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Biopesticide Controls of Plant Diseases: Resources and Products for Organic Farmers in Ohio

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Different agricultural practices, such as the use of crop rotation, cover crops, disease resistant varieties, and good seed bed preparation have been applied to control pests and diseases. However, such practices are not always sufficient protection from crop losses. Because of this, many certified organic growers turn to biopesticides to insure and/or enhance their abilities to grow and market high-quality produce. Approved organic products for plant disease control include many EPA-registered biopesticides. Such products have been developed to control numerous plant diseases and to provide useful tools for growers to decrease the incidence and/or severity of plant diseases.

Biopesticides that can be used by organic growers can be classified as either microbial or biochemical, based on the active ingredient. Microbial pesticides include live organisms (e.g., beneficial bacteria, fungi, nematodes, and viruses) and/or their fermentation products as the active ingredient. Biochemical pesticides include plant extracts, pheromones, plant hormones, natural plant-derived regulators, clay, potassium bicarbonate, and enzymes as the active ingredient. In this fact sheet, only commercially available microbial and biochemical biopesticides are discussed.

Biopesticides are used primarily as preventative measures, so they may not perform as quickly as some synthetic chemical pesticides. However, biopesticides are generally less toxic to the user and are non-target organisms, making them desirable and sustainable tools for disease management. While their use is not overly complicated, the application of some biopesticides may require a high level of understanding and knowledge of the diseases and pathogens that they are designed to control. As with any disease management program, proper timing and application are essential to ensuring efficacy.

To help organic farmers choose an appropriate biopesticide for different plant diseases, we have provided a synthesis of numerous independent field tests for commercially available microbial biopesticides (Table 1) and biochemical biopesticides (Table 2). Both lists include only products certified for use in organic agriculture by the Organic Materials Review Institute (OMRI). The lists contain the trade name, target disease, crop, and efficacy evaluation results of each product as published in the Plant Disease Management Reports and Biological Control Tests Database between 2000 and 2009. An efficacy rating based on these reports was established based on the comparison between untreated and biopesticide-

treated plants in one or more reports. The ratings are categorized as follows: “+” indicates that control of disease or increase in yields was observed, “±” indicates that in some cases there was some positive

responses while in other cases there was no response, “o” indicates that neither positive nor negative effect was observed by the use of the product, and “*” indicates that no data are available.

Table 1. Microbial Biopesticides for the Control of Plant Pathogens

Disclaimer: The Ohio State University does not guarantee the efficacy or quality of any of these products. By law, it is the pesticide applicator’s responsibility to read and follow all current label directions for the specific pesticide being used.				
Biocontrol Organism	Trade Name	Target Disease	Target Crops	Efficacy ^{1,2}
Bacteriophages of <i>Xanthomonas</i> spp. and <i>Pseudomonas syringae</i> pv. tomato	AgriPhage™	Bacterial spot in pepper and tomatoes and bacterial speck in tomatoes	Tomatoes and pepper	Bell pepper/bacterial spot: +
<i>Pseudomonas syringae</i> strain ESC 10	Bio-Save® 10LP ³	Post-harvest frost damage and biological decay	Apples, pears, lemons, oranges, or grapefruit after the fruit is harvested	Sweet potato/ <i>Rhizopus</i> soft rot: +
<i>Pantoea agglomerans</i> strain E325	Bloomtime Biological™ ³	Fireblight (<i>Erwinia amylovora</i>)	Apples and pears	Apple/fire blight: ±
	Bloomtime Biological™ FD ³	Fireblight (<i>Erwinia amylovora</i>)	Apples and pears	Apple/fire blight: ±
<i>Streptomyces lydicus</i> WYEC 108	Actinovate® SP	Soilborne pathogens: <i>Pythium</i> spp., <i>Rhizoctonia</i> spp., <i>Phytophthora</i> spp., <i>Fusarium</i> spp., <i>Verticillium</i> spp., <i>Phymatotrichum omnivorum</i> , and other root decay fungi Foliar pathogens: <i>Podosphaera</i> spp., <i>Botrytis</i> spp., <i>Schlerotinia</i> spp., <i>Monilinia</i> spp., <i>Alternaria</i> spp., <i>Peronospora</i> spp., and other foliar fungi	Greenhouse, nursery, and turf	Pumpkin/powdery mildew: + Pumpkin/ <i>Phytophthora</i> leaf blight: o Pepper/ <i>Phytophthora</i> foliar blight: +
<i>Bacillus pumilus</i> QST 2808	Ballad® Plus Biofungicide	Rust, powdery mildew, <i>cercospora</i> , and brown spot	Soybeans, cereal crops, and potatoes	Soybean/Asian soybean rust: ± Soybean/target spot: ± Snap bean/ashy stem blight: ± Snap bean/rust: +

