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# Chapter 18. Biopesticides and Alternative Disease and Pest Management Products

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**Table 18.1.** Biopesticides and other alternative products labeled for plant disease management.

**Labels change frequently. Be sure to read a current product label before applying any pesticide.**
**Refer to crop-specific tables for conventional pesticides labeled for disease and pest management.**

| Product (active ingredient), Fungicide Group[1] | Crops | Pertinent Diseases or Pathogens | Minimum Days to: Harvest | Minimum Days to: Reentry | OMRI Listed | Remarks[2] |
|---|---|---|---|---|---|---|
| **Actinovate, ActinoGrow** (*Streptomyces lydicus* WYEC 108), NC | All Vegetables & Strawberries | *Alternaria* spp., Anthracnose, *Aphanomyces*, Botrytis, Charcoal Rot (*Macrophomina phaseolina*), Club root (*Plasmodiophora brassicae*), Downy Mildew, *Erwinia* spp., *Fusarium* spp., *Gaeumannomyces*, Powdery Mildew, Pseudomonas spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Sclerotinia* spp., Southern Blight, Verticillium spp., *Xanthomonas* spp. | 0 | 1 hr | Yes | See label for specific rates and application recommendations. |
| **Afla-guard GR** (Aspergillus flavus NRRL 21882) | Sweet Corn | Aspergillus | - | 4 hr | No | Do not exceed 20lb/acre per growing season. See label for specific application instructions. |
| AgriPhage (bacteriophage), NC | Tomato, Pepper | Bacterial spot, Bacterial speck | 0 | 0 | No | Bacterial strains must be characterized preiodically by manufacturer to correctly formulate the bacteriophage mixture. |
| **Armicarb 100** **Eco-mate Armicarb "O"** (potassium bicarbonate), NC | All Vegetables & Strawberries | Anthracnose, Botrytis, Downy mildew, Phoma, Powdery mildew, Septoria leaf spot | 0 | 4 hr | No | See label for specific rates and application recommendations. |
| Ballad Plus, (*Bacillus pumilus* strain QST 2808) NC | All Legumes & Sweet Corn | Bacterial blight, Brown spot, Cercospora leaf spot, Common Rust, Downy mildew, Northern and Southern leaf blight, Pseudomonas spp. Xanthomonas spp. | 0 | 4 hr | No | See label for specific rates and application recommendations. |
| BioCover (Oil, petroleum) | All Vegetables & Strawberries | Powdery mildew, Rust | 0 | 4 hr | No | See label for specific rates, application recommendations, and precautions regarding use with other pesticides. |
| BIO-TAM (*Trichoderma asperellum* strain ICC 012 + *Trichoderma gamsii* strain ICC 080) NC | All Vegetables & Strawberries | *Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Sclerotinia* spp., *Sclerotium rolfsii*, *Thielaviopsis basicola*, and *Verticillium* spp. | - | 1 hr | Yes | See label for additional rates and recommendations for transplant production and details for specific diseases. Check label for product incompatibility with certain chemical fungicides. |
| Cease (*Bacillus subtilis* strain QST 713), 44 | All Vegetables & Strawberries | Bacterial spot, Bacterial speck, Botrytis, Early Blight, Late Blight, Powdery mildew, Target spot, Rhizoctonia spp., Pythium spp., Fusarium spp., Verticillium spp., Phytophthora spp. | 0 | 4 hr | Yes | For foliar applications mix with copper compounds or other effective fungicides. Compatible with soil drench and in-furrow applications. See label for specific rates and application recommendations. |
| Contans WG (*Coniothyrium minitans* strain CON/M/91-08) | All Vegetables & Strawberries | *Sclerotinia sclerotiorum* and *Sclerotinia minor* | 0 | 4 hr | Yes | See label for specific rates and application recommendations. |
| **Double Nickel 55** **Double Nickel LC** (*Bacillus amyloliquefaciencs* strain D747), 44 | All Vegetables & Strawberries | *Alternaria* spp., Anthracnose, Bacterial diseases, Botrytis, Early blight, Late blight, *Phytophthora* spp., Powdery mildew, *Pythium* spp., Rhizoctonia, Fusarium spp., Rhizoctonia, Phytophthora spp., Pythium spp. | 0 | 4 hr | Yes | See label for additional rates and recommendations for foliar and soil application rates and details for specific diseases. Use as a soil drench at transplant and periodically throughout the season. Can also be used as a seed treatment. See label for details. |

