

Insect and Mite Control Options for plants grown in Wyoming Greenhouses

(Includes hoop houses and high tunnels).

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Whether you grow fruit and vegetables in a traditional garden space or in a protected space such as a greenhouse, low tunnel, hoop house, and/or high tunnel, you will eventually have insect or mite problems. Structures not only protect the plants from the elements but also provide optimal growing conditions for pests. Scouting, correct identification, and understanding the feeding damage and reproductive methods of these pests are critical to any good defensive strategy. It is important to understand control options available and have a plan in place to quickly implement tactics that work best for your production strategy. If you choose to use biorational or conventional pesticides as control methods it is important to know that the Wyoming Department of Agriculture classifies hoop houses and high tunnels as greenhouses. This is important to note as all Worker Protection Standard regulations for greenhouse workers must be followed. The Worker protection standard can be found at: <http://www.epa.gov/agriculture/twor.html>

There are many control options available to you and the best management plan utilizes Integrated Pest Management Strategies (IPM). IPM can be defined as: A sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. In other words it is the understanding of all possible controls and utilizing the best combination of tactics to manage the problem – consider IPM as a “toolbox” full of control options.

Integrated Pest Management (IPM)

Identify what is there - DETECTION METHODS

Pest Detection by Traps

In order to implement a proper control plan you must first identify the insects present and one way to do this is by trapping what is there. Commercially available (Table 1) yellow sticky traps in high tunnels will catch winged insects including aphids, leafminers, thrips, whiteflies, fungus gnats, and shore flies. Blue traps are sometimes better at detecting western flower thrips.

Table 1. Commercial Sources of Insect Traps

Great Lakes IPM 10220 Church Street, NE Vestaburg, MI 48891 (989) 268-5693 www.greatlakesipm.com	Trece, Inc. P.O. Box 6278 Salinas, CA 93912 (408)758-0204 www.trece.com (pheromone lures and traps)	Gempler's P.O. Box 270 Belleville, WI 53508 (800)382-8473 http://www.gemplers.com (general supplier)	Olson Products Inc. P.O. Box 1043 Medina, OH 44258 (216)723-3210 www.olsonproducts.com (sticky card traps)
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Attach sticky traps to a wooden stake and place the stake vertically in or near a plant at or just above the top of the foliage. Other pests can be trapped by placing the sticky trap just above the soil surface. Be sure to place some traps near vents, doors, and other areas where pests may be found. Some growers place traps outside of a high tunnel to help detect insects moving in from outside. The number of traps to use will depend upon your objectives and ability to inspect them. A minimum number should be two to three per structure, but more will be better, especially if using traps to monitor whitefly population trends. A good rule of thumb in large structures is to use 1 trap per 1,000 square feet of farmable or production space.

Traps should be visually inspected weekly. Captured insects should be identified and counted to determine the infestation level. Estimates of pest population densities are usually sufficient to determine if control measures are needed. Some people prefer to deploy traps for shorter periods; for example, a few hours or a day, to get a better picture of insect activity at that moment. Number the traps and create a map for reference so all traps can be monitored.

Pest Detection by Plant Inspection

Sticky traps will not replace plant inspection as a pest detection method. Whiteflies occur in localized infestations that traps may not detect. Non-winged aphids and spider mites are not caught on traps. Therefore, plant inspection is a very important part of a pest management program. Inspect plants in all areas of the high tunnel, looking underneath leaves near the top, middle, and lower parts of plants. A 10-30X hand lens can aid in detecting plant pests. It is important to identify what is there and take appropriate control measures when necessary.

INSECT IDENTIFICATION

The most common greenhouse pests include: whiteflies, aphids, mealybugs, scale insects, thrips, flies, leafminers, “caterpillars”, and spider mites. A little knowledge of insect biology particularly the types of mouthparts and feeding damage they inflict can assist you in the identification of these and other insect pests (Table 2).

Table 2. Insect identification via damage to plants.

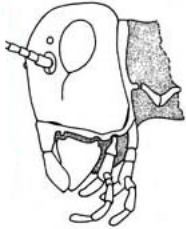
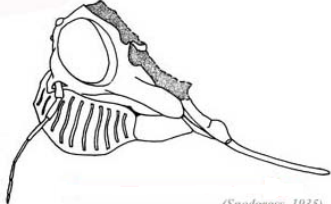
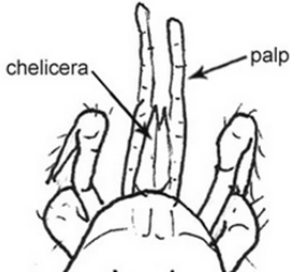
Mouthpart type	Damage	Example	
Chewing	Insects are grazers. Leaf tissue is removed.	"caterpillars" Lepidoptera larvae, grasshoppers	 <small>(Snodgrass, 1935)</small>
Piercing-sucking (needle-like)	Insects feed on plant sap (phloem). Feeding wounds may not be evident - but plant may be wilted or covered with sticky honeydew.	Whiteflies, Aphids, Mealybugs, Scale Insects	 <small>(Snodgrass, 1935)</small>
Scraping – modified cone shaped piercing sucking	Pierce or scrap the leaf surface, disrupting cell membranes, consume cell fluid as it leaks out. Feeding damage described as being "mottled" or blotchy.	Thrips and Spider mites	 chelicera ← palp

Table 3 will assist you in identification of the usual suspects that can be found damaging garden and greenhouse produced crops.