Table 1. Microbial Biopesticides for the Control of Plant Pathogens (cont'd.)

<p><i>Coniothyrium minitans</i> strain CON/M/91-08</p>	<p>Contans® WG</p>	<p><i>Sclerotinia minor</i>, <i>Sclerotinia sclerotiorum</i></p>	<p>Agricultural soils</p>	<p>Snap beans/white mold: ± Snap beans/gray mold: 0 Lettuce/white mold: ± Lettuce/lettuce drop: +</p>
<p><i>Bacillus subtilis</i> GB03</p>	<p>Kodiak® Concentrate Biological Fungicide</p>	<p><i>Rhizoctonia</i>, <i>Fusarium</i>, <i>Alternaria</i>, <i>Aspergillus</i>, and others that attack the root systems of plants</p>	<p>Cotton, peanuts, soybeans, wheat, barley, peas, and beans</p>	<p>Snap beans/<i>Fusarium</i> root rot: ± Snap bean/<i>Rhizoctonia</i> root rot: 0 Pea/<i>Fusarium</i>, <i>Phoma</i> and <i>Pythium</i>: ± Wheat/<i>Fusarium</i> crown rot: 0 Cucumber/damping- off: 0</p>
<p><i>Trichoderma harzianum</i> Rifai strain KRL-AG2</p>	<p>PlantShield® HC Biological Foliar and Root Fungicide</p>	<p><i>Fusarium</i>, <i>Pythium</i>, and <i>Rhizoctonia</i></p>	<p>Cucurbit vegetables, flowers, bedding plants, ornamentals, fruiting and leafy vegetables, cole crops, hydroponic crops, pome fruits, shade house, outdoor nursery, stone fruit, and tree nuts</p>	<p>Dry beans/<i>Fusarium</i> root rot: ± Snap beans/ <i>Rhizoctonia</i> root rot: 0 Tomato/grey mold: 0 Potato/silver scurf: + Gladiolus/<i>Fusarium</i> root rot: 0 African daisy/powdery mildew: ± Geranium/black leg disease: 0</p>
	<p>RootShield® Granules</p>	<p><i>Fusarium</i>, <i>Pythium</i>, and <i>Rhizoctonia</i></p>	<p>Flowers, bedding plants, ornamentals, fruiting vegetables, herbs and spices, hydroponic crops, leafy vegetables, cole crops, pome fruits, stone fruits, and tree nuts</p>	<p>Myrtle/leaf milkwort: + Potato/<i>Rhizoctonia</i> canker and black scurf: 0 Gladiolus/<i>Fusarium</i> corn rot: 0 Tomato/bacterial speck: ±</p>

Table 1. Microbial Biopesticides for the Control of Plant Pathogens (cont'd.)