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|---|---|---|---|---|---|---|
| **Glacial Spray Fluid** (Oil, petroleum), NC | All Vegetables & Strawberries | Powdery mildew, Rust | 0 | 4 hr | Yes | See label for specific rates, application recommendations, and precautions regarding use with other pesticides. |
| JMS Stylet-Oil **Organic JMS Stylet-Oil** (paraffinic oil), NC | All Vegetables & Strawberries | Potato Virus Y, Tobacco Etch Virus, Cucumber Mosaic Virus | 0 | 4 hr | Yes, but only for one label. | See label for specific rates, application recommendations, and precautions regarding use with other pesticides. |
| Kaligreen (potassium bicarbonate), NC | All Vegetables & Strawberries | Powdery mildew | 0 | 4 hr | Yes | See label for specific rates and application recommendations. |
| Milstop (potassium bicarbonate), NC | All Vegetables & Strawberries | Anthracnose, *Alternaria* spp., Botrytis, Downy mildew, Powdery mildew | 0 | 1 hr | Yes | See label for specific rates and application recommendations. |
| Oxidate 2.0 (mono- and di-potassium salts of phosphorous acid + hydrogen peroxide), 33 + NC | All Vegetables & Strawberries | *Alternaria* spp., Anthracnose, Bacterial diseases, Botrytis, Early blight, Late blight, *Phytophthora* spp., Powdery mildew, *Pythium* spp., Rhizoctonia, Fusarium spp., Rhizoctonia, Phytophthora spp., Pythium spp. | 0 | 1 hr for enclosed areas; until spray dries in open field areas. | No | See label for additional rates and recommendations for transplant production and details for specific diseases. Use as a soil drench at transplant and periodically throughout the season. Can also be used as a seed treatment. |
| OxiPhos (hydrogen peroxide), NC | All Vegetables & Strawberries | Bacterial diseases, Gummy stem blight, Late blight, *Phytophthora* spp., *Pythium* spp., Phytophthora spp., Pythium spp. | 0 | 4 hr | No | See label for recommedations for rates, application methods, and details for specific diseases. |
| **(potassium phosphite; mono- and di-potassium** salts of phosphorous **acid), 33** **Many brands available:** Alude, Appear, Confine Extra T&O, Fosphite, Fungi-Phite, Helena Prophyt, K-Phite 7LP AG, Phorcephite, Phostrol, Rampart, Reveille | All Vegetables & Strawberries | *Alternaria spp., Anthracnose, Bacterial diseases,* Downy mildew, *Fusarium* spp., Late blight, Leaf blights caused by *Cercospora* and *Septoria* spp., *Phytophthora* spp., Powdery mildew, *Pythium* spp., *Rhizoctonia* spp., Root rots | 0 | 4 hr | No | See label for details, specific recommendations, and precautions for tank mixing with copper-based fungicides. |
| PlantShield HC (*Trichoderma harzianum* Rifai strain KRL-AG2), NC | All Vegetables & Strawberries | *Fusarium* spp., Rhizoctonia, *Pythium* spp. | 0 | 4 hr | Yes | Can be applied to plant as a direct drench, furrow spray, chemigation, or in transplant starter solution. See label for details. |
| **Procidic** (Citric acid), NC | All Vegetables & Strawberries | Broad spectrum fungicide | 0 | 0 | No | See label for specific rates, application recommendations, and precautions regarding use with other pesticides. |
| Purespray Green (Oil, petroleum), NC | All Vegetables & Strawberries | Powdery mildew, Rust | 0 | 4 hr | Yes | See label for specific rates, application recommendations, and precautions regarding use. |
| Regalia SC (extract of *Reynoutria sachalinensis*), P | All Vegetables & Strawberries | Bacterial canker , Bacterial speck, Bacterial spot, Botrytis, Early blight, Phytophthora spp., Powdery mildew, Target spot, Late blight | 0 | 4 hr | Yes | Tank mix with other effective fungicides for improved disease control under heavy pressure. See label for details. |
| Rendition ZeroTol 2.0 (Hydrogen peroxide + peroxyacetic acid), NC | All Vegetables & Strawberries | Broad spectrum fungicide | 0 | 1 hr for enclosed areas; until spray dries in open field areas. | No | See label for specific rates, application recommendations, and precautions regarding use with other pesticides. Can be used as a soil drench at transplant and periodically throughout the season. Can also be used as a seed treatment. |
| RootShield Granular (Trichoderma harzianum Rifai strain KRL-AG2), NC | All Vegetables & Strawberries | *Fusarium* spp., Rhizoctonia, *Pythium* spp. | 0 | 0 | Yes | Granular formulation can be applied in furrow in the field, or to greenhouse planting mix. See label for details. |
| RootShield WP (*Trichoderma harzianum* Rifai strain KRL-AG2), NC | All Vegetables & Strawberries | *Fusarium* spp., Rhizoctonia, *Pythium* spp. | 0 | Until spray has dried. | Yes | Can be applied as a greenhouse soil drench, or by chemigation in field and greenhouse operations. In furrow or transplant starter solution. |

