

Biopesticides for Managing Diseases of Leafy Vegetables Organically

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More information at: <http://livegpath.cals.cornell.edu/organic/organic-management-of-vegetable-diseases/>

Following is a list of some biopesticides labeled for disease control in leafy vegetables. The active ingredient follows product name. Most products are labeled for managing multiple diseases on many crops. The diseases of leafy vegetables that are specified on these labels and occur in the northeastern U.S. are included below. The leafy vegetable crop group (EPA group 4-A and 4-B) includes head and leaf lettuce, arugula, endive, celery, fennel, spinach, Swiss chard, radicchio and rhubarb. On some labels asparagus, parsley, and/or watercress are listed with these crops; they are among the miscellaneous commodities not assigned to a group under EPA classification. The leafy Brassica greens subgroup (5-B), which includes mustard greens, collards, kale, and bok choy, is grouped with the leafy vegetable group on some labels. Some products are labeled broadly (general label) with separate lists for crops and target diseases and pathogens. Products listed with OMRI (Organic Materials Review Institute) are NOP compliant. Some products were reviewed by a different organization. Check state registration: each product may not be registered in all states. Also, always check with your certifier before purchasing any product. 'No Ag Label' indicates an agricultural label was not found for the product. This list does not include the few conventional biopesticides (e.g. phosphorous acid fungicides) that are not permitted in organic production.

Actinovate AG. 0.0371% *Streptomyces lydicus* strain WYEC 108. Labeled for application to soil for damping-off, Fusarium wilt, Fusarium yellows, Rhizoctonia bottom rot, and Sclerotinia lettuce drop, and to foliage for downy mildew, gray mold, and powdery mildew. For best results with applications to foliage, label indicates to use a spreader-sticker. OMRI-listed. EPA Reg. No. 73314-20. Novozymes.

Aviv. 0.08% *Bacillus subtilis* strain IAB/BS03. Labeled for bacterial blight, Cercospora leaf spot, downy mildew, powdery mildew, and Sclerotinia head and leaf drop in leafy vegetables. Replaces Prevont. OMRI-listed. EPA Reg. No. 91473-1-86182. Seipasa S.A.

BioST Nematicide 100. 95% heat-killed *Burkholderia* spp. strain A396 cells and spent fermentation media. Labeled for several nematodes including root-knot. OMRI-listed. EPA Reg. No. 84059-14-42750. Albaugh, LLC.

Bio-Tam. 2% *Trichoderma asperellum* strain ICC 012 and 2% *Trichoderma gamsii* strain ICC 080. These beneficial fungi have different modes of action and are active over different temperature ranges (starting at 45°F) and environmental conditions. General label with pathogens and crops listed separately. For soil-borne fungal pathogens. Those that can affect leafy vegetables include *Fusarium*, *Phytophthora*, *Pythium*, *Rhizoctonia*, *Sclerotinia*, and *Verticillium*. OMRI-listed. EPA Reg. No. 80289-9-67690. Manufactured by Isagro USA; distributed by SePRO Corporation.

Brandt Organics Aleo. 78% garlic oil. Labeled generally for bacterial and fungal diseases including Pythium damping off. OMRI-listed. Exempt from EPA registration. Brandt Consolidated, Inc.

Carb-O-Nator. 85% potassium bicarbonate. Labeled for anthracnose, downy mildew, gray mold, powdery mildew, and Septoria leaf spot. OMRI-listed. EPA Reg. No. 70051-117. Certis USA, LLC.

Cease. 1.34% *Bacillus subtilis* strain QST 713. Broadly labeled for use on greenhouse vegetables. Labeled for downy mildew, pink rot, powdery mildew, and Sclerotinia head and leaf drop in leafy vegetables. OMRI-listed. EPA Reg. No. 69592-19-68539. BioWorks, Inc.

Cinnerate. 60% cinnamon oil. Labeled for diseases such as powdery mildew and pathogens such as *Botrytis cinerea* which causes gray mold (label has separate lists of crops and diseases). OMRI-listed. Exempt from EPA registration. Seipasa S.A.

Companion. 0.03% *Bacillus subtilis* strain GB03. Broadly labeled for foliar and soil-borne diseases, including Alternaria blight, black root rot, bottom rot, Fusarium wilt, gray mold, powdery mildew, Sclerotinia lettuce drop, and root rot caused by *Pythium* and *Rhizoctonia* in leafy vegetables. EPA Reg. No. 71065-3. Growth Products, Ltd.