Some control strategies can be implemented ahead of time to mitigate a potential problem. Other control strategies must be implemented immediately once you have identified the pest. Regardless, you must have a control strategy that can be best implemented to suit your needs.

CONTROL METHODS

Cultural Control

Destroy crop residues promptly after harvest. The longer these plants remain, the greater the chances for pest problems. It is recommended not to compost plant residue in a high tunnel as it can become a pest harborage. Also, do not place the crop residues immediately outside of the high tunnel; the flying adults from many insect species will simply move back inside. Vegetable gardens planted adjacent to a high tunnel can also become sources for recurring infestations. If an infestation is isolated to a few plants remove them or the affected tissue and discard away from the area of production

Table 3. Insects commonly found in vegetable gardens, greenhouses, hoop houses, and high tunnels.






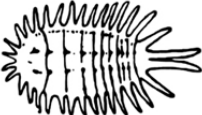

Pest	Description	Tell Tale indicators	Other comments	Looks like
whiteflies	Adults are small, white, “flies”, poor fliers. Immature whiteflies are small green/yellow discs. All life stages have piercing-sucking mouth parts and feed on plant sap. Prefer Tomatoes.	Plants off color, wilted, surface may be sticky – look off color (dark) or blotchy (stipled). Ants and other hymenopterans may be present.	Generally found on the underside of plant leaves.  Whitefly	 UGA1316008 Scott Bauer, USDA Agricultural Research Service, Bugwood.org
aphids	Small, tear-dropped shaped. Long Slender legs. Immature aphids look just like adults only smaller. Cornicles (pipe-like protrusions) on abdomen. Some adults may have wings. Poor fliers. Can be any color. All life stages have piercing-sucking mouth parts and feed on plant sap. Parthenogenic (reproduce without males) and Ovoviviparous (born pregnant) = High reproductive rate.	Plants may be wilted, surface may be sticky – look off color (dark) or blotchy (stipled). White “cast skins” may be present. Ants and other hymenopterans may be present.  Aphids	Honeydew-plant sap excreted through Cornicles. Sooty or Black mold (fungus) may be growing on honeydew. Found on underside of leaves and plant stems.  DGA526860 Christina DiFonzo, Michigan State University, Bugwood.org	 5368255 Merle Shepard, Gerald R.Carner, and P.A.C Ooi, Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia, Bugwood.org
mealybugs	Small, oval, immature stages have waxy white “fuzz” over back side of body. Immature stages most common and more easily noticed, adults are winged. All life stages have piercing-sucking mouth parts and feed on plant sap.	Plant leaves may be distorted and yellow. “White fuzzy stuff on leaves and stems of plants”.	Usually “hide” near plant veins or nodes on stems or cracks in bark. 	 DGA1435063 Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Table 3. Insects commonly found in vegetable gardens, greenhouses, hoop houses, and high tunnels. (cont'd)




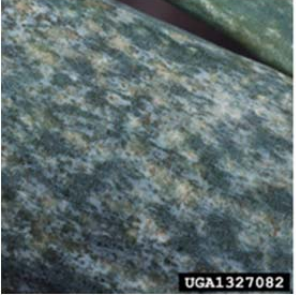



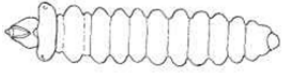





Pest	Description	Tell Tale indicators	Other comments	Looks like
scale insects	<p>Adult females are round to oval and attached to host. Males are winged. Scale insects are categorized as being soft, hard, or cottony. Most likely will only see adult females. All stages have piercing-sucking mouthparts.</p>	<p>General decline of plant, plant may be sticky.</p> 	<p>Immature scale insects overwinter underneath the dead female and emerge in the spring as “crawlers”. Crawlers move to new locations on the plant and can be mistaken for mites.</p>	 <p>5402150 Lesley Ingram, Bugwood.org</p>
thrips	<p>Small, rod or cigar-shaped. Immature and adults look similar – adults will have wings. Scraping mouthparts.</p> 	<p>Feeding damage appears to be thin scraps on plant surface. Can be found on all parts of the plant. Damage can make plant have tan/brown or frosted color.</p>	<p>Can use sticky traps to catch, monitor and identify.</p>  <p>UGA1327082 Damage - Alton N. Sparks, Jr., University of Georgia, Bugwood.org</p>	 <p>UGA1327077 Alton N. Sparks, Jr., University of Georgia, Bugwood.org</p>
flies	<p>Fungus gnat adults are small, dark and relatively poor fliers. Larvae are white, slender, legless, “maggots” with a black head and smooth semi-transparent skin revealing digestive tract contents. They feed on root tissue – can be a pest in potted plants.</p>	<p>Pesky small flies, in and around plants.</p>  <p>Adult</p>	<p>Can use sticky traps to catch, monitor and identify.</p>	 <p>UGA1455189 Whitney Cranshaw, Colorado State University, Bugwood.org</p>

