Biopesticides and their Modes of Action

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How You Grow Matters™

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Tri-State Greenhouse IPM Workshop

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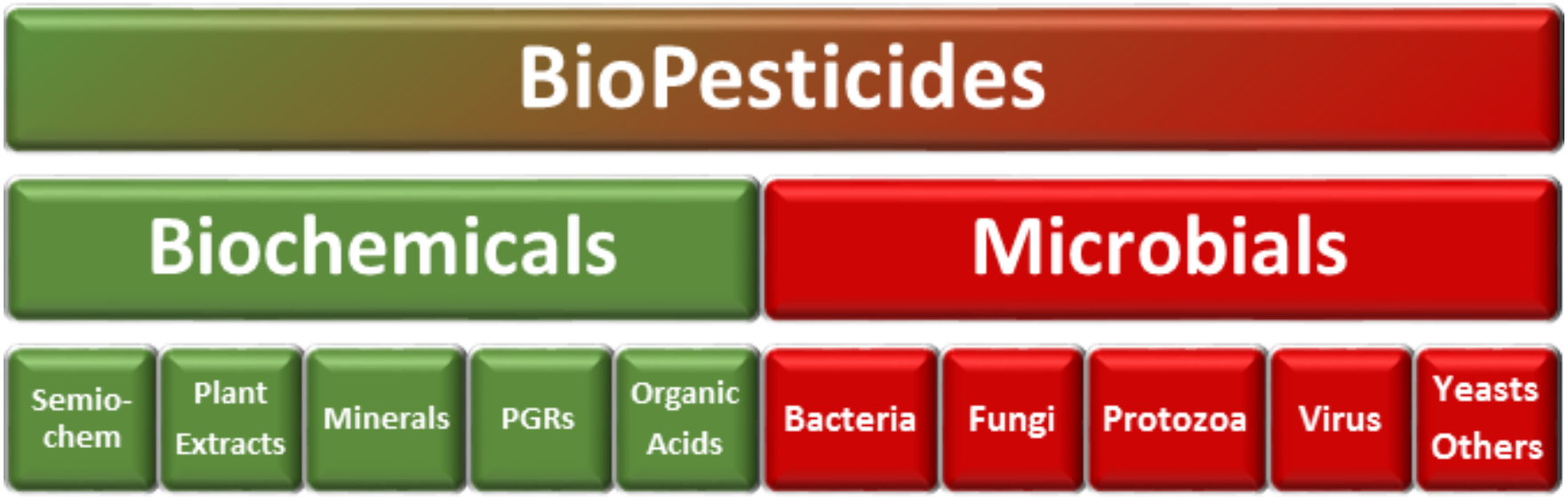

According to the U.S. EPA

Biopesticides include naturally occurring substances that control pests (biochemical pesticides), micro-organisms that control pests (microbial pesticides), and pesticidal substances produced by plants containing added genetic material (plant-incorporated pro-tectants) or PIPs.

DunhamTrimmer
International Bio Intelligence

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Biopesticide Advantages

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

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EPA Registration

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.

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Biopesticide Discovery

http://www.mycosphere.com.sg

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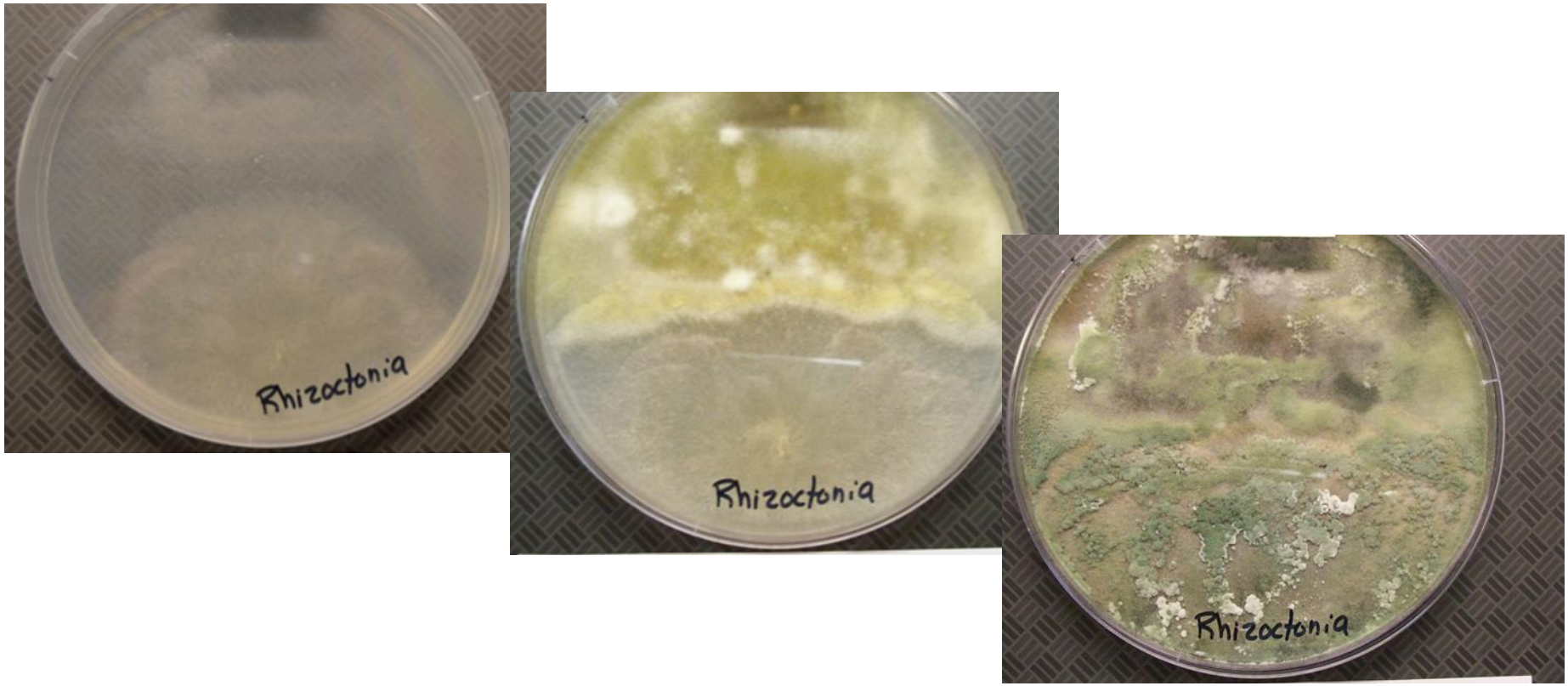
Laboratory Testing