Contans WG. 5.3% *Paraconiothyrium minitans* strain CON/M/91-08. Soil-applied product for *Sclerotinia sclerotiorum* (white mold pathogen). OMRI-listed. EPA Reg. No. 72444-1. SipcamAdvan.

DiTera DF Biological Nematicide. 90% *Myrothecium verrucaria* strain AARC-0255 fermentation solids and solubles. Labeled for several nematodes including root-knot. OMRI-listed. EPA Reg. No. 73049-67. Valent BioSciences LLC.

Double Nickel 55 LC and WDG. *Bacillus amyloliquefacinens* strain D747, 98.8% and 25%, respectively. Broadly labeled for foliar and soil-borne diseases, including bacterial blights, bottom rot, Cercospora leaf spot, downy mildew, Sclerotinia head and leaf drop, pink rot, powdery mildew, and damping off, root rot and crown rot caused by *Pythium*, *Fusarium*, *Phytophthora*, *Verticillium*, and *Rhizoctonia* in leafy vegetables. OMRI-listed. EPA Reg No. 70051-107 and 108, respectively. Certis USA, LLC.

EcoSwing Botanical Fungicide. 82% extract of *Swinglea glutinosa*. Labeled for powdery mildew. OMRI-listed. EPA Reg. No. 10163-357. Gowan Co.

ECOWORKS EC. 70% cold pressed neem oil. Labeled generally for powdery mildew, downy mildew, leaf spot, botrytis, anthracnose, etc. and also several insects and mites. OMRI-listed. EPA Reg. No. 89152-4. ECOSTADT Technologies LLC.

FungOUT. 1.07% citric acid. Labeled for powdery mildew in field and greenhouse crops. OMRI-listed. Exempt from EPA registration. AEF Global Inc.

GreenFurrow BacStop. 2.0% thyme, 2.0% clove & clove oil, 1.5% cinnamon, 1.0% peppermint & peppermint oil, and 1.0% garlic oil. Broadly labeled primarily for bacterial diseases; diseases not specified for some crops including leafy vegetables. Exempt from EPA registration. Mar Vista Resources.

GreenFurrow EF400. 8.2% clove, 8.1% rosemary, and 6.7% peppermint oils. Labeled for downy mildew, powdery mildew, and Sclerotinia white mold in leafy vegetables. Exempt from EPA registration. Mar Vista Resources.

Howler. 50% *Pseudomonas chlororaphis* strain AFS009. Labeled for foliar spray for diseases caused by *Botrytis* (gray mold) and soil treatment for *Fusarium*, *Phytophthora*, *Pythium*, *Rhizoctonia*, and *Sclerotinia*. OMRI-listed. EPA Reg. No. 91197-3-92488. AgBiome Innovations Inc.

Kaligreen. 82% potassium bicarbonate. Labeled only for powdery mildew. OMRI-listed. EPA Reg. No. 11581-2. Arysta LifeScience North America LLC.

KeyPlex 350 OR. 0.063% yeast extract hydrolysate from *Saccharomyces cerevisiae*. Combination of defensive proteins (alpha-keto acids) and secondary and micronutrients. Elicits

systemic acquired resistance in plants against fungal and bacterial pathogens. Labeled for general disease control in vegetables. EPA approval for organic production. EPA Reg. No. 73512-4. KeyPlex.

LALSTOP G46 WG. 93.0% *Gliocladium catenulatum* strain J1446. Labeled generally for seed-borne and soil-borne plant diseases such as damping-off and root rot caused by several pathogens including *Fusarium*, *Phytophthora*, *Pythium*, *Rhizoctonia*, *Sclerotinia* and *Verticillium*, and foliar diseases caused by several pathogens including powdery mildew on field and greenhouse crops. OMRI-listed. EPA Reg. No.: 64137-13. Lallemand Specialties Inc./Lallemand Plant Care.

LifeGard WG. 40% *Bacillus mycoides* isolate J. Biological Plant Activator. Labeled for anthracnose, downy mildew, gummy stem blight, and powdery mildew. OMRI-listed. EPA Reg. No. 70051-119. Certis USA, LLC.

MeloCon WG. 6% *Paecilomyces lilacinus* strain PL251. This soil fungus parasitizes many types of plant parasitic nematodes, including root knot and root lesion, without adverse impact on beneficial nematodes. OMRI-listed. EPA Reg. No. 72444-2. Certis USA, LLC.