Table 3. Insects commonly found in vegetable gardens, greenhouses, hoop houses, and high tunnels. (cont'd)

Pest	Description	Tell Tale indicators	Other comments	Looks like
leafminers	Usually small maggot-like larvae. Can be legless or have legs depending on which Order they belong. Can be the larvae of beetles, flies, or moths.	Larvae feed and develop in between the tissue layers of leaves. Tunnels in the leaf. 	Many different pests in this group – larvae are the stage causing damage. Most damage is cosmetic. Control can be as simple as removing infested leaves.	 UGA1296198 Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
caterpillars	“Worm-like” larvae, adults are butterflies and moths. 	Larvae cause damage. Have chewing mouthparts – remove large portions of plants while feeding.	Aggressive feeders, many host plants, may produce webbing.	 5454411 Charles Ray, Auburn University, Bugwood.org
spider mites	Very Small, may need a hand lens to see (about the size of a period on this page. Eggs are round, smooth and shiny.	Webbing on and around leaves. Plant will be stipled – very small feeding wounds intermixed with more normal tissue. Damaged tissue can turn brown described as “bronzing”.	Leaves may become misshaped, galls may form.  Spider mite	 UGA1224020 Jerry A. Payne, USDA Agricultural Research Service, Bugwood.org

Physical/Mechanical Control

Screens can be useful in reducing the movement of some insects into a high tunnel. Whiteflies, leafminers, Lepidoptera (moths), and winged aphids can be excluded relatively easily. Thrips are very difficult to exclude because of the small screen mesh size required. The use of screens will require increasing the screen surface area over openings in a high tunnel to compensate for reduced air flow. The calculations for surface area increase can be made in cooperation with the screen supplier. High tunnels with mechanical ventilation can be screened more easily than high tunnels with natural ventilation. Colored plastic mulches have been shown to have some repellency of some of the pest insects.

Biological Control

Biological control of insects and mites on high tunnel vegetable crops is practiced worldwide. There are beneficial insects and mites available from commercial sources for control of nearly every major insect or mite pest. The most difficult pest to control biologically (and chemically) is the western flower thrips. Many growers are able to use biological control as their primary pest management method. Other growers will try to integrate pesticides with few or no harmful effects on beneficials into their program, or apply pesticides only to localized areas where pest infestations are above acceptable levels. Some growers will use biological controls for part of the year, changing to pesticides if pests become too numerous. Even more than when using pesticides, biological control requires a good pest scouting and monitoring program. One of the keys to success while using predators and parasites is to keep the predators and parasites in the structure long enough for them to reproduce. This can be achieved by caging the predators and parasites with the prey species (or adequate alternative food and water source) for at least 7 days. Tables 4-6 provide data on available predator and prey species and United States suppliers from whom they can be ordered. Additional references concerning insect suppliers and biological control are listed in Appendices I & II.

Table 4. Common predators and their Prey.