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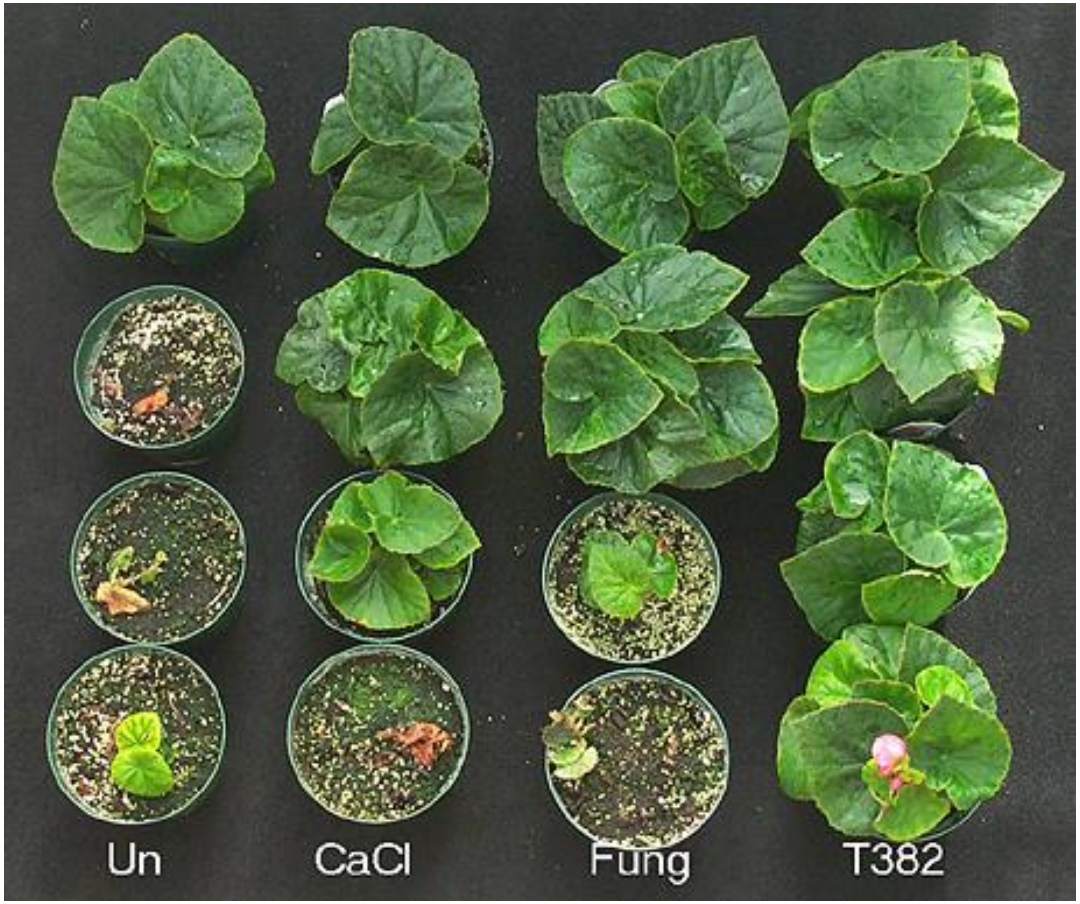
Greenhouse Testing