Mildew Cure (formerly GC-3 Organic fungicide). 30% cottonseed oil, 30% corn oil, 23% garlic extract. Labeled only for powdery mildew in lettuce and spinach. OMRI-listed. Exempt from EPA registration. JH Biotech, Inc.

MilStop. 85% potassium bicarbonate. Broadly labeled including anthracnose, Alternaria leaf spot, Botrytis gray mold, Cercospora leaf spot, powdery mildew, and Septoria leaf spot in leafy vegetables. OMRI-listed. EPA Reg. No. 70870-1-68539. BioWorks, Inc.

Minuet. 9.89% *Bacillus subtilis* strain QST 713. Labeled for application to soil for *Fusarium*, *Phytophthora*, *Pythium*, *Rhizoctonia*, *Sclerotinia*, and *Verticillium*. OMRI listed. EPA Reg No. 264-1202. Bayer CropScience.

Mycostop. 35% *Streptomyces griseoviridis* strain K61. Can be incorporated in potting mix, applied as a seed treatment, used as a transplant dip, and applied to soil as a spray, drench, or through drip irrigation. Labeled for seed and root rots caused by *Fusarium*, *Pythium*, *Phytophthora* and *Rhizoctonia*. OMRI listed. EPA Reg No. 64137-5. Lallemand Plant Care.

Organocide. 5% sesame oil. Labeled broadly for several fungal diseases and insects. OMRI-listed. Exempt from EPA registration. No Ag Label. Organic Laboratories, Inc.

OSO. 5% polyoxin D zinc salt. Labeled for Alternaria leaf spot, bottom rot, downy mildew, drop, and powdery mildew in leafy vegetables. OMRI-listed. EPA Reg No. 68173-4-70051. Certis USA, LLC.

OxiDate 2. 27% hydrogen dioxide and 2% peroxyacetic acid. Labeled diseases include Botrytis (gray mold), downy mildew, and powdery mildew in leafy vegetables. OMRI-listed. EPA Reg. No. 70299-12. BioSafe Systems, LLC.

PerCarb. 85% sodium carbonate peroxyhydrate. Labeled for downy mildew and powdery mildew in cucurbits. OMRI-listed. EPA Reg. No. 70299-15. BioSafe Systems, LLC.

Prestop. 93% *Gliocladium catenulatum* strain J1446. Broadly labeled for seed-borne and soil-borne diseases (such as those caused by *Phytophthora*, *Pythium*, *Rhizoctonia*, *Sclerotinia*, and *Verticillium*) and foliar diseases (*Alternaria*, *Colletotrichum*, *Botrytis*, *Didymella*, and *Fusarium* plus powdery mildew). Can be incorporated in potting mix, applied to soil and to foliage. OMRI-listed. EPA Reg. No. 64137-13. Lallemand Plant Care.

Prevont. Renamed AVIV.

Promax. 3.5% thyme oil. Protective and curative soil fungicide and nematicide for control of soil-borne diseases and plant parasitic nematodes on a broad range of crops. OMRI-listed. Exempt from EPA registration. Bio Huma Netics, Inc.

Rango. 70% cold pressed neem oil. Generally labeled for anthracnose, downy mildew, powdery mildew, and foliar diseases caused by fungal pathogens such as *Alternaria* and *Botrytis*, and for soil applications for nematodes and soil-borne fungal pathogens including *Fusarium*, *Pythium*, and *Rhizoctonia solani* (label has separate lists of crops and diseases). OMRI-listed. EPA Reg. No. 88760-10. Terramera, Inc.

Regalia. 5% extract of *Reynoutria sachalinensis*. Boosts the plant's natural defense mechanisms against certain fungal and bacterial diseases. Broadly labeled including bacterial blight/rot, downy mildew, Cercosora leaf spot, late blight, pink rot, powdery mildew, Sclerotinia head and leaf drop, and white rust in leafy vegetables. OMRI-listed. EPA Reg. No. 84059-2. ProFarm Group (Formerly Marrone Bio Innovations, Inc).

