



# Biological Fungicides

## What are biological fungicides?

Biological fungicides (“biofungicides”) are composed of beneficial microorganisms including specialized fungi, bacteria and actinobacteria (filamentous bacteria) that are used against fungi and bacteria that cause plant diseases. Many of these microorganisms are found naturally occurring in soils. Researchers have isolated specific strains that have been formulated with additives to enhance their performance and storage.

More greenhouse growers are incorporating biological fungicides into their disease management programs. However, it is important to understand how biological fungicides differ from conventional fungicides, to understand their benefits and limitations in order for them to be an effective part of your disease management plan.

Biological fungicides are living organisms that are best used **preventively** before disease occurs and not as a rescue treatment for diseased plants. They are best used in conjunction with good cultural practices, proper sanitation and promotion of plant health.

## How do biofungicides work?

Biofungicides work (their mode of action) in a number of different ways including direct competition or exclusion, antibiosis, predation or parasitism, induced resistance and plant growth promotion. Many biological fungicides work in multiple ways, such as by competition and parasitism, so are less likely to develop resistance than conventional fungicides that often work in a single way with a specific mode of action.

**Direct Competition/ Exclusion** Before root infection can occur, pathogens must gain access to the zone closely associated with the root, known as the rhizosphere. For foliar diseases, the pathogen must make contact with the leaf or flower zone. The biofungicide grows a defensive barrier around this root, leaf or flower zone. The beneficial microbes compete with plant pathogens for nutrients, infection sites and space, excluding the pathogen.

**Antibiosis** The biofungicide produces chemical compounds or secondary metabolites such as antibiotics or other toxins that kill the target organism. The biofungicide create compounds that inhibit fungal or bacterial spores from germinating and causing plant disease, or the compounds restrict the pathogen’s growth.

**Predation or parasitism** The biofungicide attacks and feeds on the pathogen, producing cell wall degrading enzymes, inhibiting or killing the pathogen.

**Induce Resistance to the Host Plant** The biofungicide triggers the host plant to turn on its own defense mechanisms. Plants produce salicylic acid (a derivative of aspirin) which travels to other parts of the plant and signals these tissues to activate their natural defense mechanisms. This is known as systemic acquired resistance (SAR) which improves the plants response to pathogen attack by priming the metabolism of plant defense compounds.

**Plant Growth Promotion** The biofungicide promotes root and shoot growth in the absence of disease causing pathogens. There may be increased nutrient availability of iron and other micronutrients by changing the pH or enzymes help dissolve insoluble elements.

### **Some Common Beneficial Microorganisms that are Commercially Available**

Beneficial fungi such as *Trichoderma* have been isolated from soil, decaying wood and plant organic matter. Different species are commercially available including *T. harzianum*, *T. virens*, *T. asperellum* and *T. gamsii*. Dormant spores of *Trichoderma* are applied, the spores germinate and the fungal mycelia coils around plant roots blocking the pathogen, which results in a barrier to infection. The fungus also attacks the pathogen by secreting enzymes that attack the pathogen's cell wall. There is also enhanced plant and root growth so the fungus has more roots to colonize. The combination of *T. harzianum* and *T. virens* suppresses of *Pythium aphanidermatum* and has more benefit against *Phytophthora* than *T. harzianum* alone.

*Gliocladium catenulatum* is a fungus isolated from Finnish field soil. It colonizes the leaf and root surface. *Gliocladium* works by hyperparasitism and competition for nutrients and space.

### **Bacteria**

*Bacillus subtilis* is a naturally occurring saprophytic bacterium. There are different strains commercially available. *Bacillus subtilis* works in a number of ways producing antibiotics, displacing the pathogen by inhibiting spore germination and interfering with the attachment of the pathogen to the plant. It improves plant immunity and signals these tissues to activate their natural defense mechanisms inducing systemic acquired resistance (SAR) against bacterial pathogens.

