

Organic Pest Management for Vegetable Bedding Plants Grown in Greenhouses

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Table 1. Selected Insecticides Labeled for Insects and Mites on Vegetable Bedding Plants

Insecticide	Target Pests	Labeled Crops	Comments
Azadirachtin- Group 18B (Aza-Direct) 4 hr. REI Organic product	Aphids, beetles, weevils, thrips, true bugs, caterpillars, leafhoppers, leafminers, whiteflies, and fungus gnat larvae	Many vegetables including bulb, cole, cucurbit, leafy and fruiting types (eggplant, tomato, peppers) (see specific labels)	Insect growth regulator for immature stages of insects. Repeat applications needed. Repels some insects and can be used as an antifeedant.
(Azatrol) 4 hr. REI Organic product	Beetles, weevils, thrips, true bugs, leafhoppers, cutworms, loopers, fungus gnat larvae		
(AzaGuard) 4 hr. REI Organic Product	Leafminers, soft scales, mealybugs, thrips, aphids, fungus gnat larvae, whiteflies, caterpillars, beetles, weevils		
(Azahar) 4 hr. REI Organic product	Beetles, weevils, thrips, true bugs, leafhoppers, whiteflies, aphids, leafrollers, cutworms, loopers, fungus gnat larvae		
(Neemix 4.5) 12 hr. REI Organic product	Aphids, beetles, caterpillars, fungus gnat larvae, leafhoppers, leafminers, thrips, whiteflies		
Bacillus thuringiensis <i>subsp.</i> aizawai (XenTari) 4 hr. REI Group 11B Organic product	Certain caterpillars (see label)	Brassica and fruiting vegetables in the greenhouse (see label)	Stomach poison that must be ingested to be active. Most effective against small, newly hatched larvae. Insects stop feeding and dies 1 to 5 days later.

<p><i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> (DiPel Pro DF) 4 hr. REI Group 11B Organic product</p>	<p>Certain caterpillars (see label)</p>	<p>Many vegetables including leafy, cole, and fruiting types (see label)</p>	<p>Stomach poison that must be ingested to be active. Thorough coverage of all plant parts is important. Most effective against young, newly hatched larvae. Insects stop feeding and dies 1 to 5 days later.</p>
<p><i>Bacillus thuringiensis</i> subsp. <i>israelensis</i> (Gnatrol WDG) 4 hr. REI Group 11A1 Organic product</p>	<p>Fungus gnat larvae</p>	<p>Vegetable plants such as leafy and cole crops, cucumbers, peppers, tomatoes and eggplants</p>	<p>Stomach poison that must be ingested to be active. Most effective against first instar larvae. Apply as soil drench to control fungus gnat larvae. Larvae must ingest material to be killed. May be applied through drip or sprinkler irrigation system. Do not combine with fungicides or fertilizers containing copper or chlorine.</p>
<p><i>Beauveria bassiana</i> (Mycotrol O) 4 hr. REI Organic products</p>	<p>Aphids, thrips, whitefly, psyllids, mealybugs, leafhoppers, plant bugs (See labels for more information)</p>	<p>Many vegetables including cole crops, greens, eggplant, peppers, and squash.</p>	<p>Contact insecticide. Active ingredient is an insect killing fungus. To be effective needs relative humidity greater than 70% and 65-75°F for 8 to 10 hours. Treat when insect populations are low. Repeated applications may be needed.</p>
<p>Horticultural oil Petroleum Oil (Pure Spray Green) 4 hr. REI NC Organic product</p>	<p>Aphids, leafminers, mites, thrips, whiteflies, leafhoppers</p>	<p>Many vegetables (see labels for specific crops)</p>	<p>Works by contact. Thorough coverage of all plant parts is important. Foliar injury may occur if applied during humid conditions. See labels for information on plant safety. All applications should be preceded by a phytotoxicity check to ensure that the material is safe for that particular plant variety.</p>
<p>Petroleum Oil (Saf-T-Side) 4 hr. REI NC Organic product</p>	<p>Aphids, leafhoppers, leafminers, thrips, mites, whiteflies</p>	<p>Vegetable crops (see label)</p>	