<p><i>Bacillus subtilis</i> QST 708</p>	<p>Rhapsody®</p>	<p>Fungal and bacterial diseases, brown patch, anthracnose, and dollar spot</p>	<p>Turf, ornamentals, trees, shrubs, flowers, bedding plants, tropical plants, seedlings, conifers, fruity and leafy vegetables, and bulbs</p>	<p>Creeping bent grass/dollar spot, abiotic stress, brown patch and anthracnose: o Annual bluegrass (60%) and creeping bentgrass (40%)/anthracnose: + Tall fescue/<i>Pythium</i> blight and gray leaf spot: o Geranium/<i>Botrytis</i> blight: + Dogwood/powdery mildew: + Dogwood/<i>Cercospora</i> leaf spot and spot anthracnose: o</p>
<p><i>Bacillus subtilis</i> strain QST 713</p>	<p>Serenade® Garden Disease Control Concentrate</p>	<p>Bacterial spot, powdery mildew, rust, gray mold, leaf blight, scab, and more</p>	<p>Fruits, vegetables, and flowers</p>	<p>*</p>
	<p>Serenade® Garden Disease Control Ready to Use</p>	<p>Bacterial spot, powdery mildew, rust, gray mold, leaf blight, scab, and more</p>	<p>Vegetable, fruit, nuts, ornamentals plants, annual and perennial flowering plants, tropical foliage, trees, and shrubs</p>	<p>*</p>
	<p>Serenade® MAX™</p>	<p>Fire blight, <i>Botrytis</i>, Sour rot, rust, <i>Sclerotinia</i>, powdery mildew, bacterial spot</p>	<p>Vegetables, fruit, nut, and vine crops</p>	<p>Blueberry/anthracnose fruit rot: + Blueberry/mummy berry: ± Cranberry/fruit rot: o Apple/fire blight: o Apple/flyspeck: o Apple/sooty blotch: o Apple/black pox: o Apple/brooks fruit spot: o</p>

Table 1. Microbial Biopesticides for the Control of Plant Pathogens (cont'd.)

<i>Bacillus subtilis</i> strain QST 713 (cont'd.)	Serenade® Wettable Powder Biofungicide	Fire blight, <i>Botrytis</i> , sour rot, rust, <i>Sclerotinia</i> , powdery mildew, bacterial spot	Vegetables, fruit, nut, and vine crops	Apple/fire blight: o Red raspberry/fruit rot: o Grape/bunch rot and powdery mildew: + Turnip greens/bacterial leaf spot: o Hydrangea/powdery mildew: + Pansy/ <i>Cercospora</i> leaf spot: + Pumpkin, cantaloupe, and honeydew/powdery mildew: + Lettuce/lettuce drop: ± Lettuce/powdery mildew: + Broccoli/downy mildew: +
	Serenade® ASO	Fungi and bacteria that cause scab, powdery mildew, sour rot, downy mildew, and early leaf spot, early blight, late blight, bacterial spot, and walnut blight diseases	Food crops including cherries, cucurbits, grapes, leafy vegetables, peppers, potatoes, tomatoes, and walnuts	Cranberry/cotton ball: ± Spinach/ <i>Stemphylium</i> leaf spot: o Snap bean/ <i>Rhizoctonia</i> root rot: o Radish/hypocotyl root rot and clubroot: ±
<i>Trichoderma virens</i> (formerly <i>Gliocladium virens</i>)	SoilGard 12G ³	<i>Pythium</i> , <i>Rhizoctonia</i> , and root rots	Ornamental and food crop plants grown in greenhouses, nurseries, interiorscapes, and outdoors	Geranium/root rot: o Gladiolus/ <i>Fusarium</i> corn rot: o Poinsettia/ <i>Pythium</i> root rot: + Azalea/ <i>Phytophthora</i> root rot: o Potato/black scurf: + Potato/ <i>Rhizoctonia</i> and <i>Streptomyces</i> : o Snap beans/gray mold: ± Snap beans/white mold: o Cucumber/damping-off: o

Table 1. Microbial Biopesticides for the Control of Plant Pathogens (cont'd.)