When combating bacterial diseases, growers can alternate *Bacillus* with copper fungicides to help reduce the potential for plant damage or phytotoxicity that

may occur from repeated sprays of some copper products under certain conditions. *Bacillus* can also be used against fungal leaf spots. *Bacillus amyloliquefaciens* colonizes the plant rhizosphere, stimulating plant growth and suppressing competing fungal and bacterial pathogens.

*Streptomyces* is a filamentous bacterium found in soil and decaying vegetation that produces spores and antibiotics. Streptomycin takes its name directly from *Streptomyces*. *Streptomyces griseoviridis* K 61 was originally isolated from sphagnum peat and *S. lydicus* strain WYEC 108 is a naturally occurring bacterium found in the soil.

### **Benefits of Biological Fungicides**

- Reduced risks to applicators and the environment
- Shorter re-entry intervals and days to harvest intervals than many conventional fungicides
- Many are labeled for use on edible crops including herbs and vegetables
- Most (but not all) are OMRI approved for organic production. Check company labels or websites or see the OMRI website at [www.omri.org](http://www.omri.org)
- Less chance of plant damage, but not always, so consult product labels
- Generally compatible with beneficial predators and parasites (natural enemies), beneficial nematodes (check company websites for more information)
- Improved nutrient uptake of certain elements
- Can be used in rotation with conventional chemicals to reduce the risk of pathogens developing resistance to conventional fungicides (especially systemic fungicides)
- Not genetically modified

### **Limitations of Biological Fungicides**

- Must be used preventively, for they will not cure diseased plants
- Must be used with proper cultural controls for plant growth, including clean starter material
- Must use strict sanitation protocols
- Have a shorter shelf life (consult labels) than conventional fungicides and need to be stored under proper conditions
- May need to be re-applied more often than conventional fungicides
- May need to integrate traditional fungicides in rotation for more aggressive pathogens such as *Thielaviopsis* and *Phytophthora* or stem rots such as *Rhizoctonia* or *Phytophthora*

## How to Apply Biofungicides

You must start with clean greenhouse and clean starter material. Biological fungicides **MUST** be used as a preventive treatment in the growing media or as a foliar application. For foliar diseases, it may be helpful to combine their use with the selection of disease resistant cultivars for disease suppression.

Apply immediately after mixing with water. Check company websites for compatibility information with other materials. Because biofungicides are living organisms, they have a limited shelf life and need to be stored under proper conditions. Do not stock pile biofungicides and be aware of the expiration date on the package.

In University studies, researchers sometimes see an uneven effect when applying biological fungicides; however, these studies are conducted with higher disease pressures than in commercial greenhouses. In order to complete your own in-house trials, leave a number of plants untreated to serve as your control treatment. Differences in your crop, potting mix, media pH, fertilizer use and disease pressure may influence how well these different products work for you. Use in alternation with conventional fungicides.

Biological fungicides are a useful tool for growers if they are used preventively, in combination with proper sanitation and good cultural practices. In the future, more combination products may become available.

### Some Selected Biological Fungicides Used in Greenhouse Production

*If any information is inconsistent with the label, then follow the label.*

<b>Trade Name/ Re-Entry Interval (REI)/ Organic Product/ Manufacturer</b>	<b>Organism</b>	<b>Targets</b>	<b>Crops</b>	<b>Shelf Life</b>
Actinovate SP 1 hr. REI OMRI- certified Product  Novozymes BioAg	<i>Streptomyces lydicus</i> strain WYEC 108	Soil Drench: <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Phytophthora</i> Foliar: Powdery Mildew, Botrytis Blight & others	Greenhouse ornamentals, vegetables and herbs	1 year