Predators	Classification	Common Name	Predatory Life Stage	Prey	Supplier
<i>Cybocephalus nipponicus</i>	beetle	Scale picnic beetle	all	general predator	2
<i>Chrysoperla carnea</i>	lacewing	Aphid Lion; Pearly Green Lacewing	larvae	aphids, caterpillars, leafhoppers (nymphs), mealybugs, spider mites, scales, thrips, whiteflies in field crops, orchards, and greenhouses	2,3,4,5,6,8,9
<i>Chrysoperla rufilabris</i>	lacewing	Aphid Lion; Green Lacewing	larvae	aphids, mites and insect eggs	1&7
<i>Cryptolaemus montrouzieri</i>	ladybird beetle	Mealybug Destroyers	all	mealybugs (as well as aphids, whiteflies, soft scales when mealybugs not present) on citrus, grapes, and ornamentals	1-8
<i>Delphastus catalinae</i>	ladybird beetle	Whitefly predatory lady beetle	all	sweetpotato whitefly and greenhouse whitefly	1,3
<i>Delphastus pusillus</i>	ladybird beetle	Whitefly Exterminator	all	sweetpotato whitefly and greenhouse whitefly	2,4,6
<i>Rhyzobius lophanthae</i>	ladybird beetle	NA	all	Scales in citrus, interiorscapes, ornamentals	1,2
<i>Hippodamia convergens</i>	ladybird beetle	convergent ladybeetle	all	Aphids, thrips, whiteflies, and other soft-bodied insects in vegetables and orchards	2,3,4,5,6,7,8
<i>Stethorus punctillum</i>	ladybird beetle	Spider mite destroyer	all	Two-spotted and red spider mites	2,3,4
<i>Atheta coriaria</i>	rove beetle	NA	all	fungus gnats & Shore flies	1&2
<i>Tenodera ardifolia sinensis</i>	mantis	Chinese mantid	all	aphids, scale, mites, mosquitoes	2,3,4,8
<i>Aphidoletes aphidimyza</i>	midge	cecidomyiid fly	larvae	aphids	1,2,5,6,7
<i>Amblyseius cucumeris</i>	mite	NA	all	thrips in greenhouse vegetables and ornamentals	1-8
<i>Amblyseius degenerans</i>	mite	NA	all	thrips in greenhouse sweet peppers	1&2
<i>Amblyseius fallacis</i>	mite	NA	all	mites in apples, mint, strawberries, greenhouses, and nurseries	1&2
<i>Amblyseius swirskii</i>	mite	NA	all	mites, thrips, whiteflies in cucumbers, eggplant, peppers, and strawberries	1&2
<i>Feltiella acarisuga</i>	mite	NA	all	red spider mites on tomatoes	2,3,4
<i>Galendromus occidentalis</i>	mite	NA	all	corn, grapes, tomatoes (russet mite), and ornamentals	1,2,3,5
<i>Mesoseiulus longipes</i>	mite	NA	all	greenhouses and interiorscapes for use on almonds, grapes, strawberries, and ornamentals	1-5
<i>Phytoseiulus persimilis</i>	mite	NA	all	mites in greenhouses, interiorscapes, tomatoes	2,3,4,5,6,7,8
<i>Stratiolaelaps scimitus</i>	mite	Hypoaspis mites	all	Whiteflies, aphids, lepidoptera larvae, fungus gnat larvae and soil-dwelling insects in greenhouse vegetables and ornamentals.	1,2,3,4,7
<i>Dicyphus hesperus</i>	true bug	NA	all	whiteflies on tomatoes	2
<i>Orius insidiosus</i>	true bug	Minute Pirate bug	all	control of thrips on greenhouse vegetables, ornamentals	3,4,7

Table 4. Common predators and their Prey. (cont'd)

Predators	Classification	Common Name	Predatory Life Stage	Prey	Supplier
<i>Podisus maculiventris</i>	true bug	Spined soldier bug	all	Mexican bean beetle, cabbage looper, and imported cabbageworm	3
<i>Xylocoris flavipes</i>	true bug	Warehouse pirate bug	all	general predator	2

Table 5. Common Parasites and their Hosts.

Parasites	Classification	Host	Supplier
<i>Aphelinus abdominalis</i>	wasp	potato aphid	1&2
<i>Aphidius colemani</i>	wasp	aphids	1,2,3,5,7
<i>Aphidius ervi</i>	wasp	potato aphid	1,2,7
<i>Aphidius matricariae</i>	wasp	aphids	2,4,6,7
<i>Aphytis melinus</i>	wasp	red scale, yellow scale, San Jose scale, and oleander scale	1,2,3,4,6,7
<i>Cotesia plutella</i>	wasp	lepidoptera larvae	2,3
<i>Diglyphus isaea</i>	wasp	Leafminers in greenhouse tomatoes	1,2,3,4
<i>Encarsia formosa</i>	wasp	whiteflies in greenhouse cucumbers, peppers, tomatoes	1-8
<i>Eretmocerus eremicus</i>	wasp	silverleaf and sweetpotato whiteflies	1,2,3,7
<i>Eretmocerus mundus</i>	wasp	sweetpotato whitefly in greenhouses	2
<i>Leptomastix dactylopii</i>	wasp	mealybugs	2
<i>Metaphycus spp.</i>	wasp	scale insects	7
<i>Muscidifurax spp.</i>	wasp	fly control	1,2,3,4,9
<i>Pediobius foveolatus</i>	wasp	Mexican bean beetle on beans, soybeans	2,3
<i>Trichogramma spp.</i>	wasp	moth eggs of: armyworm, bollworm, caneborer, codling moth, cutworm, fruitworm, leafworm, loopers	1,2,3,4,5,7,8,9,10

Table 6. US suppliers of Predators and Parasites (reference number corresponds with information in tables 3 and 4).