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**Refer to crop-specific tables for conventional pesticides labeled for disease and pest management.**

| Product (active ingredient), Fungicide Group[1] | Crops | Pertinent Diseases or Pathogens | Minimum Days to: Harvest | Minimum Days to: Reentry | OMRI Listed | Remarks[2] |
|---|---|---|---|---|---|---|
| Serenade ASO<br>Serenade Max<br>Serenade Opti<br>**Serenade Optimum**<br>(*Bacillus subtilis* strain QST 713), 44 | All Vegetables & Strawberries | Bacterial speck, Bacterial spot, Botrytis, Early Blight, Late Blight, Powdery mildew, Target spot | 0 | 4 hr | Yes | For foliar applications mix with copper compounds or other effective fungicides for improved disease control. See label for details. |
| Serenade Soil<br>(Bacillus subtilis strain QST 713), 44 | All Vegetables & Strawberries | *Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Verticillium* spp. | 0 | 4 hr | Yes | Formulation compatible with soil drench, in-furrow, and chemigation applications. Mix with other effective fungicides for improved disease control. See label for details. |
| Sil-Matrix<br>(potassium silicate), NC | All Vegetables & Strawberries | Broad spectrum fungicide | 0 | 4 hr | No | Must be used in a rotational program with other fungicides when conditions are conducive for disease development. See label for details. |
| Soilgard 12G<br>(Gliocladium virens GI-21), NC | All Vegetables & Strawberries | Fusarium root and crown rot, *Phytophthora capsici, Pythium* spp., Rhizoctonia, *Sclerotinia* spp., *Sclerotium* spp. | 0 | 0 | Yes | For best results apply to transplants or as a drench during transplanting. Subsequent applications can be made as drench, directed spray, or by chemigation. Chemical fungicides should not be mixed with or applied to soil or plant media at the same time as SoilGard 12G. See label for details. |
| Sonata<br>(*Bacillus pumilus* QST 2808), NC | All Vegetables & Strawberries | Early Blight, Downy mildew, Late Blight, Powdery mildew, Rust | 0 | 4 hr | Yes | Mix or alternate with other effective fungicides for improved disease control. See label for details. |
| **Sporatec**<br>(oils of clove, rosemary and thyme), NC | All Vegetables & Strawberries | Bacterial spot, Botrytis, Early blight, Gray mold, Late blight, Powdery mildew | 0 | 0 | Yes | Exercise care when applying. Begin applications once disease is observed. Use of a spreader and/or penetrant adjuvant recommended for improved performance. Do not apply when temps are above 90ºF. See label for details. Ingredients are exempt from FIFRA. |
| Taegro ECO<br>(*Bacillus amyloliquefaciencs* strain FZB24), NC | Cucurbits: cantaloupe, honey dew, cucumber, squash, watermelon; Leafy vegetables: lettuce, celery, spinach, radicchio, endive, arugula, mache, parsley, rhubarb, and swiss chard; Fruiting vegetables: tomato and pepper. | Foliar diseases: Downy mildew, Powdery mildew, Pseudomonas spp., Xanthomonas spp.; Soilborne diseases: *Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Sclerotinia* spp. | - | 1 day | No | See label for specific instructions regarding soil injected, spray, or incorporated applications. Maximum of 12 applications per season. For best efficacy, product should be applied prior to disease or disease establishment. May be applied to greenhouse produced crops. |
| Tenet<br>(*Trichoderma asperellum* ICC 012; *Trichoderma gamsii* ICC 080), NC | All Vegetables & Strawberries | *Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Sclerotium rolfsii*, *Sclerotinia* spp., *Thielaviopsis basicola*, and *Verticillium* spp. | 0 | 1 hr | Yes | For best results apply 1 week prior to planting, with 2 or more additional applications throughout the production cycle. May be applied through fertigation systems in combination with most common fertilizers. Can be applied to fumigated soil after fumigant has dissipated. Tenet has no curative activity. See label for details regarding application and fungicide incompatibility. |
| **Terraclean**<br>(hydrogen dioxide), NC | All Vegetables & Strawberries | Soilborne plant pathogens caused by species of *Fusarium, Phytophthora, Pythium,* and *Rhizoctonia* | 0 | 0 | No | Can be applied by flood irrigation, drip irrigation, or as a soil drench. See label for application details and instructions regarding applications with liquid fertilizer mixtures. |