Asperello T34 BioControl 4 hr. REI OMRI- certified product  Biobest USA Inc.	<i>Trichoderma asperellum</i> strain T34	Suppression of root diseases caused by <i>Fusarium</i> , <i>Rhizoctonia</i> , <i>Pythium</i> and <i>Phytophthora</i>	Greenhouse ornamentals	2 years (at 40°F )
BioTam 2.0 4 hr. REI OMRI- certified product  Isagro USA	<i>Trichoderma asperellum</i> (ICC 012) plus <i>Trichoderma gamsii</i> (ICC 080)	<i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Thielaviopsis</i> , <i>Sclerotinia</i>	Greenhouse ornamentals, vegetables and herbs	15 months (below 75 °F, well ventilated, dry)
BotryStop 4 hr. REI OMRI- certified product  Bioworks, Inc.	<i>Ulocladium oudemansii</i> (U3 Strain)	<i>Botrytis cinerea</i> , <i>Sclerotinia sclerotiorum</i>	Greenhouse ornamentals, vegetables	1 year (Refrigerated) Do not freeze.
Cease 4 hr. REI OMRI- certified product  Bioworks, Inc.	<i>Bacillus subtilis</i> strain QST 713	Soil Drench: <i>Rhizoctonia</i> , <i>Pythium</i> , <i>Fusarium</i> , <i>Phytophthora</i> Foliar spray: Anthracnose, Bacterial leaf spots, Botrytis Blight, Downy Mildew, Fungal Leaf Spots, Powdery Mildew, Rust (depends upon crop, see label)	Greenhouse ornamentals, vegetables, and herbs	3 years (70-75° F)
Companion Liquid Biological Fungicide	<i>Bacillus subtilis</i> strain GBO3	<i>Alternaria</i> , <i>Botrytis</i> , Powdery mildew, <i>Fusarium</i> ,	Greenhouse ornamentals, vegetables, and herbs	2 years

Nursery & Ornamental Crops 4 hr. REI  Growth Products		<i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Xanthomonas</i>		
Double Nickel 4 hr. REI OMRI-certified Product  Certis USA	<i>Bacillus amyloqueliciens</i> strain D747	Damping off ( <i>Rhizoctonia</i> , <i>Pythium</i> , <i>Fusarium</i> ), Anthracnose, Bacterial & Fungal leaf spots, Botrytis Blight, Downy Mildew, Powdery Mildew, Sclerotinia blight, Rust	Greenhouse ornamentals, vegetables and herbs	2 years
Mycostop 4 hr. REI OMRI-certified product  Ag Bio, Inc.	<i>Streptomyces griseoviridis</i> strain K61	Botrytis blight (suppression), Damping Off: <i>Alternaria</i> , <i>Rhizoctonia</i> (suppression) Root rot diseases: <i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i>	Greenhouse ornamentals, vegetables, and herbs	1 year
Obtego 4 hr. REI OMRI-certified product  SePro	<i>Trichoderma asperellum</i> (ICC 012) and <i>Trichoderma gamsii</i> (ICC 080)	<i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Sclerotinia</i> , <i>Thielaviopsis basicola</i>	Greenhouse ornamentals, vegetables and herbs	15 months
PreFence BioFungicide 4 hr. REI OMRI-	<i>Streptomyces sp.</i> strain K61	<i>Fusarium</i> , <i>Alternaria</i> , <i>Phomopsis</i> , Suppression of	Greenhouse ornamentals, vegetables, herbs	6 months (Refrigerated)