1	2	3	4	5
IPM Laboratories, Inc. P.O. Box 300 Locke, NY 13092-0300 315-497-2063 www.ipmlabs.com	Rincon-Vitova Insectaries, Inc. P.O. Box 1555 Ventura, CA 93002-1555 805-643-5407 www.rinconvitova.com	ARBICO Organics P.O. Box 8910 Tuscon, AZ 85738-0910 520-825-9785 www.arbico-organics.com	Nature's Control P.O. Box 35 Medford, OR 97501 541-245-6033 www.naturescontrol.com	Harmony Farm Supply 3244 Hwy. 116 N. Sebastopol, CA 95472 707-823-9125 www.harmonyfarm.com
6	7	8	9	10
Hydro-Gardens, Inc. 8765 Vollmer Rd. Colorado Springs, CO 80908 719-495-2266 www.hydro-gardens.com	M&R Durango, Inc. P.O. Box 886 Bayfield, CO 81122 970-259-3521 www.goodbug.com	Natural Pest Controls 8320-B (barn) Hazel Ave. Orangevale, CA 95662 916-871-3159 www.natural-pest-controls.com	Beneficial Insectary, Inc. 9664 Tanqueray Ct. Redding, CA 96003 530-226-6300 www.insectary.com	A-1 Unique Insect Control 5504 Sperry Dr. Citrus Heights, CA 95621 916-961-7945 www.a-1unique.com

Chemical Control

Many products used to control pest insects can also be harmful to beneficial insects. However, sometimes pesticides will be the only management choice that makes sense. With proper management, potential harmful effects can be mitigated. One of the ways to lessen these effects is to not use pesticides for at least 30 days before beginning a biological control program and do not use them anywhere in the structure after beginning a biological control program. Local or "spot" applications generally are less harmful to natural enemies than treating the entire high tunnel. Some registered pesticides are "soft" on beneficial insects and mites. These products are considered "bio-rational pesticides" and are listed in table 7. All of these products are OMRI (Organic Materials Review Institute) listed and include *Bacillus thuringiensis*, which is a bacterium specific for controlling the pest species. Insecticidal soaps, an insect specific fungus *Beauveria bassiana*, azadirachtin (extract from seeds of the neem tree), and pyrethrum tend to be less harmful than conventional materials. This does not mean these materials are harmless, but that natural enemies can be re-introduced soon after an application without any deleterious effects.

Application method and formulation will affect the toxicity, or lack thereof, of pesticides to natural enemies. There are a number of studies that have conflicting information concerning how long a particular pesticide will remain harmful to a natural enemy. When in doubt, be conservative.

A list of conventional products registered in Wyoming for use in greenhouses (including hoop houses and high tunnels) can be found in Table 8. Several of these are insect growth regulators which disrupt the development of insects and are classified as "reduced risk" products. Insect growth regulators are insect specific and have been proven to be nontoxic mammals.

When managing pesticide resistance, it is important to understand the mode of action of a particular product. This indicates how the product works on the insect. It is a good idea to rotate products with different IRAC (Insecticide Resistance Action Committee) action in order to reduce the chance of a pest becoming resistant to a particular product. Appendix III provides more detailed information on IRAC modes of action and is provided for your information and own research.

If choosing to use a pesticide, whether it is considered a bio-rational product or conventional, always read, understand, and follow the label instructions. Calibrate your application equipment and pay particular attention to sections of the label listing the personal protective equipment (PPE), the restricted entry interval (REI), and the postharvest interval (PHI).

One does not need to be afraid of pesticides but they do need to be handled with respect.

Table 7. OMRI listed Bio-rational Pesticides.

