



Biological Fungicides

What are biological fungicides?

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

Biological fungicides are living organisms that are best used **preventively** before disease occurs and not as a rescue treatment for already diseased plants. They should always be combined with proper sanitation and other cultural practices that promote 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, particularly single-site fungicides 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) or induced systemic resistance (ISR)

improving 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 plant pathogens. There may be increased nutrient availability of iron and other micronutrients by changing the pH or enzymes that help break down insoluble nutrient 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 (Mycelium is the vegetative part of a fungus or fungus-like bacterial colony, consisting of a mass of branching, thread-like hyphae) 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.

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 amylolquefaciens* 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 sp. 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 vegetable bedding plants.
- Most (but not all) are OMRI approved for organic production. Check company labels or websites or see the OMRI website at www.omri.org
- Less chance of plant damage, but not always, so consult product labels and company websites.
- Generally compatible with beneficial predators and parasites (natural enemies), beneficial nematodes (check company websites for more information).
- Improved uptake of certain nutrients.
- Can be used in rotation with conventional chemicals to reduce the risk of pathogens developing resistance to conventional fungicides (especially single-site systemic fungicides).

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 plant material and growing conditions.
- Must use strict sanitation protocols.
- Have a shorter shelf life (consult labels) than conventional fungicides and need to be stored under proper conditions to avoid mortality.
- May need to be re-applied more often than conventional fungicides.

How to Apply Biofungicides

You must start with clean greenhouse and clean plant material. Biological fungicides **MUST** be used as a preventive treatment. 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 other cultural practices.

Some Selected Biological Fungicides Used in Greenhouse Production

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

Trade Name/ Re-Entry Interval (REI)/ Organic Product/ Manufacturer	Organism	Targets	Crops	Shelf Life
Actinovate SP 4 hr. REI OMRI-certified Product Valent/Nufarm	<i>Streptomyces lydicus</i> WYEC 108	Soil Drench: <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Phytophthora</i> Foliar: Powdery Mildew, Botrytis Blight, Xanthomonas	Greenhouse ornamentals	1 year
Asperello T34 BioControl 4 hr. REI OMRI-certified product Biobest USA	<i>Trichoderma asperellum</i> T34	Suppression of root rot diseases (<i>Fusarium</i> , <i>Rhizoctonia</i> , <i>Pythium</i> and <i>Phytophthora</i>)	Greenhouse ornamentals	2 years (at 40°F)
BotryStop 4 hr. REI OMRI-certified product Bioworks	<i>Ulocladium oudemansii</i> U3	<i>Botrytis cinerea</i> , <i>Sclerotinia sclerotiorum</i>	Greenhouse ornamentals, vegetables	1 year (Refrigerated) Do not freeze.
Cease 4 hr. REI OMRI-certified product	<i>Bacillus subtilis</i> QST 713	Soil Drench: <i>Rhizoctonia</i> , <i>Pythium</i> , <i>Fusarium</i> , <i>Phytophthora</i>	Greenhouse ornamentals, vegetables, herbs	3 years (70- 75° F)

Bioworks		Foliar spray: Anthracnose, Bacterial leaf spots, Botrytis Blight, Downy Mildew, Fungal Leaf Spots, Powdery Mildew, Rust		
Companion Biological Fungicide Wettable Powder 4 hr. REI Douglas Plant Health	<i>Bacillus amyloliquefaciens</i> ENV503	Alternaria, Botrytis, Powdery mildew, <i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Xanthomonas</i>	Greenhouse ornamentals, vegetables, and herbs	2 years
Double Nickel 55 4 hr. REI OMRI-certified Product Certis USA	<i>Bacillus amyloliquefaciens</i> D747	Damping off (<i>Rhizoctonia</i> , <i>Pythium</i> , <i>Phytophthora</i> , <i>Fusarium</i>), Anthracnose, Bacterial & Fungal leaf spots, Botrytis Blight, Downy Mildew, Powdery Mildew, Rust Sclerotinia blight	Greenhouse ornamentals, vegetables and herbs	2 years
EcoSwing 4 hr. REI OMRI-certified product Gowan	<i>Swinglea glutinosa</i> extract	Alternaria Leaf spot, Basil Downy Mildew, Powdery Mildew	Greenhouse ornamentals, vegetables and herbs	3 years
LALSTOP G46 WG 4 hr. REI OMRI-certified product Lallemand Plant Care	<i>Gliocladium catenulatum</i> J1446	Botrytis blight, Root rots (<i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i>), Powdery Mildew	Greenhouse ornamentals, vegetables and herbs	1 year
Mycostop 4 hr. REI OMRI-certified	<i>Streptomyces</i> sp. K61	Suppression of Botrytis blight, Damping Off, and	Greenhouse ornamentals, vegetables,	1 year