APS/Dr. Hoitink

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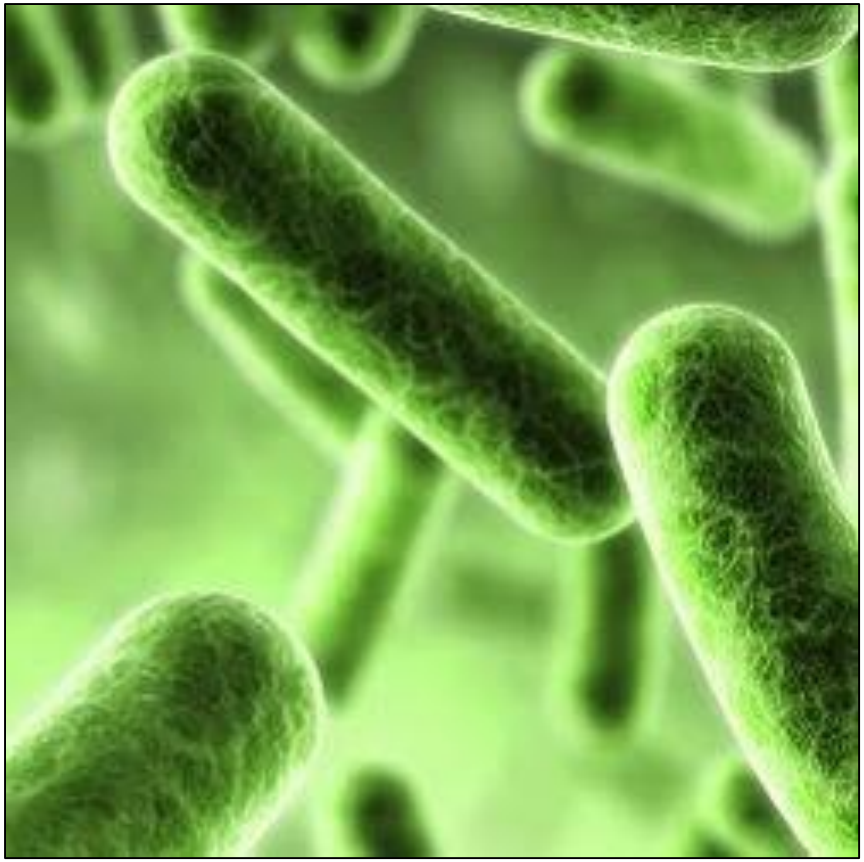
Biofungicides: Bacterial-Based Products

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



Bacillus subtilis
www.hexonlaboratories.com

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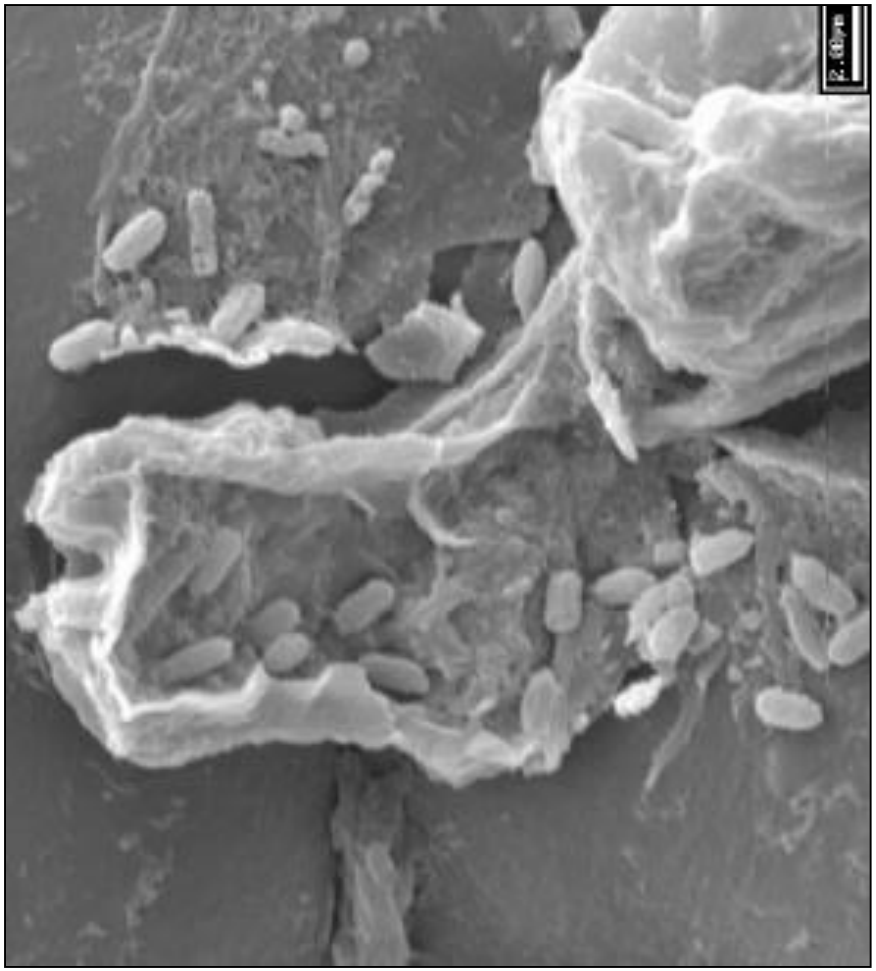
Biofungicides: Bacterial-Based Products