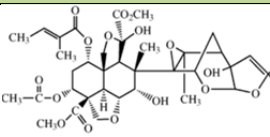

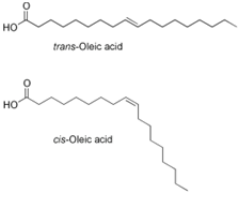
Active Ingredient	Trade Name(s)	Action	Chemistry	Mode of Action	Target	Signal Word	Mammalian Toxicity	PPE	REI (hours)
Azadirachtin	AzaGuard, Azatin XL Plus, Neemix, Neemgold, + multiple others	Insect Growth Regulator, Insecticide IRAC Group 18B	 Classified as a Botanical	Ecdysone agonist/moulting disruptor	Aphids, beetles, borers, caterpillars, flies, leafhoppers, leafminers, nematodes, scales, thrips, weevils, whiteflies	Caution	(Rat): Oral LD ₅₀ >5000 mg/kg. (Rabbit): Dermal LD ₅₀ >2000 mg/kg	Chemical-resistant gloves, Long-sleeved shirt and long pants, Protective eyewear, Shoes plus socks.	4
<i>Bacillus thuringiensis</i> subsp. <i>Kurstaki</i>	Dipel, Foray XG + others	Insecticide IRAC Group 11A1	Spores and crystalline delta-endotoxin as A.I. which are produced by <i>Bacillus thuringiensis</i> subsp. <i>Kurstaki</i> , Serotype H3a3b in fermentation. Classified as a Bacterium	Microbial disruptor of insect midgut membranes	lepidopterous larvae	Caution	Nontoxic	Chemical-resistant gloves, Long-sleeved shirt and long pants, Shoes plus socks.	4
<i>Beauveria bassiana</i>	Mycotrol O, Botanigard, + multiple others	Insecticide	Classification Fungus	Fungal Pathogen	Aphids, mealybugs, psyllids, thrips, weevils, and whiteflies	Caution	Nontoxic	Long-sleeved shirt and long pants, Shoes plus socks, waterproof gloves	4
Diatomaceous Earth	Diatomaceous earth, Insecta-kill, Perma-Guard Crawling Insect Control, + others	Insecticide	 Fossilized remains of diatoms – silicon-dioxide shelled algae.	Physical membrane disruptor, desiccant	Crawling Insects	Caution	Nontoxic – Avoid creating, breathing quantities of dust	None Specified	None Specified
Fatty Acids	Insecticidal Soap, M-Pede, + others	Fungicide, Herbicide, Insecticide, Plant Health Product, Repellent		Physical membrane disruptor	Insects, Weeds, pathogens	Danger, Warning Caution	Toxic to Birds and Fish	Chemical-resistant gloves, Coveralls over short-sleeved shirt and short pants, chemical resistant footwear plus socks. Protective eyewear.	12
Horticultural Oil	Sunspray, Scalecide, Saf-T-Side + others	Fungicide, Insecticide, Miticide	Refined Petroleum Distillate also known as mineral oils, or paraffin oils	Physical membrane disruptor	scales, aphids, mites	Caution Can be phytotoxic	Temporary eye irritant, (Rat) Oral LD ₅₀ >5000 mg/kg	Chemical-resistant gloves, Long-sleeved shirt and long pants, Shoes plus socks.	4

Table 7. OMRI listed Bio-rational Pesticides. (cont'd)

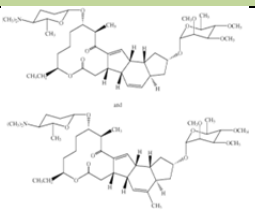
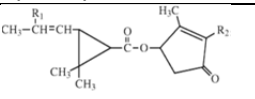
Active Ingredient	Trade Name(s)	Action	Chemistry	Mode of Action	Target	Signal Word	Mammalian Toxicity	PPE	REI (hours)
Spinosad	Entrust, Monterey Insect Spray, + multiple others	Insecticide, Seed Treatment/Protectant IRAC Group 5	 <p>Classification Spinosyn</p>	Nicotinic acetylcholine receptor agonist (allosteric)	Lepidoptera, Diptera, Thysanoptera, and some Coleoptera	Caution	(Rat) Oral LD ₅₀ >5000 mg/kg (female)	Long-sleeved shirt and long pants, Shoes plus socks.	4
Pyrethrins or Pyrethrum	PyGanic + others	Insecticide IRAC group 3	 <p>Classified as a Botanical</p>	Sodium channel modulator	chewing and sucking insects and spider mites	Caution	(Rat): Oral LD ₅₀ 1500 mg/kg. Dermal LD ₅₀ >1800 mg/kg Toxic to Fish and Bees	Chemical-resistant gloves, Long-sleeved shirt and long pants, Shoes plus socks. Approved respirator for fogging concentrates	12

Table 8. Conventional Pesticides (Wyoming Registration for Gardens and Greenhouses)

