Biological Fungicides

What are biological fungicides?
Biological fungicides ("biofungicides") are composed of beneficial microorganisms including specialized fungi, bacteria and actinobacteria (filamentous bacteria). These microorganisms are often found naturally occurring in soils and are used to suppress 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 rescue treatments for already diseased plants. They should always be combined with proper sanitation and other cultural practices that promote plant health.

How do biological fungicides work?
Biofungicides work (their mode of action) in several 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 accesses to the zone closely associated with the root, known as the rhizosphere. For foliar diseases, the pathogen must contact 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 enzymes that degrade cell walls, 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 nutrients.

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 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 catenulaturm 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 that induces systemic resistance. It forms a protective endospore that can survive extreme environmental conditions. There are different strains commercially available*. Bacillus subtilis* works in several 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. *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* 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 Organic Materials Review Institute (OMRI) approved for organic production.
- There may be less chance of plant damage, but not always, so consult product labels and company websites for plant safety precautions.
- 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 greenhouses 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 stockpile biofungicides and be aware of the expiration date on their package. Most need to be stored under cool, dry conditions.

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. To complete your own in-house trials, leave several 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.

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 1 hr. REI OMRI-certified Product FRAC BM 02 Mycorrhizal applications	*Streptomyces lydicus* WYEC 108	Soil Drench: *Pythium, Rhizoctonia, Fusarium, Phytophthora* Foliar: Powdery Mildew, Botrytis Blight, downy mildew, Sclerotina, Alternaria	Greenhouse ornamentals	1 year
Botrystop WP 4 hr. REI OMRI-certified product BioWorks	*Ulocladium oudemansii U3*	*Botrytis cinerea, Sclerotinia sclerotiorum*	Greenhouse ornamentals, vegetables & fruits	1 year (Refrigerated) Do not freeze.
CEASE 4 hr. REI OMRI-certified product FRAC BM 02 BioWorks	*Bacillus subtilis* QST 713	Soil Drench: *Rhizoctonia, Pythium, Fusarium, Phytophthora* Foliar spray: Anthracnose, Bacterial leaf spots, Botrytis Blight, Downy Mildew, Fungal Leaf Spots, Powdery Mildew, Rust, and others (see label for specifics)	Greenhouse ornamentals, vegetables, herbs, fruits	3 years (70-75° F)
Companion Biological Fungicide Wettable Powder 4 hr. REI OMRI-certified product FRAC BM 02 Douglas Plant	*Bacillus amyloliquefaciens* ENV503	Alternaria, Botrytis, Powdery mildew, *Fusarium, Phytophthora, Pythium, Rhizoctonia, Xanthomonas*	Greenhouse ornamentals, vegetables, and herbs	2 years

Health				
Eco Swing 4 hr. REI OMRI-certified product FRAC BM 01 Gowan	*Swinglea glutinosa* extract	Alternaria Leaf spot, Basil Downy Mildew, Powdery Mildew	Greenhouse ornamentals, vegetables, herbs, fruits	3 years
Howler 4 hr. REI OMRI- certified product FRAC BM 02 AgBiome	*Pseudomonas chlororaphis AFS009*	Foliar diseases: Alternaria Leaf Spot, Anthracnose, Downy mildews, Botrytis, Powdery Mildews Root rots: *Fusarium, Phytophthora, Pythium, Rhizoctonia*	Greenhouse Ornamentals	
LALSTOP G46 WG 4 hr. REI OMRI-certified product FRAC BM 02 Lallemand Plant Care	*Clonostachys rosen J1446 (formerly Gliocladium catenulatum J1446)*	Botrytis, Fusarium, *Phytophthora, Pythium, Rhizoctonia*, Powdery Mildew, leaf spots & blights	Greenhouse ornamentals, vegetables, herbs, fruits	1 year
LALSTOP K61 WP 4 hr. REI OMRI-certified product FRAC BM 02 Lallemand Plant Care	*Streptomyces* K61	Supression of Botrytis blight, Damping off, root rot diseases (*Fusarium, Phytophthora, Pythium, Rhizoctonia)*	Greenhouse ornamentals, vegetables, and herbs	1 year
Obtego 4 hr. REI OMRI-certified product FRAC BM 02 SePro	*Trichoderma asperellum ICC 012* and *Trichoderma gamsii ICC 080*	*Fusarium, Phytophthora, Pythium, Rhizoctonia, Sclerotinia, Thielaviopsis* and others	Greenhouse ornamentals, vegetables, herbs, fruits	15 months
Regalia GC 4 hr. REI OMRI-certified product	*Reynoutria sachalinensis extract*	Anthracnose, Bacterial Leaf Spots, Botrytis Blight, Downy Mildew,	Greenhouse ornamentals, vegetables herbs, fruits	3 years

FRAC P05 ProFarm		Fungal Leaf Spots, Late Blight, Powdery Mildew		
RootShield Granules 4 hr. REI OMRI-certified product FRAC BM 02 BioWorks	*Trichoderma harzianum* Rifai T-22	Root rot diseases: *Pythium, Rhizoctonia, Fusarium, Cylindrocladium, Thielaviopsis*	Greenhouse ornamentals, some vegetables, herbs, fruits	10 months (Refrigerated)
RootShield WP 4 hr. REI OMRI-certified product FRAC BM 02 BioWorks	*Trichoderma harizanum* Rifai T-22	Root rot diseases: *Pythium, Rhizoctonia, Fusarium, Cylindrocladium, Thielaviopsis*	Greenhouse ornamentals, vegetables, herbs, fruits	10 months (Refrigerated)
RootShield Plus Granules 4 hr. REI OMRI-Certified product FRAC BM 02 BioWorks	*Trichoderma harzianum* Rifai T-22 and *Trichoderma virens* G-41	Root rot diseases: *Pythium, Phytophthora, Rhizoctonia, Fusarium, Cylindrocladium, Thielaviopsis*	Greenhouse ornamentals, vegetables, herbs	10 months Refrigerated
RootShield Plus WP 4 hr. REI OMRI-certified product FRAC BM 02 BioWorks	*Trichoderma harzianum* Rifai T-22 and *Trichoderma virens* G-41	Root rot diseases: *Pythium, Phytophthora, Rhizoctonia, Fusarium, Cylindrocladium, Thielaviopsis, Sclerotina*	Greenhouse ornamentals, vegetables, herbs, fruits	10 months Refrigerated
Soil Gard 4 hr. REI OMRI-certified product Certis USA	*Gliocladium virens* GL-21	Root and crown rots (*Pythium, Rhizoctonia, Sclerotina, Phytophthora, Sclerotium* and *Fusarium*)	Greenhouse ornamentals and vegetables	1 year (If opened will keep 3 months if refrigerated (40°F to 45°F))
Triathlon BA 4 hr. REI OMRI-certified product FRAC BM 02 OHP	*Bacillus amyloliquefaciens* D747	Damping off (*Pythium, Phytophthora, Rhizoctonia, Fusarium*), Bacterial & Fungal	Greenhouse ornamentals, vegetables, herbs, fruits	1 year

		Leaf Spots, Downy Mildew, Powdery Mildews, Botrytis blight, Rust (depending upon crop, see label)		

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. UConn Extension. 2015. Latest revision 2023

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Bioworks Product Shelf Life

https://bioworksinc.com/wp-content/uploads/products/shared/product-shelf-life.pdf
(accessed July 2023)