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| Product (active ingredient), Fungicide Group[1] | Crops | Pertinent Diseases or Pathogens | Minimum Days to: Harvest | Minimum Days to: Reentry | OMRI Listed | Remarks[2] |
|---|---|---|---|---|---|---|
| Trilogy (clarified hydrophobic extract of neem oil), NC | All Vegetables & Strawberries | *Alternaria* spp., Anthracnose, Botrytis, Early blight, Powdery mildew | 0 | 4 hr | Yes | See label for specific rates, application recommendations, and precautions regarding use with other pesticides. |
| **Vacciplant** (laminarin), P | All Vegetables & Strawberries | Anthracnose, Bacterial speck, Bacterial spot, Early blight, Phytophthora blight, Powdery mildew | 0 | 4 hr | No | Start applications preventively, when weather conditions are favorable for disease development. Repeat applications until disease conditions end. Add a labeled copper product to VacciPlant if the disease symptoms appear. |

[1] FRAC code (fungicide group): Number (33 and 44) and letters (NC and P) are used to distinguish the fungicide mode of action groups. All fungicides within the same group (with same number or letter) indicate same active ingredient or similar mode of action. This information must be considered for the fungicide resistance management decisions. However, products with NC or P are considered low risk and don't require any rotation unless specifically directed on the label. NC = not classified, includes mineral oils, organic oils, potassium bicarbonate, and other materials of biological origin; P = host plant defense inducers. Source: FRAC Code List 2013; http://www.frac.info/ (FRAC = Fungicide Resistance Action Committee).

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**Table 18.2.** Biopesticides and other alternative products labeled for plant pest management.

**Labels change frequently. Be sure to read a current product label before applying any pesticide.**
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| Product (active ingredient) | Rate | REI | PHI | Insects | MOA Code[1] | Notes |
|---|---|---|---|---|---|---|
| Agree WG (*Bacillus thuringiensis* subspecies *aizawai*) | 0.5-2.0 lb | 4 | 0 | lepidopteran larvae (caterpillar pests) | 11A | Apply when larvae are small for best control. Can be used in greenhouse. OMRI-listed. |
| **Aza-Direct** (azadirachtin) | 1-2 pts, up to 3.5 pts, if needed | 4 | 0 | aphids, beetles, caterpillars, leafhoppers, leafminers, thrips, weevils, whiteflies | un | Antifeedant, repellant, insect growth regulator. OMRI-listed. |
| Azera (pyrethrins, azadirachtin) | 1.0-3.5 qt | 12 | 0 | aphids, beetles, caterpillars, leafminers, whiteflies | 3A, un | Apply when larvae are small for best control. Can be used in greenhouse. For organic production. |
| **Biobit HP** (*Bacillus thuringiensis* subspecies *kurstaki*) | 0.5-2.0 lb | 4 | 0 | caterpillars (will not control large armyworms) | 11A | Treat when larvae are young. Good coverage is essential. Can be used in the greenhouse. Can be used for organic production. |
| Botanigard ES (*Beauvaria bassiana* strain GHA) | up to 3 quarts per 100 gallons water; 0.33-1.00 fl. oz. per gallon water | 4 | 0 | whiteflies, aphids, thrips, mealybug, leafhoppers, planthoppers, plant bugs, two spotted spider mites | un | Works by contact. Spores attach to insects, germinate and penetrate insect cuticle. |
| Captiva (*Capsicum oleoresin* extract, garlic oil, soybean oil) | 8 oz per 100 gallons water | 4 | 0 | mites, thrips, leafhoppers, whiteflies | un | |
| Deliver (*Bacillus thuringiensis* subspecies *kurstaki*) | 0.25-1.5 lb | 4 | 0 | caterpillars | 11A | Use higher rates for armyworms. OMRI-listed. |
| Des-X (soap, insecticidal) | 2 % V/V | 12 | 0 | aphids, mites, plant bugs, whiteflies | -- | OMRI-listed. |
| DiPel DF (*Bacillus thuringiensis* subspecies *kurstaki*) | 0.5-2.0 lb | 4 | 0 | caterpillars | 11A | Treat when larvae are young. See label for rates for specific pests. Good coverage is essential. OMRI-listed. |
| Entrust SC (spinosad) | see label for specific crops | 4 | See label | caterpillers, some beetles, thrips. See label for specific pests on specific crops | 5 | See label for resistance management and for maximum allowed amount per season. OMRI-listed. |