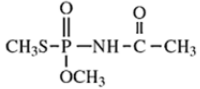
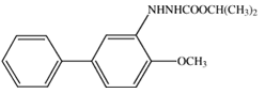
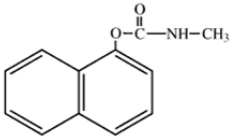
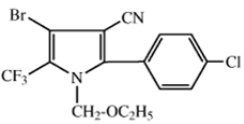
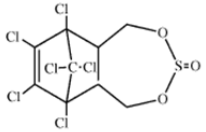
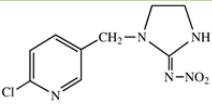
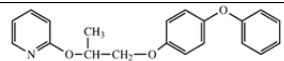
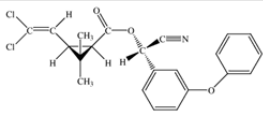
Active Ingredient	Trade Name(s)	Action	Chemistry	Mode of Action	Target	Signal Word	Mammalian Toxicity	PPE	REI (hours)
Acephate	Acephate 75SP, Orthene 75S, + others	Insecticide IRAC group 1	 Classified as Organophosphate	Acetylcholine esterase inhibitor	Leafhoppers, Plant hoppers, & Aphids	Caution	(Rat): Oral LD ₅₀ 1447 mg/kg (male); 1030 mg/kg (female); Inhalation >61.7 mg/kg. (Rabbit): Dermal LD ₅₀ >10,250 mg/kg; Inhalation >14.8 mg/l	Long-sleeved shirt and long pants, Shoes plus socks, Waterproof gloves	24
Bifenazate	Acramite 4SC	Insecticide, miticide IRAC group 25	 <i>Reduced Risk Product</i>	Neuroactive (unknown mode of action)	mites on ornamentals and nonbearing fruit trees	Caution	(Rat): Oral LD ₅₀ >5000 mg/kg; Dermal LD ₅₀ >2000 mg/kg. Inhalation LC ₅₀ (Rat): >4.4 mg/l	Long-sleeved shirt and long pants, Shoes plus socks	12
Carbaryl	Sevin 4F	Insecticide IRAC group 1	 Classified as Carbamate	Acetylcholine esterase inhibitor	Insects on citrus, fruit, vegetables, forage, forests, field crops, nuts, ornamentals, rangeland, turf, shade trees	Warning Caution	(Rat): Oral LD ₅₀ 500-850 mg/kg. (Rabbit): Dermal LD ₅₀ >2000 mg/kg	Long-sleeved shirt and long pants, Shoes plus socks	12
Chlorfenapyr	Pylon	Insecticide, Miticide IRAC group 13		Uncoupler of oxidative phosphorylation via disruption of proton gradient	Insects and mites on vegetables	Caution	(Rat): Oral LD ₅₀ 441 mg/kg (male); 1152 mg/kg (female).	Long-sleeved shirt and long pants, Chemical-resistant gloves, Shoes plus socks	12
Endosulfan	Phaser 3EC, Thiodan 3EC, + others	Insecticide, Miticide IRAC group 2	 Classified as Chlorinated Hydrocarbon	GABA-gated chloride channel antagonist	Insects on vegetables and small fruits – relatively nontoxic to beneficials	Danger-Poison	(Rat): Oral LD ₅₀ 160 mg/kg (male), 22.7 mg/kg (female). (Rat): Dermal >500 mg/kg, (Rabbit) 359 mg/kg	Approved respirator, Long-sleeved shirt and long pants, Shoes plus socks, Waterproof gloves. Hat	24

Table 8. Conventional Pesticides (cont'd)

Active Ingredient	Trade Name(s)	Action	Chemistry	Mode of Action	Target	Signal Word	Mammalian Toxicity	PPE	REI (hours)
Imidacloprid	Admire 2F, Alias 2F, Couraze 2F, + others	Fungicide, Seed treatment, Insecticide IRAC group 4	 Classified as Neonicotinoid	Nicotinic acetylcholine receptor agonist/anatagonist	aphids, Colorado potato beetle, ricehoppers, thrips, whiteflies, on vegetables	Caution	(Rat): 4,690 mg/kg (male rat); 4,070 mg/kg (female rat)	Long-sleeved shirt and long pants, Chemical-resistant gloves plus socks	12
Pyriproxyfen	Distance IGR	Hormone Mimic IRAC Group 7	 Juvenile Insect Hormone Reduced Risk Product	Inhibits molting and adult emergence.	Whiteflies & thrips	Caution	(Rat): Acute Oral LD ₅₀ >5000 mg/kg; Inhalation LC ₅₀ (4 h) >1300 mg/m ³ . (Rabbit): Dermal LD ₅₀ >2000 mg/kg	coveralls over short-sleeved shirt and short pants or long-sleeved shirt, long pants, chemical-resistant gloves	12
Zeta-Cypermethrin	Mustang Max EC	Insecticide IRAC group 3A Restricted use Product (RUP)	 Classified as Non-ester synthetic pyrethroid	Sodium channel modulator	psyllids, leafminers, mites	Warning	(Rat): Acute Oral LD ₅₀ 810 mg/kg	Chemical-resistant gloves, Long-sleeved shirt and long pants, Protective eyewear	12

Appendix

Appendix I. Additional Suppliers of Beneficial Insects and Mites in the United States		
Alternative 349 East 86 th Street, Suite 259 Indianapolis, IN 46240 (317) 823-0432	Biotactics, Inc. 7765 Lakeside Drive Riverside, CA 92509 (909) 320-1366 www.manta.com/c/mm2fncw/biotactics	Koppert Biological Systems, Inc. 28465 Beverly Road Romulus, MI 48174 (800) 928-8827 (734)641-3763 www.koppert.com/
Associates Insectary P.O. Box 969 Santa Paula, CA 93061 (805) 933-1301 www.associatesinsectary.com/	The Green Spot 93 Priest Road Nottingham, NH 03290 (603) 942-8925	Planet Natural P.O. Box 3146 Bozeman, MT 59772 (800) 289-6656 www.planetnatural.com/
<i>The above list is for information only. Contact the individual company for information on prices and ability to supply the required biological controls.</i>		

Appendix II. Additional Information sources concerning biological control:

Resource	Web Address
California Environmental Protection Agency.	http://www.cdpr.ca.gov/docs/ipminov/ben_supp/ben_sup2.htm
Cornell University's site for general information on biological control	http://www.nysaes.cornell.edu/ent/biocontrol/
Association of Natural Biological Control Producers	http://www.anbp.org/

Appendix III. IRAC* Mode of Action and Pest Activity.