<i>Bacillus pumilus</i> QST 2808	Sonata®	Fungal pests such as molds, mildews, blights, and rusts	Many food and non-food crops, including trees susceptible to sudden oak death syndrome. For use outdoors, including nurseries, landscapes, and rights-of-way, and for use in greenhouses	Lima beans/white mold: o Lettuce/powdery mildew: + Lettuce/lettuce drop: ± Broccoli/downy mildew: + Pumpkin/powdery mildew: o Radish/downy mildew: + Radish/clubroot and <i>Rhizoctonia</i> hypocotyl root rot: o
<i>Trichoderma harzianum</i> <i>Rifai</i> strain KRL-AG2	T-22™ HC	<i>Fusarium</i> , <i>Pythium</i> , and <i>Rhizoctonia</i>	Agronomic field and row crops, alfalfa, hay and forage crops, bulb crops, cucurbits, fruiting vegetables, herbs, spices, leafy vegetables, cole crops, legumes, root crops, small grains, and tuber crops	Soybean/ <i>Rhizoctonia solani</i> and drought: o
	T-22™ Planter Box	<i>Fusarium</i> , <i>Pythium</i> , and <i>Rhizoctonia</i>	Agronomic field and row crops, alfalfa, hay and forage crops, bulb crops, cucurbits, fruiting vegetables, herbs, spices, leafy vegetables, cole crops, legumes, root crops, small grains, and tuber crops	Pea/root rot: ± Bean (baby lima)/root rot: o Pea/root rot: o
<i>Bacillus pumilus</i> GB34	Yield Shield® Concentrate Biological Fungicide	<i>Rhizoctonia</i> and <i>Fusarium</i>	Legumes	Soybean/root rot: o Soybean/ <i>Rhizoctonia</i> damping-off: o Snap beans/root rot: o
<p>1. The efficacy ratings are based on the results of studies published between 2000 and 2009 in the Plant Disease Management Reports (www.plantmanagementnetwork.org). These ratings are built on a comparison between untreated controls and the application of each product independently.</p> <p>2. + Evidence for disease control and/or yield increase, ± mixed results, o no obvious response to treatment, and * no data available in the selected PDM reports.</p> <p>3. These products are not currently registered for use in the state of Ohio.</p>				

Table 2. Biochemical Biopesticides for the Control of Plant Pathogens

Disclaimer: The Ohio State University does not guarantee the efficacy or quality of any of these products. By law, it is the pesticide applicator's responsibility to read and follow all current label directions for the specific pesticide being used.					
Trade Name	Ingredient	Manufacturer	Target Crop	Target Disease	Efficacy ^{1,2}
Garlic Barrier®	garlic oil	Garlic Research Labs, Inc.	Cucurbit crops, forage crops, fruiting vegetables, herbs, kiwi, leafy vegetables, legume vegetables, nut trees, ornamentals, peanuts, pome fruit trees, root and tuber vegetables, small fruits and berries, stone fruit trees, sugarcane, sunflowers, tropical fruits, turfgrass	Brown spot, insect infestation	Tomato/early blight: 0
Green Light® Neem Concentrate	Neem oil	Green Light Company	Vegetables, fruits, nuts, and spices	Powdery mildew, rust, anthracnose, leaf spot, and other diseases	Crapemyrtle/ <i>Cercospora</i> leaf spot: 0 Dogwood/powdery mildew: + Dogwood/spot anthracnose: 0 Dogwood/ <i>Cercospora</i> leaf spot: ±
Trilogy®	Neem oil	Certis USA	Citrus, tree fruits, cucurbits, bulb, cole and leafy vegetables, legume and fruiting vegetables, root and tuber vegetables, small fruits and berries, herbs and spices, cereal and grains, nuts, corn, alfalfa, cotton	<i>Alternaria</i> , anthracnose, leaf blight, <i>Botrytis</i> , greasy spot, leaf spot, post bloom fruit drop, powdery mildew, molds, scabs, rusts, shot hole	Tomato/early blight: 0 Bean, snap/white mold; gray mold: ± Grape/powdery mildew: 0 Pumpkin/Powdery mildew: ± Almond/brown rot: + Almond/scab: 0 Sweet cherry/ powdery mildew: ±