Mode of Action



Biofungicides: Fungal-Based Products

Background

1. *Trichoderma* spp.
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

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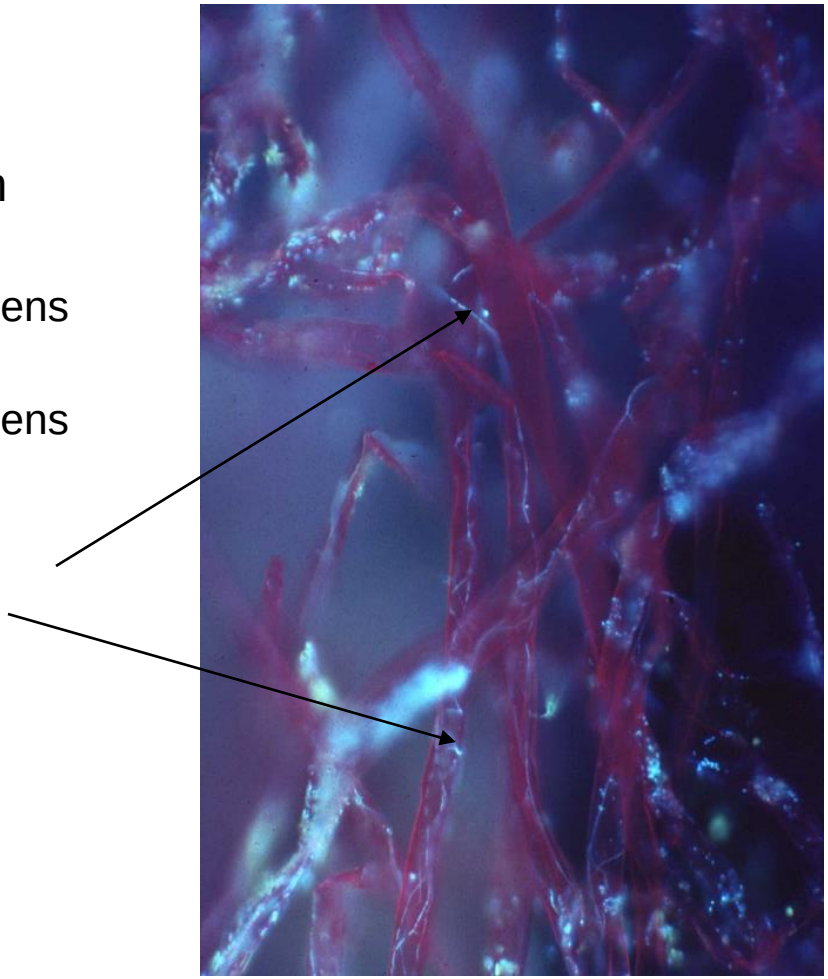
Biofungicides: Fungal-Based Products

RootShield Plus Modes of Action

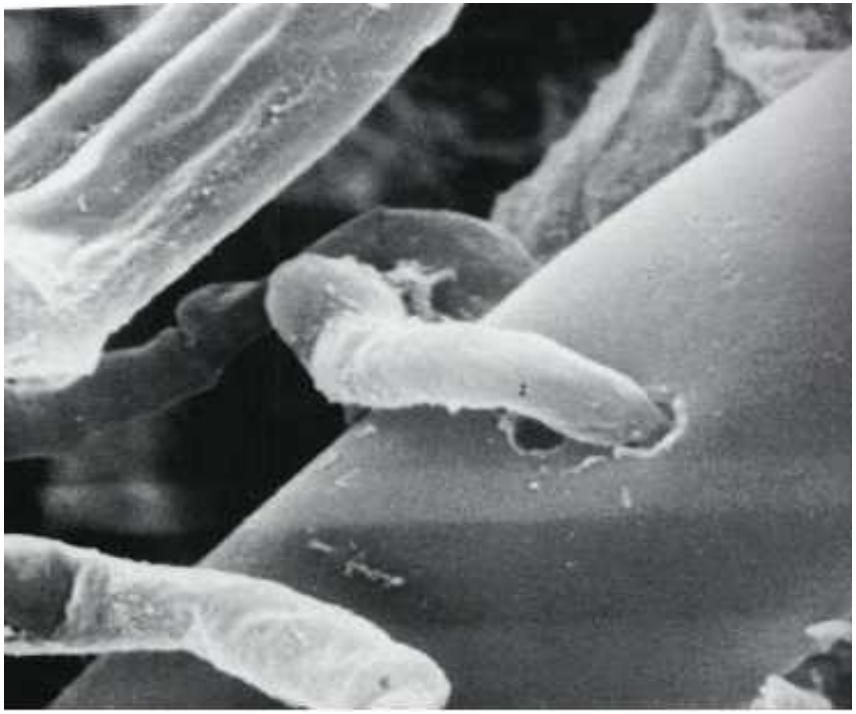
1. Competitive exclusion - growth around the root system
   - Competition with fungal pathogens for space on the plant's roots
   - Competition with fungal pathogens for food



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.

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Biofungicides: Fungal-Based Products

RootShield Plus Modes of Action

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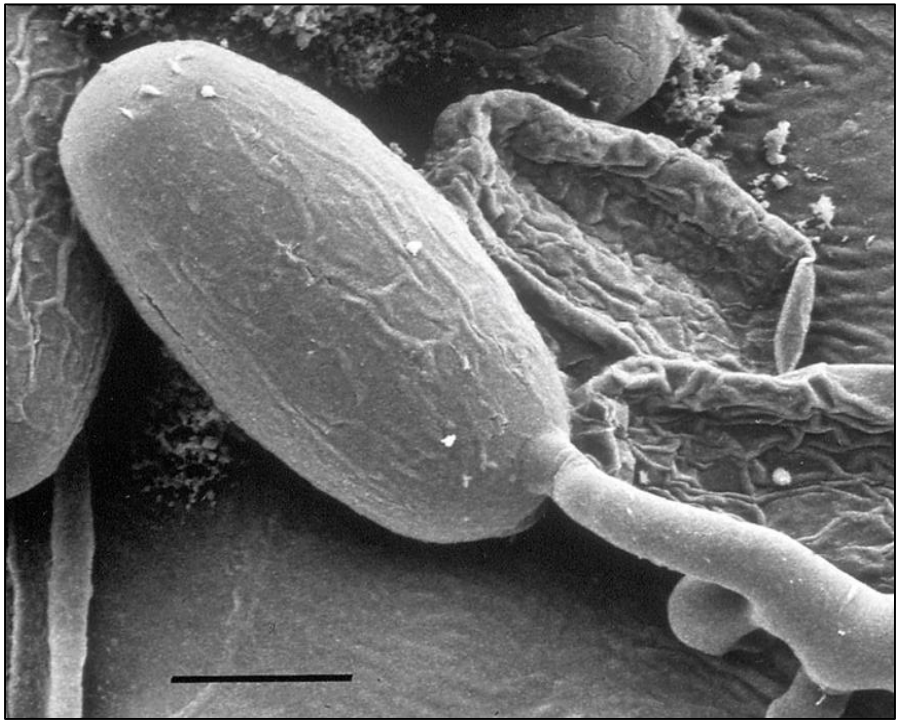
Biofungicides: Mineral-Based Products