Mode of Action	IRAC*	Pest Control Materials Active Ingredient	Type	Pest Activity (based on label)								
				Whitefly	Aphids	Thrips	Mealybugs	Spider Mites	Fungus Gnats	Shore Flies	Leafminers	Lepidoptera Caterpillars
Acetylcholine Esterase Inhibitors	1B	Acephate	C,S,T	X	X	X	X					
	1B	Chlorpyrifos	C		X	X	X		X	X	X	X
	1A	Methiocarb	C		X	X						
Prolong Opening of Sodium Channel	3	Bifenthrin	C	X	X	X	X	X	X			X
		Cyfluthrin	C	X	X	X	X		X			X
		Fenpropathrin	C	X	X	X	X	X			X	X
		Fluvalinate	C	X	X	X		X				X
		Lambda-cyhalothrin	C	X	X	X	X	X			X	X
Nicotinic Acetylcholine Receptor Disruptors	4A	Acetamiprid	C,S,T	X	X	X	X		X		X	X
		Dinotefuran	C,S,T	X	X	X	X		X		X	
		Imidacloprid	C,S,T	X	X	X	X		X		X	
		Thiamethoxam	C,S,T	X	X		X		X			
Nicotinic Acetylcholine Receptor Agonist and GABA Chloride Channel Activator	5	Spinosad	C,T, ST			X		X			X	X
GABA Chloride Channel Activator	6	Abamectin	C,T	X	X	X		X			X	X
Juvenile Hormone Mimics	7B	Fenoxycarb	C	X	X	X	X	X			X	X
	7A	Kinoprene	C	X	X	X	X		X			
	7C	Pyriproxyfen	C,T	X	X		X		X	X	X	
Chitin Synthesis Inhibitors	16	Buprofezin	C	X			X					
	17	Cyromazine	C						X	X	X	
	15	Diblubenzuron	C	X					X	X	X	X
	10B	Etoxazole	C,T					X				
	15	Novaluron	C	X		X					X	X
Growth and Embryogenesis Inhibitors	10A	Clofentezine	C					X				
	10A	Hexthiazox	C					X				
Selective Feeding Blockers	9C	Flonicamid	C,S,T	X	X	X	X					
	9B	Pymetrozine	C,S,T	X	X							
Disruptors of Insect Midgut Membranes	11A1	<i>Bacillus thuringiensis</i> var. <i>israelensis</i>	ST						X			
	11B2	<i>Bacillus thuringiensis</i> var. <i>kurstak</i>	ST									X

Appendix III. IRAC* Mode of Action and Pest Activity (cont'd).

Mode of Action	IRAC*	Pest Control Materials Active Ingredient	Type	Pest Activity (based on label)								
				Whitefly	Aphids	Thrips	Mealybugs	Spider Mites	Fungus Gnats	Shore Flies	Leafminers	Lepidoptera Caterpillars
Oxidative Phosphorylation Uncoupler	13	Chlorfenapyr	C,T			X		X	X			X
Ecdysone Antagonist	18B	Azadirachtin	C	X	X	X	X		X	X	X	X
Mitochondria Electron Transport Inhibitor	20B	Acequinocyl	C					X				
	25	Bifenazate	C					X				
	21	Fenazaquin	C	X				X				
	21	Fenpyroxinate	C				X	X				
	21	Pyridaben	C	X				X				
	21A	Tolfenpyrad	C	X	X	X						X
Desiccation or Membrane Disruptors		Neem oil	C	X	X		X	X				
		Paraffinic oil	C	X	X	X	X	X	X	X		X
		Petroleum Oil**	C	X	X	X	X	X	X	X		X
		Potassium salts of fatty acids ***	C	X	X	X	X	X				
Lipid Biosynthesis Inhibitor	23	Spiromesifen	C,T	X				X				
	23	Spirotetramat	C,S,T	X	X		X	X				
Unknown		<i>Beauveria bassiana</i>	C	X	X	X	X					X
		Pyridalyl	C,T,ST			X						X
Type Codes												
C = Contact												
S = Systemic												
T = Translaminar – moves across cell membranes (usually leaf tissue)												
ST = Ingested												
*Insecticide Resistance Action Committee (IRAC) designation, which appears on product label.												
**Products=PureSpray Green, Ultra-Pure Oil, SuffOil-X												
***Products=Insecticidal Soap and M-Pede												

References

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www.attra.org/attra-pub/gh-whitefly.html

www.attra.org/attra-pub/gh-thrips.html

www.bugguide.net

<http://www.bioworksinc.com/products/shared/mode-of-action-chart.pdf>

<http://www.invasive.org/>

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