Triact® 70EC	Neem oil	Certis USA	Citrus, tree fruits, cucurbits, bulb, cole and leafy vegetables, legume and fruiting vegetables, root and tuber vegetables, small fruits and berries, herbs and spices, cereal and grains, nuts, corn, alfalfa, cotton	<i>Alternaria</i> , anthracnose, leaf blight, <i>Botrytis</i> , greasy spot, leaf spot, post bloom fruit drop, powdery mildew, molds, scabs, rusts, shot hole	Poinsettia/ powdery mildew: +
Actino Iron®	Iron	Natural Industries, Inc.	Food and fiber crops, ornamentals, landscape plants, tree seedlings for transplanting to the forest	Soil-borne plant root rot and damping-off disease	Snapdragon/root rot: +
ECO E-RASE®	Jojoba oil	IJO Products, LLC	Garden and commercial vegetables and crops	Powdery mildew and whitefly	Pumpkin/powdery mildew: ±
SeaCide®	Fish oil	Omega Protein, Inc.	Field crops, orchards, vineyards, and greenhouse	Black spot, powdery mildew, and greasy spot	Tomato/late blight, bacterial spot: 0 Tomato/bacterial spot; early blight: + Summer squash/ powdery mildew: ±
Heads Up® Plant Protectant	Extract of <i>Chenopodium quinoa saponins</i>	Heads Up Plant Protectants	Soybeans, potato, tomato, peas, beans, and wheat	Soil-borne plant root rot and damping-off disease	Peas/root rot: + Tomato/early blight: +
Promax™	Thyme oil	Bio Huma Netus, Inc.	Crops, ornamental plants, and turf	Fungal disease	Pumpkin/ <i>Phytophthora</i> blight: ± Squash/ <i>Phytophthora</i> blight: ±
Proud 3™	Thyme oil	Bio Huma Netus, Inc.	Crops, ornamental plants, and turf	Fungal disease	Turnip greens/ Bacterial leaf spot: 0 Pumpkin/ <i>Phytophthora</i> blight: ± Squash/ <i>Phytophthora</i> blight: ±

Organic JMS Stylet-Oil®	Paraffinic oil	JMS Flower Farms, Inc.	Grape, tree fruit, grass seed, and vegetable crops	Powdery mildew and <i>Botrytis</i> bunch rot	Pumpkin/powdery mildew: + Tomato/powdery mildew: o Bacterial speck <i>Septoria</i> leaf spot: o Strawberry/leaf spot: o Phomopsis/leaf blight: o Black currant/white pine blister rust: +
PureSpray™ Green	Petroleum oil	Petro-Canada	Apples and pears, almonds, apricots, cherries, nectarines, peaches, pistachio, plums, prunes, avocados, citrus, grapes, olives, tropical fruit, ornamental fruits, and vegetable crops	Powdery mildew	Grape/powdery mildew: o
Saf-T-Side®	Petroleum oil	Brandt Consolidated	Apples and pears, almonds, apricots, cherries, nectarines, peaches, pistachio, plums, prunes, avocados, citrus, grapes, olives, tropical fruits, ornamental fruits, and vegetable crops	Powdery mildew, black spot, and rust	Cucumber/downy mildew: o Apple/powdery mildew: + Almond/brown rot: + Almond/scab: +

1. The efficacy ratings are based on the results of studies published between 2000 and 2009 in the Plant Disease Management Reports (www.plantmanagementnetwork.org). These ratings are built on a comparison between untreated controls and the application of each product independently.

2. + Evidence for disease control and/or yield increase, ± mixed results, o no obvious response to treatment, and * no data available in the selected PDM reports.

3. These products are not currently registered for use in the state of Ohio.

Additional Resources

American Phytopathology Society (APSnet). APS is a global community of researchers that provides valuable information about plant health (www.apsnet.org).

IR-4 Project. This federally-funded effort supports biopesticide development and registration efforts. The IR-4 Project has developed a database for biopesticide labels and products in the United States (<http://ir4.rutgers.edu/biopesticides.html>).

Ohio Department of Agriculture (ODA). ODA is the state agency that provides regulatory protection to producers, agribusinesses, and the consuming public in Ohio (www.ohioagriculture.gov).

Organic Food and Farming Education and Research Program (OFFER). OFFER is a group of researchers from The Ohio State University that offers research and education for organic production, processing, and marketing (<http://oardc.osu.edu/offer>).

Organic Review Materials Institute (OMRI). OMRI is an institution that evaluates and certifies products for use in certified organic productions, handling, and processing (www.omri.org).

United States Department of Agriculture (USDA)/ National Organic Program and Economic Research Service. The USDA works to set organic farming production standards (www.ams.usda.gov/AMSV1.0/NOP) and to collect information about organic agriculture (<http://www.ers.usda.gov/Briefing/Organic>).

United States Environmental Protection Agency/ Biopesticides. This subdivision of the EPA is responsible for regulating and registering biopesticides in the United States (www.epa.gov/pesticides/biopesticides).

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