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

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Bioinsecticides: Fungal-Based Products

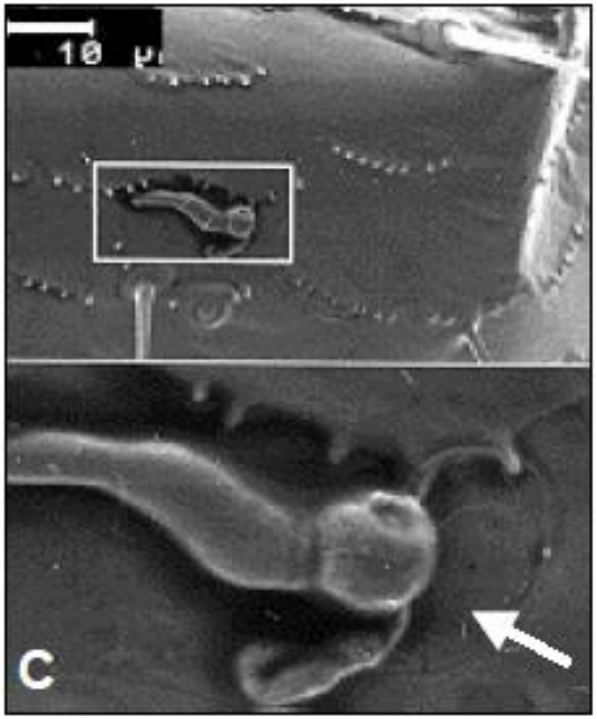
Background

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

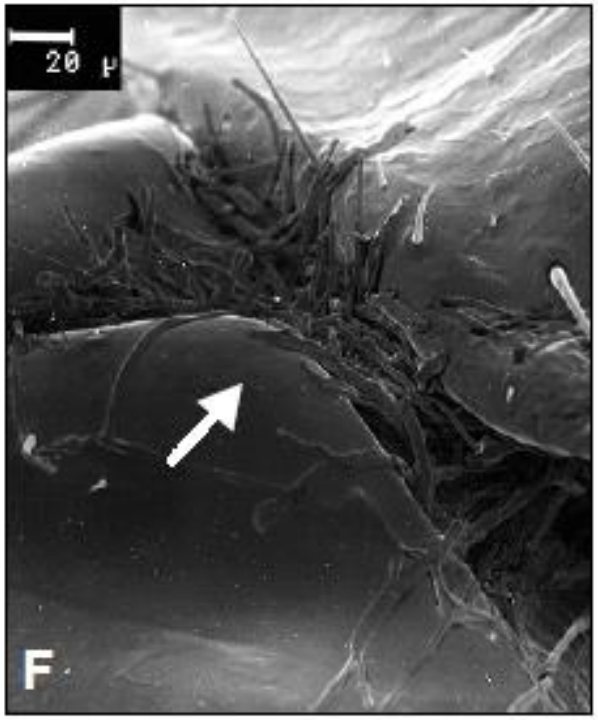
Bioinsecticides: Fungal-Based Products

BotaniGard Mode of Action

0-6 hours



12-48 hours



96-120 hours

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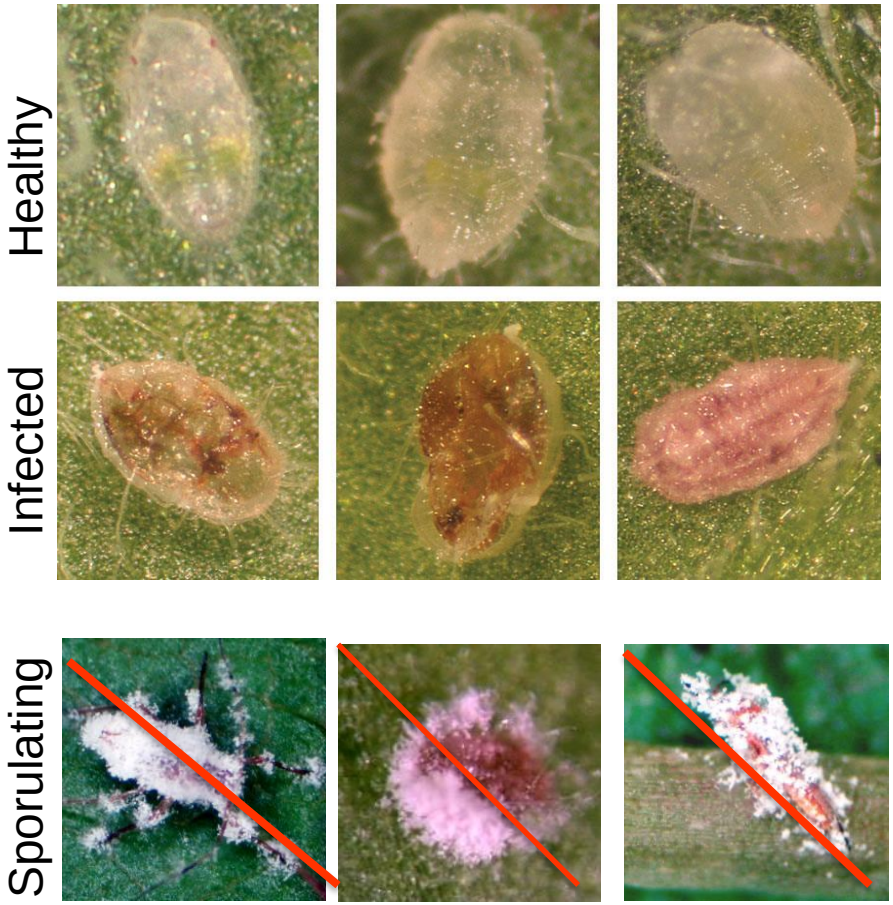
Bioinsecticides: Fungal-Based Products