<p>Petroleum Oil (SuffOil-X) 4 hr. REI NC Organic product</p>	<p>Aphids, leafhoppers, leafminers, mites, thrips, whiteflies</p>	<p>Vegetable crops (see label)</p>	<p>Works by contact. Thorough coverage of all plant parts is important. Foliar injury may occur if applied during humid conditions. See label for information on plant safety.</p>
<p>Paraffinic Oil - White Mineral Oil (Organic JMS Stylet Oil) 4 hr. REI Organic product</p>	<p>Leafhoppers, leafminers, mites, whiteflies</p>	<p>Many vegetables (see label)</p>	<p>Works by contact. See label for information on plant safety.</p>
<p>Insecticidal soap Potassium salts of fatty acids (M-Pede) 12 hr. REI NC Organic product</p>	<p>Aphids, mites, thrips, whiteflies, broad mites, leafminers, leafhoppers</p>	<p>Many vegetables including bulb, cole, leafy, fruiting and cucurbit types</p>	<p>Works by contact. Short residual activity. Thorough coverage of all plant parts is needed. Refer to label for information on plant safety. Can be tank mixed with other products to increase efficacy.</p>
<p>Iron phosphate (Sluggo Snail and Slug Bait) 0 hr. REI NC Organic product</p>	<p>Slugs and snails</p>	<p>Many vegetables (see label)</p>	<p>Ingestion causes the slugs and snails to cease feeding, become less mobile and begin to die in 3 to 6 days. Best applied in the evening. Non-toxic to cats and dogs.</p>
<p>Neem Oil (Triact 70) 4 hr. REI Organic Product (Trilogy) 4 hr. REI Organic product</p>	<p>Mites and insects (whiteflies, aphids, leafhoppers) <hr/> Aphids, mites, mealybugs Whiteflies and thrips (suppression)</p>	<p>Many vegetable transplants (see labels)</p>	<p>Works by contact. Thorough coverage of all plant parts is important. Refer to label for information on plant safety and precautions for use in the greenhouse.</p>

Parasitic nematodes (NemaShield, Nemasys, Scanmask)	Fungus gnat larvae Nemasys: western flower thrips	Greenhouse vegetables	Available in packages. Remove screens and filters from fertilizer injector or sprayer. Nematodes are very sensitive to ultra violet light and desiccation. For soil dwelling pests such as fungus gnat larvae: Drench on soil surface and then water in. Apply to moist growing media at temperatures between 50-85 °F. For western flower thrips (Nemasys). Foliar application. Do not apply in direct sunlight. Lightly mist plants before application. Efficacy will be variable depending upon relative humidity, temperature, concentration, frequency of application and insect growth stage.
Pyrethrins (PyGanic EC) 12 hr. REI Group 3A Organic product	Aphids, caterpillars, fungus gnat adults, thrips, leafhoppers, whiteflies and others	Many vegetables including bulb, leafy, cole, fruiting and cucurbit types	Contact insecticide. Provides rapid knockdown of pests.
Soybean Oil (Golden Pest Spray Oil) 4 hr. REI NC Organic product	Aphids, mites, leafminers, certain caterpillars, whiteflies, thrips and others	Vegetables such as cabbage, cauliflower, cucurbits, lettuce, melon, peppers, squash and tomatoes	Works by contact. See label for information on plant safety.
Sucrose Octanoate Esters (SucraShield) 48 hr. REI NC Organic product	Aphids, caterpillars, leafhoppers, mites, thrips and whiteflies	Many vegetables (see label for specific types)	Contact insecticide with limited residual activity. Thorough coverage of all plant parts is needed. Sucrose octanoate esters are produced in the hairs of tobacco leaves.

Resistance Groups (number and letter) indicate products with a common mode of action based on the Insecticide Resistance Action Committee (IRAC) guidelines at <http://www.irac-online.org/>. For multiple applications to one crop, select products from different resistant groups.

NC = Not Classified

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Table 2. Selected Fungicides and Bactericides Labeled for Vegetable Bedding Plants