certified product  Bioworks, Inc.		Botrytis and root rots ( <i>Pythium</i> , <i>Phytophthora</i> , <i>Rhizoctonia</i> ) Depending upon crop, see label		
Prestop WP 0 hr. REI OMRI-certified product  Ag Bio, Inc.	<i>Gliocladium catenulatum</i> strain J1446	Botrytis blight, Damping off and root diseases caused by <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Phytophthora</i>	Greenhouse ornamentals, vegetables, and herbs	1 year
PVent 4 hr. REI OMRI-certified product  BioSafe Systems	<i>Gliocladium catenulatum</i> strain J1446	Alternaria, <i>Botrytis</i> , <i>Colletotrichum</i> , <i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Sclerotinia</i> , Powdery mildew (suppression)	Greenhouse ornamentals, vegetables, and herbs	1 year (41° F)
Regalia GC 4 hr. REI OMRI-certified product  Marrone Bio Innovations	Extract of <i>Reynoutria sachalinensis</i>	Anthracnose, Bacterial Leaf Spots, Botrytis Blight, Early Blight, Downy Mildew, Fungal Leaf Spots, Late Blight, Powdery Mildew	Greenhouse ornamentals, vegetables and herbs	Three years
RootShield WP O hr. REI OMRI-certified product  Bioworks, Inc.	<i>Trichoderma harizanum</i> Rifai strain KRL-AG2	Root diseases: <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Cylindrocladium</i> , <i>Thielaviopsis</i>	Greenhouse ornamentals, vegetables, and herbs. No overhead spray for food crops.	6 months (Refrigerated)

RootShield Granules 0 hr. REI OMRI-certified product Bioworks, Inc.	<i>Trichoderma harzianum</i> Rifai strain T-22	<i>Pythium</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Cylindrocladium</i> , <i>Thielaviopsis</i>	Greenhouse ornamentals, some vegetables, herbs (incorporation into planting mix)	9 months (Refrigerated)
RootShield Plus WP 4 hr. REI OMRI-certified product Bioworks, Inc.	<i>Trichoderma harzianum</i> Rifai strain T-22 and <i>Trichoderma virens</i> strain G-41	Root diseases: <i>Pythium</i> , <i>Phytophthora</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Cylindrocladium</i> , <i>Thielaviopsis</i>	Greenhouse ornamentals, vegetables, herbs. No overhead spray for food crops.	10 months Refrigerated
RootShield Plus Granules 0 hr. REI OMRI-Certified product Bioworks, Inc.	<i>Trichoderma harzianum</i> Rifai strain T-22 and <i>Trichoderma virens</i> strain G-41	Root diseases: <i>Pythium</i> , <i>Phytophthora</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Cylindrocladium</i> , <i>Thielaviopsis</i>	Greenhouse ornamentals, vegetables, herbs.	1 year Refrigerated
Stargus 4 hr. REI OMRI-certified product Marrone Bio Innovations	<i>Bacillus amyloliquefaciens</i> strain F727	Foliar: Downy Mildews, Botrytis Blight, Late Blight Soil Drench: <i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i>	Greenhouse ornamentals, vegetables, herbs	2 years
Subtilix NG 4 hr. REI BASF	<i>Bacillus subtilis</i> Strain MB1 600	<i>Fusarium</i> , <i>Rhizoctonia</i> , <i>Pythium</i> , Powdery Mildew, Botrytis Blight (depending upon crop, see label)	Greenhouse ornamentals, vegetables (Cucurbit and Fruiting)	2 years
Triathlon BA 4 hr. REI	<i>Bacillus amyloliquefaciens</i>	Damping off Disease	Greenhouse ornamentals,	One year

OMRI-certified product  OHP, Inc.	Strain D747	( <i>Alternaria</i> , <i>Pythium</i> , <i>Phytophthora</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> ), Anthracnose, Bacterial & Fungal Leaf Spots, Downy Mildew, Powdery Mildews, Botrytis blight, Rust	vegetables, herbs	
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*This information is supplied with the understanding that no discrimination is intended and no endorsement implied. Due to constantly changing regulations, we assume no liability for suggestions. If any information in these tables is inconsistent with the label, follow the label. Always follow label instructions regarding registered uses and note cautions. To avoid any phytotoxicity problems, spot test first before widespread use.*

Biological fungicides are regulated by the EPA and have an EPA registration number, whereas microbial inoculants do not. Some of the active ingredients in biological fungicides may also be sold as microbial inoculants.

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Bioworks Product Shelf Life

<https://www.bioworksinc.com/products/shared/product-shelf-life.pdf>

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