BotaniGard Mode of Action

Sporulation is not a measure of efficacy



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Bioinsecticides: Azadirachtin-Based Products

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

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Bioinsecticides: Mineral Oil-Based Products

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

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Low Likelihood of Resistance Development

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

16 ½ pages of products

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BotaniGard® Technical Bulletin

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.

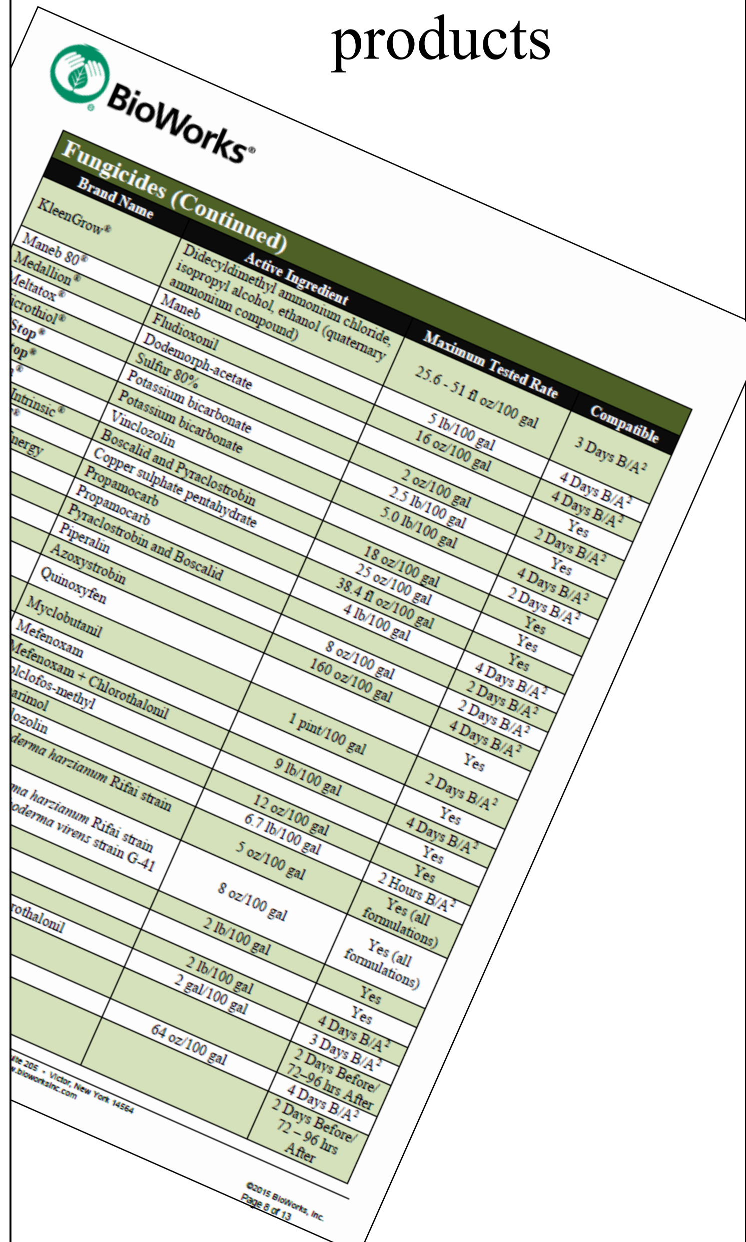
- Always maintain constant agitation in your spray tank.
- Read and follow label directions for all tank mix materials.
- Make applications of tank mix solutions as soon as possible after mixing.

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

Brand Name	Active Ingredient	Maximum Tested Rate	Compatible
1st Choice® 2220	Alkylarlypolyoxyethylene glycols and isopropyl alcohol + sodium ethylene diamine tetra-acetate	4 oz/100 gal	Yes
1st Choice® 4440	Cottonseed oil and adjuvant	1 gal/100 gal	Yes
1st Choice® 9300	Cottonseed oil and adjuvant	2 gal/100 gal	Yes
1st Choice® Spreader Sticker	Alkylarlypolyoxyethylene glycols and isopropyl alcohol	1 gal/100 gal	Yes
6E	Mineral oil	1 gal/100 gal	Yes, phyto concern
7N	Mineral oil	1 gal/100 gal	Yes, phyto concern
Activate® Plus	Alkylarylpolyethylene glycols, free fatty acids & isopropyl alcohol	2 qt/100 gal	Yes
Activator® 90	Aklylphenol ethoxylate, alcohol ethoxylate, tall oil fatty Acids	2 qt/100 gal	Yes
Agicide Activator®	Petroleum Oil & polyol fatty acid esters	6 qt/100 gal	Yes
Agra Wet®	Ethoxylated soybean derived Surfactants	1 qt/100 gal	Yes



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Biological Control Agents

Use with BioWorks Products:

BotaniGard® 22WP | Mycotrol® WPO | CEASE® | MilStop®| Molt-X® | RootShield®/RootShield®*PLUS*+ | SuffOil-X®

The introduction of Biological Control Agents (BCAs) is often a component of an Integrated Pest Management (IPM) program and an awareness of use with BioWorks products is essential to the success of the program.