Fungicide	Targeted Pest	Labeled Crops	Comments
<p><i>Bacillus pumilus</i> (Sonata) 4 hr. REI Group 44 Organic product</p>	<p>Downy mildew, powdery mildew on many different crops (see label) Early blight, late blight on certain fruiting vegetables</p>	<p>Many including cole crops, cucurbits, fruiting, leafy vegetables</p>	<p>Broad spectrum preventative biological fungicide. Begin applications when conditions in the greenhouse favor disease development.</p>
<p><i>Bacillus subtilis</i> (Cease) 4 hr. REI Group 44 Organic product</p>	<p>Fungal and bacterial leaf spots, powdery mildew, botrytis blight, downy mildew (see label)</p>	<p>Many including cole crops, cucurbits, fruiting vegetables, leafy vegetables, bulb vegetables</p>	<p>Broad spectrum, preventative biological fungicide. Begin applications when conditions in the greenhouse favor disease development. Thorough coverage is essential.</p>
<p><i>Bacillus subtilis</i> (Companion Liquid Biological Fungicide) 4 hr. REI NC Organic product</p>	<p>Damping off fungi, root rots (<i>Fusarium</i>, <i>Pythium</i>, <i>Phytophthora</i>, <i>Rhizoctonia</i>) <i>Botrytis</i>, leaf spots, (fungal and bacterial), powdery mildew</p>	<p>Many including cole crops, cucurbits, fruiting vegetables, leafy vegetables, bulb vegetables</p>	<p>Preventative biological fungicide for control and suppression of soil and foliar diseases. Activates ISR (induced systemic resistance).</p>
<p>Copper Hydroxide (Champ WG) Organic product Group M1</p>	<p>Leaf spots, <i>Anthracnose</i>, Bacterial spots and other diseases (see label)</p>	<p>See label for specific crops.</p>	<p>Protectant, contact fungicide. See label for specific usage instructions. Several</p>
<p>Copper soap (Camelot O) 4 hr. REI Organic Product</p>	<p>Anthracnose, bacterial spot, early blight, late blight, leaf spots (various), downy mildew, powdery mildew</p>	<p>Cole crops, lettuce, onions, tomatoes, eggplant, peppers and others</p>	<p>Works by contact. See label for specific usage instructions.</p>
<p>Hydrogen dioxide (Oxidate) 0 hr. REI 1 hr. REI (spray) Organic product N/A</p>	<p>downy mildew, powdery mildew, leaf spots and blights, and root rots (see label)</p>	<p>Tomatoes, peppers, leafy and cole crops, cucurbits, bulb crops and others</p>	<p>Works by contact. Strong oxidizing agent.</p>

Insecticidal soap Potassium salts of fatty acids (M-Pede) 12 hr. REI Organic product	Powdery mildew	Greenhouse cucumber	Works by contact. See label for usage instructions.
Kaolin (Surround WP) 4 hr. REI Group NC Organic product	Powdery mildew	Cucurbit vegetables	Forms a mineral-based particle film resulting in a dry, white film. May be unsightly for retail sales. Uniform coverage important for effectiveness.
Neem Oil (Trilogy) 4 hr. REI Organic product	<i>Alternaria</i> , <i>Anthraco</i> se, Early blight, <i>Botrytis</i> , Leaf spots, Downy Mildews, powdery mildew	Many different vegetables (see label).	Broad spectrum, contact fungicide.. See label for plant safety precautions. Plant injury may occur during humid conditions in the greenhouse.
Potassium bicarbonate (Milstop) 1 hr. REI (Kaligreen) 4 hr. REI Group NC Organic product	Powdery mildew (see labels for more information) Kaligreen is only labeled for powdery mildew	Many vegetables including cabbage, cucumber, eggplant, broccoli, cauliflower, lettuce, peppers, tomatoes and squash	Contact fungicide. Through coverage essential. Potassium bicarbonate disrupts the potassium ion balance in the fungus cell, causing the cell walls to collapse.
<i>Reynoutria sachalinsis</i> (Regalia) 24 hr. REI Organic product	Powdery mildew, downy mildew, gummy stem blight, bacterial blight, bacterial leaf spot, early and late blight (depends upon crop)	Edible crops such as cucurbits, peppers, leafy vegetable crops, and tomato	Formulation of an extract from the Giant Knotweed. Use preventatively to increase natural defense system of plants.
<i>Streptomyces griseoviridis</i> strain K 61 (Mycostop) 4 hr. REI Group NC Organic product	For control of seed rot, root and stem rot (<i>Fusarium</i> , <i>Alternaria</i> , and <i>Phomopsis</i>). Suppression of <i>Botrytis</i> , and root rots of <i>Pythium</i> , <i>Phytophthora</i> and <i>Rhizoctonia</i> in the greenhouse	Many including lettuce, cole crops, cucumbers, melons, peppers, tomatoes and others	Preventative biological fungicide. Contains a beneficial bacterium. Repeat applications may be needed. Use as a soil spray or drench.