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| Product (active ingredient) | Rate | REI | PHI | Insects | MOA Code[1] | Notes |
|---|---|---|---|---|---|---|
| **Gemstar LC** (*Helicoverpa zea* NPV) | 4-10 fl oz | 4 | 0 | corn earworm (tomato fruitworm), tobacco budworm | – | Naturally occurring insect virus. OMRI-listed. |
| Grandevo (*Chromobacterium subtsugae* strain PRAA4-1) | 1.0-3.0 lb | 4 | 0 | See label for specific pests for specific crops. For control of caterpillars, aphids, whiteflies and other insects. | – | Can be used in organic production. OMRI-listed |
| Javelin WG (*Bacillus thuringiensis* subspecies *kurstaki*) | 0.12-1.50 lb | 4 | 0 | most caterpillars, but not *Spodoptera* species (armyworms) | 11A | Treat when larvae are young. Thorough coverage is essential. OMRI-listed. See label for crops (most cole crops). |
| JMS Stylet oil (paraffinic oil) | 3-6 quarts per 100 gallons water | 4 | 0 | leafhoppers, leafminers, mites, whiteflies | | |
| **MBI-203 EP bioinsecticide** (*Chromobacterium subtsugae* strain PR AA4-IT) | 4-12 quarts | 4 | 0 | various caterpillars, mites, plant bugs | _ | OMRI listed |
| Met52 EC (*Metarhizium anisopliae* Strain F52) | drench: 40-80 fl. oz.; foliar: 0.5-2 quarts | 0 | 0 | thrips, whiteflies, mites | _ | Composed of spores of insect pathogenic fungus *Metarhizium anisopliae* strain F52. |
| Met52 granular (*Metarhizium anisopliae* strain F52) | | 0 | 0 | thrips pupae | 1.5-3.0 lb/yd[3] | Product is incorporated into growing medium. |
| M-Pede 49% EC (soap, insecticidal) | 1-2 % V/V | 12 | 0 | aphids, leafhoppers, mites, thrips, whiteflies | -- | OMRI-listed. |
| **Mycotrol O** (*Beauveria bassiana*) | 0.5-1.0 qt | 4 | 0 | aphids, thrips, whiteflies, psyllids | -- | May be used in greenhouses. Not compatible in tank mix with fungicides. OMRI-listed. |
| **Neemix 4.5** (azadirachtin) | 4-16 fl oz | 12 | 0 | aphids, armyworms, cabbage looper, caterpillars, cutworms, leafminers, imported cabbageworm, whiteflies | un | IGR and feeding repellant. Greenhouse and field. OMRI-listed. |
| PFR-97 20% WDG (*Isaria fumosoroseus* Apopka Strain 97) | Foliar and soil: 1-2 lb | 4 | 0 | Foliar: whiteflies, aphids, thrips, spider mites, broad mites, *Liriomyza* leafminers, pysllids, plant bugs: Soil: thrips pupae, rootworms, wireworms, grubs, symphylans | – | Can be used on vegetables grown for transplant. Do not mix with fungicides or apply within 5 days of fungicide applications other than copper. Dust/mist respirator must be used for mxing and applying. For organic production. |
| **Pyganic 5.0** (pyrethrins) | | 12 | 0 | most insects | 3A | Harmful to bees. Can be used in greenhouses. OMRI-listed. |
| **Seduce Insect Bait** (spinosad) | 20-44 lb | 4 | see specific crops on label | cutworms, earwigs | 5 | For organic production |
| Trilogy (extract of neem oil) | 0.5-2% V/V | 4 | 0 | aphids, mites, suppression of thrips and whiteflies | un | Apply morning or evening to reduce potential for leaf burn. Toxic to bees exposed to direct treatment. OMRI-listed. |
| Venerate XC (heat killed *Burkholderia* spp. strain A396 cells and spent fermentation media) | 1-8 quarts per acre | 4 | 0 | control of caterpillars (see label); suppression of mealybugs, stink bugs, thrips, twospotted spider mite, whiteflies | | OMRI listed. |
| Xentari DF (*Bacillus thuringiensis* subspecies *aizawai*) | 0.5-2.0 lb | 4 | 0 | caterpillars | 11A | Treat when larvae are young. Thorough coverage is essential. May be used in the greenhouse. Can be used in organic production. |

[1] Mode of Action (MOA) codes for plant pest insecticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification v. 7.2 April 2012. Number codes (1 through 28) are used to distinguish the main insectide mode of action groups, with additional letters for certain sub-groups within each main group. All insecticides within the same group (with same number) indicate same active ingredient or similar mode of action. This information must be considered for the insecticide resistance management decisions. un = unknown, or a mode of action that has not been classified yet.

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