension. Prepare only as much dip suspension as can be used in one day. If plant pathogens are a concern, prepare a new dip suspension regularly. (Recent research has shown that disease transmission from Encephalitis is unlikely.)
- Use cool water when making up the suspension, keep out of direct sunlight, and maintain cool water temperatures (60 - 70°F) throughout the dipping process.
- If Nemastar® is included, keep the suspension cool (60 - 70°F) and aerate the suspension to keep the nematodes alive and vigorous.
- Dip suspension should not be used for more than one day. Nematodes in the suspension are not able to reproduce.
- Dip suspension should not be used for more than one day. Nematodes in the suspension are not able to reproduce.
- Frequently agitate dip solution throughout use.
- Avoid dipping sensitive plants such as African violet, tender ferns, etc.
- Conduct a test by dipping a small number of plants and observe for plant damage before using dip treatment. Observe plants for 7 - 10 days for signs of injury. Do not use dips if there is any visible damage to test plants.
- Do not dip stressed/wilted cuttings or transplants.

Dip Process

- Dip vegetative or hardwood cuttings prior to planting into rooting substrate. Place unrooted cuttings in a mesh bag, immersion tray with lid, or loosely in the tank. Ensure that the cuttings are not packed too tightly to promote maximum surface area coverage. Immerses the cuttings completely, gently moving the tray, bag, or plants around in the solution for at least 5 seconds to allow the solution to completely wet all surfaces. Verify that there are no dry surface areas. After dipping vegetative cuttings, keep them cool and shaded. Avoid exposing dipped cuttings to full sun, high temperature, or other stress.
- Dip trays of plugs, individual pots of liners, or other potted young plants into the solution and gently move around for at least 5 seconds. Ensure that all surfaces have been wetted. Allow plants to dry before watering.

For questions concerning these or any other BioWorks products, please contact us at 800-877-9443.

BioWorks® and Nemastar® are registered trademarks of BioWorks, Inc. BotaniGard® and Myconost® are all registered trademarks of IPM Sciences, Inc.