<i>Streptomyacin lydicus</i> (Actinovate SP) 1 hr. REI Group NC Organic product	Suppression of soil borne fungi such as <i>Fusarium</i> , <i>Rhizoctonia</i> , <i>Pythium</i> , <i>Phytophthora</i> , and foliar diseases such as downy mildew, powdery mildew, <i>Botrytis</i> , <i>Alternaria</i> and others	All greenhouse vegetables	Preventative biological fungicide for suppression of root rot diseases and some foliar pathogens
<i>Streptomyces lydicus</i> (Actino-Iron) 4 hr. REI Group NC Organic product	Suppression of <i>Fusarium</i> , <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Phytophthora</i> , and others	Greenhouse vegetables.	Preventive biological fungicide that suppresses certain diseases. Also, contains iron and humic acid.
Sulfur (Microthiol Disperss) (Micro Sulf) 24 hr. REI Group M2 Organic Product	Powdery Mildew	See labels for specific crops.	Contact fungicide. Crops grown in greenhouses may be more sensitive to sulfur injury, so the lowest label rate should be tried initially. Do not use within two weeks of a oil spray treatment.
<i>Trichoderma harzianum</i> (PlantShield HC) (RootShield) 0 hr. REI Group NC Organic product	<i>Pythium</i> , <i>Rhizoctonia</i> , <i>Fusarium</i> , <i>Cylindrocladium</i> and <i>Thielaviopsis</i>	Fruiting vegetables, leafy vegetables and cole crops; Soil applications only	Preventative biological fungicide. It will not cure diseased plants. Avoid applications of fungicides at least one week before or after application. (Foliar applications only for non-food crops.)

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. To avoid any phytotoxicity problems, spot test first before widespread use.

* Fungicides are grouped by their mode of action (MoA) and each MoA group is assigned a Fungicide Resistance Action Committee (FRAC) code. Most systemic fungicides (that are absorbed into plant tissues) are specific in their mode of action. Protectant fungicides are less likely to develop resistance problems as they have multi-site modes of action (M). To prevent the development of resistance, alternative applications among different FRAC codes and incorporate biological fungicides into your disease management plan. See www.frac.info/frac/index.htm

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Table 3. Scouting Guidelines and Biological Control Options for Vegetable Bedding Plants and Tranplants

Pest	How to Monitor	Where to Look	Biological Control Options
Aphids	Monitor weekly. Rely on plant inspection, not sticky cards. Look for small, 1/16 inch long aphids with two cornicles or “tailpipes” at the rear of their body. Identification to species is needed to determine which host specific aphid parasite to release when using biological controls. If uncertain, mixes of different species are available.	Underside of leaves and along stems on tips of new growth on eggplant, pepper, tomatoes and many different leafy vegetables. Signs of aphid activity: shed white skins, shiny honeydew, presence of ants, curled new leaves, and distorted growth.	<i>Aphidoletes aphidimyza</i> (aphid midge, predator) <i>Aphelinus abdominalis</i> (aphid parasite) <i>Aphidius matricariae</i> (aphid parasite) <i>Aphidius colemani</i> (aphid parasite) <i>Aphidius ervi</i> (aphid parasite) <i>Chrysoperla spp.</i> (green lacewing, predator)
Bacterial Leaf Spot	At first, chocolate-brown spots are less than 1/4 inch in diameter, & water-soaked in appearance on pepper. Severely spotted leaves appear scorched and defoliation may occur. Some strains cause leaf spot on tomatoes.	Seed-borne disease. More prevalent during moderately high temperatures and long periods of high humidity and leaf wetness.	<i>Bacillus subtilis</i> (Cease) (biofungicide)
Botrytis blight	Look for leaf blight and tan stem cankers. Botrytis blight produces characteristic gray fuzzy appearing spores on the surface of infected tissues during humid conditions.	In areas where plants are spaced close together and where condensation may occur.	<i>Bacillus subtilis</i> (biofungicide) (suppression) <i>Streptomyces griseoviridis</i> (suppression) <i>Streptomyces lydicus</i> (suppression)
Broad Mites	Look for symptoms of damage – leaf edges curling downward, twisted and distorted growth. Under a microscope, look on underside of leaves for mites and their eggs.	Near ornamental crops affected with broad mites.	<i>Neoseiulus californicus</i> (predatory mites) <i>Neoseiulus cucumeris</i> (predatory mites)
Cyclamen Mites	Look for symptoms of damage – inward curling of leaves, puckering and crinkling. Under a microscope, look within buds for mites and their eggs.	Near ornamental crops affected with cyclamen mites.	<i>Neoseiulus cucumeris</i> (predatory mite) <i>Neoseiulus californicus</i> (predatory mite)