BotaniGard 22 WP* and **Mycotr**
are based on the highly successfu
insect directly. Consequently, gro
example, as a spot treatment or

*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.

Biological Control Agents and Their Use with BotaniGard 22WP and Mycotrol WPO

Genus	Species	BioWorks Recommendation	Syngenta Comments
Aphidius	*colemani*	Ok on mummies. Some reduction of adult population. Wait until mummification is extensive before applying. Avoid banker plants.	Ok on mummies. Some reduction of adult population. Wait until mummification is extensive before applying. Avoid banker plants.
Aphidius	*ervi*	Ok on mummies. Some reduction of adult population. Wait until mummification is extensive before applying. Avoid banker plants.	Ok on mummies. Some reduction of adult population. Wait until mummification is extensive before applying. Avoid banker plants
Aphidoletes	*aphidimyza*	Use only with high population.	Expect reduction after application. Re-introduce after application.
Aphytis	*melinus*	Ok to apply	No experience
Bombus	spp.	Ok-Close the hive before application.	Ok-Close the hive before application.
Chrysoperla	*carnea*	Apply 5 days prior to release.	Apply 5 days prior to release.
Coleoptera	sp.	Ok to apply with adults.	Expect reduction after application.
Cryptolaemus	*montrouzieri*	Ok to apply.	Expect reduction after application.
Dacnusa	*sibirica*	DO NOT APPLY	No longer in production
Delphastus	*pusillus*	DO NOT APPLY	DO NOT APPLY
Diglyphus	*isaea*	Ok to Apply -Wait for a population of adults to build.	Expect some reduction.
Encarsia	*formosa*	Use only with high population of parasite. OK on parasitized whitefly pupae.	Ok with parasitized pupae. Expect reduction of wasps after application.
Eretmocerus	*californicus*	Use only with high population of parasite.	Ok with parasitized pupae. Expect reduction of wasps after application.
Eretmocerus	*eremicus*	Use only with high population of parasite.	
Heterorhabditis	*bacteriophora*	Ok to apply	Ok
Hippodamia	*convergens*	Ok to apply	Ok

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

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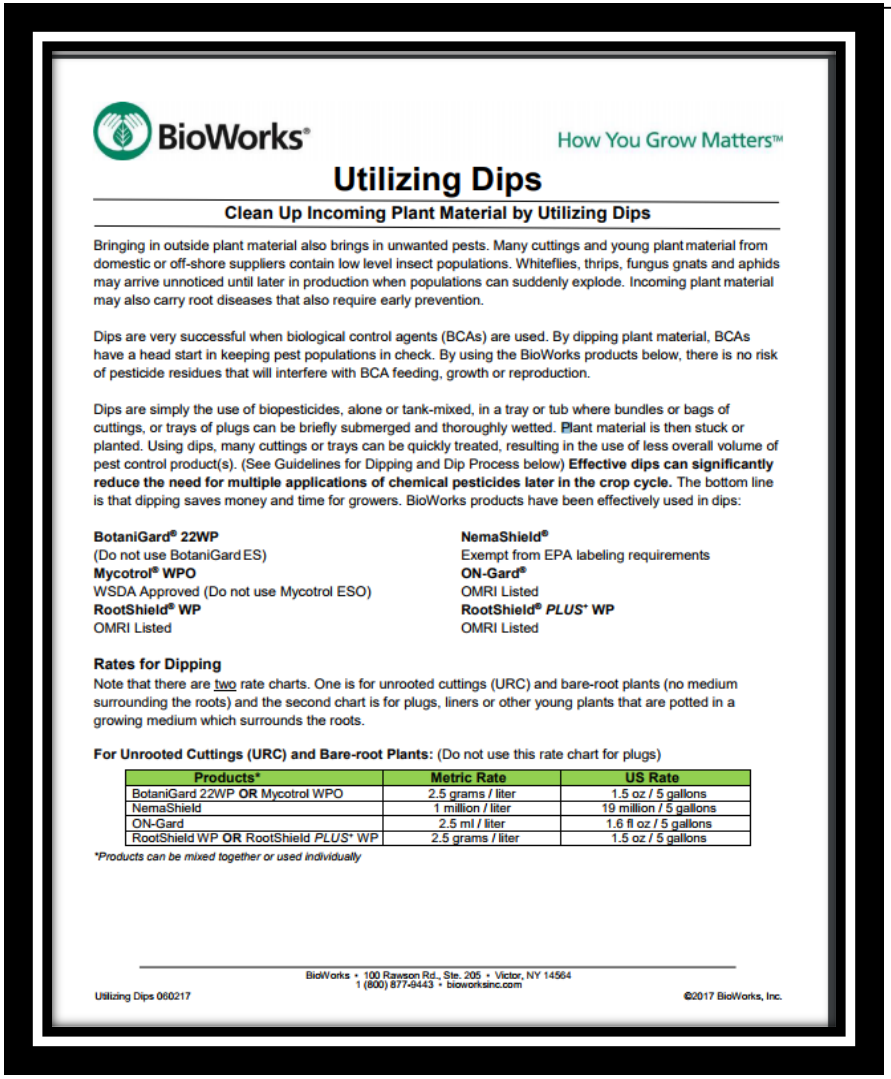
Dipping Plant Material

Responsible | Economical | Proven

Dipping Plant Material



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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 off-shore 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 tray or tub where bundles or bags of cuttings, or trays of plugs can be briefly submerged and thoroughly wetted. Plant material is then stuck or planted. Using dips, many cuttings or trays can be quickly treated, resulting in the use of less overall volume of pest control product(s). (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)
Mycotrol® WPO
WSDA Approved (Do not use Mycotrol ESO)
RootShield® WP
OMRI Listed

NemaShield®
Exempt from EPA labeling requirements
ON-Gard®
OMRI Listed
RootShield® *PLUS WP**
OMRI Listed

Rates for Dipping

Note that there are two rate charts. One is for unrooted cuttings (URC) and bare-root plants (no medium surrounding the roots) and the second chart is for plugs, liners or other young plants that are potted in a growing medium which surrounds the roots.