Romeo. 94.1% cerevisane (cell walls of *Saccharomyces cerevisiae* strain LAS117). Labeled for Botrytis gray mold, downy mildew, and Rhizoctonia. OMRI-listed. EPA Reg. No. 91810-2. Lesaffre Yeast Corporation

RootShield WP and Granules (formerly T-22 HC and PlantShield HC). 1.15% *Trichoderma harzianum* Rifai strain KRL-AG2. Protects plant roots against fungal pathogens such as *Rhizoctonia*, *Pythium*, and *Fusarium*. The biocontrol fungus accomplishes this by growing on roots and releasing enzymes that dissolve the cell wall of many fungal pathogens, which it consumes. OMRI-listed. EPA Reg. No. 68539-3 and -7 for Granules and WP formulations, respectively. BioWorks, Inc.

RootShield Plus WP. 1.15% *Trichoderma harzianum* Rifai strain T-22 and 0.61% *Trichoderma virens* strain G-41. See previous product. OMRI-listed. EPA Reg. No. 68539-9. BioWorks, Inc.

Serenade ASO. 1.34% *Bacillus subtilis* strain QST 713. This bacterium colonizes roots when applied to soil and produces compounds that affect pathogens directly and triggers metabolic pathways to activate the plant's natural defenses and modulate growth. Labeled for anthracnose, bacterial blight and leaf spot, *Botrytis* spp., downy mildew, powdery mildew, Sclerotinia head and leaf drop, and white rust in leafy vegetables and for soil diseases caused by *Fusarium*, *Phytophthora*, *Pythium*, *Rhizoctonia*, *Sclerotinia*, and *Verticillium*. Serenade ASO has replaced Serenade Soil. Previous product names and formulations: Serenade, Serenade Max, Serenade Optimum. OMRI-listed. EPA Reg. No. 264-1152. Bayer CropScience.

Serenade Opti. 26.2% *Bacillus subtilis* strain QST 713. New formulation. Labeled for pink rot and Sclerotinia head and leaf drop in leafy vegetables. OMRI-listed. EPA Reg. No. 264-1160. Previous product names and formulations: Serenade, Serenade Max, Serenade Optimum. Bayer CropScience.

Serifel. 9.9% *Bacillus amyloliquefacinens* strain MBI 600. Supplemental label has bacterial leaf spot. OMRI-listed. EPA Reg. No. 71840-18. BASF Corporation.

Serifel NG. 11% *Bacillus amyloliquefacinens* strain MBI 600. Labeled for use on greenhouse crops applied to soil for root rot pathogens and as foliar spray for powdery mildew. OMRI-listed. EPA Reg No. 71840-8. BASF Corporation.

Sil-MATRIX LC. 29% potassium silicate. Broad spectrum fungicide for fungal diseases labeled specifically for powdery mildew. OMRI-listed. EPA Reg. No. 82100-1. PQ Corp.

SoilGard. 12% *Gliocladium virens* strain GL-21. Labeled for soil application in greenhouse and field for damping-off and root rot caused by *Fusarium*, *Pythium*, and *Rhizoctonia*, *Sclerotinia*. OMRI-listed. EPA Reg. No. 70051-3. Certis USA, LLC.

Sonata. 1.38% *Bacillus pumilus* strain QST 2808. Labeled for downy mildew and powdery mildew. OMRI-listed. EPA Reg. No. 264-1153. Bayer CropScience (formerly AgraQuest).

Sporan EC². 16% rosemary oil, 10% clove oil, 10% thyme oil, 2% peppermint oil. Labeled for Alternaria leaf spot, downy mildew, gray mold, and powdery mildew in leafy vegetables. OMRI-listed. Exempt from EPA registration. KeyPlex.

Stargus. *Bacillus amyloliquefacinens* strain F727. Labeled for downy mildew and Sclerotinia drop (aka white mold). OMRI-listed. EPA Reg. No. 084059-28. ProFarm Group (Formerly Marrone Bio Innovations, Inc).

Taegro 2. 13% *Bacillus subtilis* var. *amyloliquefaciens* strain FZB24. Labeled for suppression of downy mildew, powdery mildew, and the soil-borne pathogens *Rhizoctonia*, *Fusarium*, and *Sclerotinia*. OMRI-listed. EPA Reg. No. 70127-12. Novozymes Biologicals, Ind.

Tenet WP. Same as Bio-Tam. OMRI-listed. EPA Reg. No. 80289-9. Isagro USA; distributed by SipcAmAdvan.

TerraClean 5. 27% hydrogen dioxide and 5% peroxyacetic acid. Generally labeled for control of soil-borne plant diseases such as root rot caused by *Fusarium*, *Pythium*, and *Rhizoctonia*; crops not specified on label. It penetrates soil to kill and suppress pathogens, and it releases vast amounts of oxygen that stimulates root development, nutrient uptake, and thus plant growth. OMRI-listed. EPA Reg. No. 70299-13. BioSafe Systems, Inc.