Damping Off (Pythium Root and Stem Rot)	Monitor seed flats of susceptible plants. Inspect weekly. Visually examine roots for cortex that sloughs off leaving central core.	Inspect plants weekly for signs of disease: Wilted, stunted off-color plants with discolored root systems. Focus on areas where plants stay wet. or where there may be high populations of shore flies that may carry disease spores. High soluble salts/fertility increases susceptibility.	<i>Bacillus subtilis</i> (biofungicide) <i>Trichoderma harzianum</i> (biofungicide) <i>Streptomyces griseoviridis</i> (biofungicide) <i>Streptomyces lydicus</i> (biofungicide)
Damping Off (Rhizoctonia Root and Crown rot)	Monitor seed flats of susceptible plants including cole crops, peppers, and tomatoes. Look for small, water-soaked spots on stems or leaves before seedlings collapse.	Seed flats near walkways or near dust and debris. Overcrowded seedling flats are more susceptible to damping off.	<i>Bacillus subtilis</i> (biofungicide) <i>Streptomyces griseoviridis</i> (biofungicide) <i>Streptomyces lydicus</i> (biofungicide) <i>Trichoderma harzianum</i> (biofungicide)
Fungus gnats	Use sticky cards to monitor for adults. Place cards horizontally above soil surface. Potato chunks can be used to monitor for larvae. Check every two days.	Favorable habitats include areas with standing pools of water, mud floors, spilled media and weeds.	<i>Bacillus thuringiensis</i> subsp. <i>israelensis</i> (pathogen) <i>Atheta coriaria</i> (predatory beetles) <i>Hypoaspis miles</i> (predatory mites) <i>Steinernema feltiae</i> (nematodes)
Powdery mildew	Scout weekly. Look for faint, white fungal threads and spores on leaves.	Scout near vents, or any location with a sharp change between day and night temperatures.	<i>Bacillus subtilis</i> (biofungicide) <i>Streptomyces griseoviridis</i> (biofungicide) <i>Streptomyces lydicus</i> (biofungicide)
Spider Mites (Two-spotted Spider mites)	Rely on plant inspection. Look for light flecking, speckling or discolored foliage, and webbing if high populations have developed.	Look in hot, dry locations in greenhouse (i.e. near furnace) or near entranceways.	<i>Feltiella acarisuga</i> (predatory midge) <i>Neoseiulus californicus</i> (predatory mites) <i>Phytoseilus persimilis</i> (predatory mites)
Thrips (Western flower thrips)	Rely on sticky cards (placed just above crop canopy) and foliage inspection of key plants for early detection and to evaluate treatments. Use petunia and fava bean plants to indicate early thrips feeding.	Inspect plants by tapping tender new growth over a white sheet of paper. Watch for curled, emerging leaves, distorted new growth on pepper. Look for white scarring and black fecal spots (size of pin point) on foliage of cucumber and eggplant.	<i>Amblyseius swirskii</i> (predatory mite) <i>Chrysoperla spp.</i> (green lacewing, predator) <i>Hypoaspis miles</i> (predatory mites) <i>Neoseiulus cucumeris</i> (predatory mites) <i>Orius insidiosus</i> (pirate bug, predator)

<p>Tospovirus Impatiens Necrotic Spot Virus (INSV) & Tomato Spotted Wilt Virus (TSWV)</p>	<p>Symptoms will vary depending upon the host. On pepper, look for necrotic spots on the leaf. Ringspots may also develop. On tomato, young leaves may develop small, dark brown spots.</p>	<p>Thrips populations may be highest at front and rear of the greenhouse. Use fava bean or petunia indicator plants to determine if thrips are carrying the virus. Symptomless weeds may also be a source of virus.</p>	<p>None See thrips.</p>
<p>Whiteflies</p>	<p>Rely on plant inspection to detect immature stages. Use sticky cards to monitor adults.</p>	<p>Egg laying adults are found on the uppermost tender leaves of tomatoes, eggplant and assorted greens. Immature stages are stationary and are found on the undersides of leaves.</p>	<p><i>Chrysoperla spp.</i> (green lacewing, predator) <i>Amblyseius swirski</i> (predatory mite) <i>Eretmocerus sp.</i> (sweet potato whitefly parasite) <i>Encarsia formosa</i> (greenhouse whitefly parasite)</p>