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

Products*	Metric Rate	US Rate
BotaniGard 22WP **OR** Mycotrol WPO	2.5 grams / liter	1.5 oz / 5 gallons
NemaShield	1 million / liter	19 million / 5 gallons
ON-Gard	2.5 ml / liter	1.6 fl oz / 5 gallons
RootShield WP **OR** RootShield *PLUS** WP	2.5 grams / liter	1.5 oz / 5 gallons

**Products can be mixed together or used individually*

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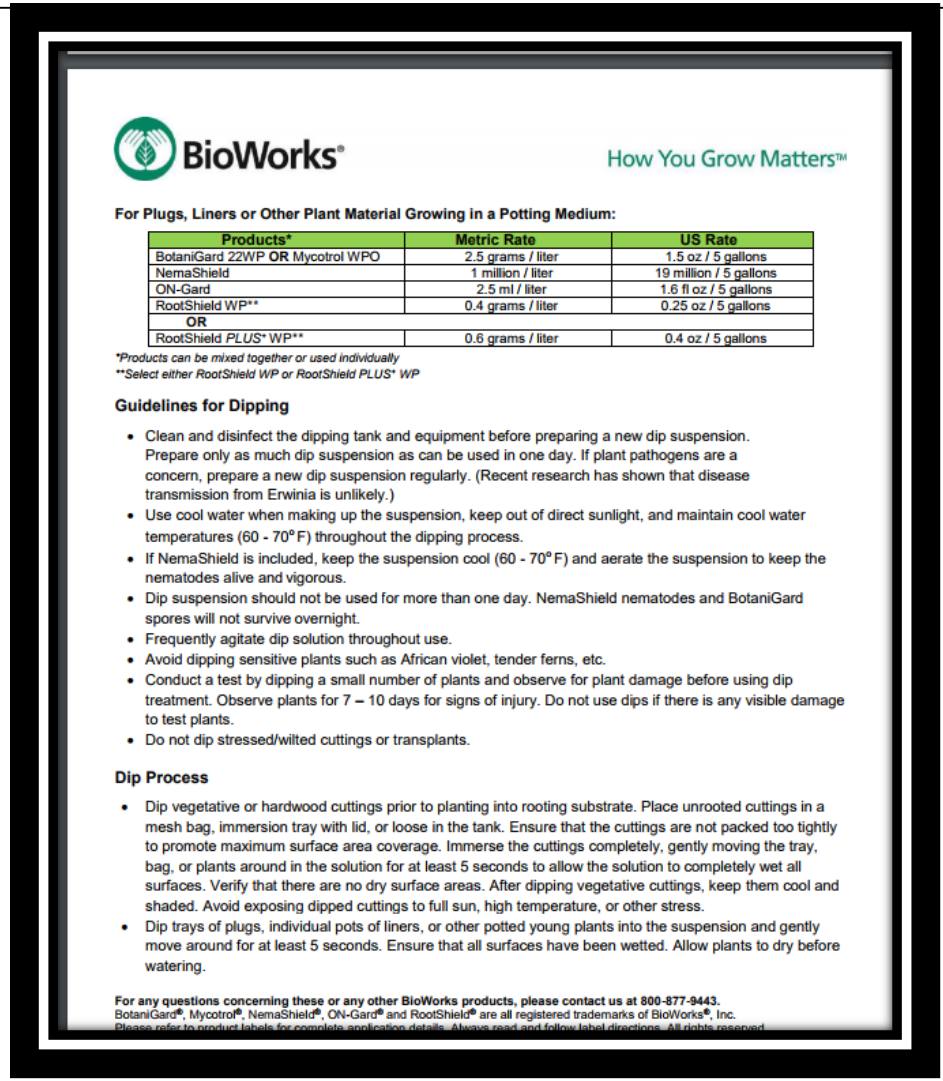
1 (800) 877-9443 • bioworksinc.com



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For Plugs, Liners or Other Plant Material Growing in a Potting Medium:

Products*	Metric Rate	US Rate
BotaniGard 22WP **OR** Mycotrol WPO	2.5 grams / liter	1.5 oz / 5 gallons
NemaShield	1 million / liter	19 million / 5 gallons
ON-Gard	2.5 ml / liter	1.6 fl oz / 5 gallons
RootShield WP**	0.4 grams / liter	0.25 oz / 5 gallons
OR		
RootShield *PLUS** WP**	0.6 grams / liter	0.4 oz / 5 gallons

**Products can be mixed together or used individually*
***Select either RootShield WP or RootShield PLUS* WP*

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 Erwinia 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 NemaShield 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. NemaShield nematodes and BotaniGard spores will not survive overnight.
- 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 loose in the tank. Ensure that the cuttings are not packed too tightly to promote maximum surface area coverage. Immerse 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 suspension and gently move around for at least 5 seconds. Ensure that all surfaces have been wetted. Allow plants to dry before watering.

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

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Thanks for listening

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