product Lallemand Plant Care		root rot diseases (<i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i>)	and herbs. Do not treat dusty miller or melon seeds.	
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</i>	Greenhouse ornamentals, vegetables and herbs	15 months
Regalia GC 4 hr. REI OMRI-certified product Marrone Bio Innovations	<i>Reynoutria sachalinensis</i> extract	Anthracnose, Bacterial Leaf Spots, Botrytis Blight, Downy Mildew, Fungal Leaf Spots, Late Blight, Powdery Mildew	Greenhouse ornamentals, vegetables and herbs	3 years
RootShield WP 4 hr. REI OMRI-certified product Bioworks	<i>Trichoderma harizanum</i> Rifai T-22	Root rot 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 4 hr. REI OMRI-certified product Bioworks	<i>Trichoderma harzianum</i> Rifai T-22	Root rot diseases: <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Cylindrocladium</i> , <i>Thielaviopsis</i>	Greenhouse ornamentals, some vegetables, herbs	9 months (Refrigerated)
RootShield Plus WP 4 hr. REI OMRI-certified product Bioworks	<i>Trichoderma harzianum</i> Rifai T-22 and <i>Trichoderma virens</i> G-41	Root rot 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 4 hr. REI	<i>Trichoderma harzianum</i> Rifai T-22 and	Root rot diseases: <i>Pythium</i> , <i>Phytophthora</i> ,	Greenhouse ornamentals, vegetables,	1 year Refrigerated

OMRI-Certified product Bioworks	<i>Trichoderma virens</i> G-41	<i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Cylindrocladium</i> , <i>Thielaviopsis</i>	herbs.	
Soilgard 4 hr. REI OMRI-certified product Certis USA	<i>Gliocladium virens</i> GL-21	Root and crown rots (<i>Pythium</i> , <i>Rhizoctonia</i> , <i>Sclerotinia</i> , <i>Phytophthora</i> , <i>Sclerotium</i> and <i>Fusarium</i>)	Greenhouse ornamentals and vegetables	1 year (If opened will keep 3 months if refrigerated (40°F to 45°F))
Stargus 4 hr. REI OMRI-certified product Marrone Bio Innovations	<i>Bacillus amyloliquefaciens</i> 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> MB1 600	<i>Fusarium</i> , <i>Rhizoctonia</i> , <i>Pythium</i> , Powdery Mildew, Botrytis Blight	Greenhouse ornamentals, vegetables	2 years
Triathlon BA 4 hr. REI OMRI-certified product OHP	<i>Bacillus amyloliquefaciens</i> D747	Damping off (<i>Pythium</i> , <i>Phytophthora</i> , <i>Rhizoctonia</i> , <i>Fusarium</i>), Bacterial & Fungal Leaf Spots, Downy Mildew, Powdery Mildews, Botrytis blight, Rust	Greenhouse ornamentals, vegetables, herbs	1 year
Zio 4 hr. REI OMRI-certified product SePro	<i>Pseudomonas chloroaphis</i> AFS009	Root and stem rots (<i>Pythium</i> , <i>Phytophthora</i> , <i>Rhizoctonia</i>), Botrytis blight (suppression)	Greenhouse ornamentals, vegetables, and herbs	18 months

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. Not all diseases are labeled for all crops. 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.

By Pundt, L. Extension Educator, UConn Extension. 2015. Updated Sept 2020

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

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