TerraNeem EC. 84.9% cold pressed neem oil. Labeled generally for anthracnose, downy mildew, powdery mildew, and foliar diseases caused by fungal pathogens such as *Botrytis*, and for soil applications for nematodes and soil-borne fungal pathogens including *Fusarium*, *Pythium*, and *Rhizoctonia solani* (label has separate lists of crops and diseases). OMRI-listed. EPA Reg. No. 88760-5. Terramera, Inc.

Theia. 100% *Bacillus subtilis* strain AFS032321. Labeled for seed treatment and soil application (greenhouse and field) for soil-borne fungal diseases caused by *Fusarium*, *Rhizoctonia*, *Pythium*, and *Phytophthora*; and also for foliar application for anthracnose, bacterial blight/leaf spot, downy mildew, gray mold, powdery mildew, and Sclerotinia head and leaf drop. OMRI-listed. EPA Reg. No. 94713-2-92488. AgBiome Innovations Inc.

Thymox Control. 27% thyme oil. Proprietary nano emulsion technology. Broadly labeled for fungal diseases such as powdery mildew and grey mold, and bacterial diseases; crops not specified. OMRI-listed. Exempt from EPA registration. Kemin Industries, Inc. Manufactured by Laboratoire M2.

Thyme Guard. 23% thyme oil extract. Broadly labeled for diseases caused by fungi, bacteria, viruses, and nematodes; crops not specified. Exempt from EPA registration. Determined to be NOP compliant by Washington State Dept of Ag. Agro Research International.

Timorex Act. 12.5% tea tree oil. Labeled for anthracnose, bacterial blight, downy mildew, gray mold, powdery mildew, Sclerotinia head and leaf drop, and applied to soil for damping-off, crown and root rot caused by *Fusarium*, *Pythium*, *Rhizoctonia*, *Sclerotinia*, *Phytophthora*, or *Verticillium*. OMRI-listed. EPA Reg. No. 86182-3-88783. Summit Agro USA, LLC.

Triathlon BA. 98.85% *Bacillus amyloliquefaciens* strain D747. Labeled for control of bacterial blights, Cercospora leaf spot, *Botrytis* (gray mold), white mold, and applied to soil for bottom rot, and for suppressing downy mildew, powdery mildew and applied to soil for damping off,

seedling blights, and root or crown diseases caused by *Pythium*, *Rhizoctonia*, *Fusarium*, *Phytophthora*, or *Verticillium* spp. OMRI listed. EPA Reg. No. 70051-107-59807. OHP, Inc.

Trilogy. 70% clarified hydrophobic extract of neem oil. Labeled generally for several insects and diseases. Labeled diseases that occur in leafy vegetables include anthracnose, downy mildew, *Botrytis* (gray mold), and powdery mildew (label has separate lists of crops and diseases). OMRI-listed. EPA Reg. No. 70051-2. Certis USA, LLC.

Zonix biofungicide. 8.5% rhamnolipid biosurfactant. Kills zoospores, which is one spore type produced by Oomycete pathogens which cause diseases such as downy mildew in some leafy vegetables. OMRI-listed. EPA Reg. No. 72431-1. PropTera, LLC.

Below are some organic fungicides with active ingredients that are considered to be biocompatible, but the ingredients have not been reviewed by EPA or are not naturally occurring substance and thus are not in the US EPA biopesticide active ingredient list at <https://www.epa.gov/ingredients-used-pesticide-products/biopesticide-active-ingredients>:

DES-X. 47% potassium salts of fatty acids. Labeled for powdery mildew and several insects and mites. OMRI-listed. EPA Reg. No. 67702-22-70051. Certis USA, LLC.

M-Pede. 49% potassium salts of fatty acids. Labeled for powdery mildew and several insects and mites. OMRI-listed. EPA Reg. No. 10163-324. Gowan Co.

Organic JMS Stylet-oil. 97.1% paraffinic oil. Labeled for several insect pests, viruses vectored by aphids, and *Alternaria* leaf spot (blight) and powdery mildew in celery and lettuce. OMRI-listed. EPA Reg. No. 65564-1. JMS Flower Farms, Inc.

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. If you are farming organically, before purchase make sure product is registered in your state and approved by your certifier. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

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