Cucurbits

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PEST MANAGEMENT GUIDELINES FOR AGRICULTURE

Contents (Dates in parenthesis indicate when each topic was updated)

An illustrated version of this guideline is available online at http://ipm.ucdavis.edu/PMG/selectnewpest.cucurbits.html

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The UC IPM Pest Management Guidelines are available from:

- Online: http://ipm.ucdavis.edu
- UC Cooperative Extension County Offices
- University of California
  ANR Communication Services
  Richmond, CA 94804
  510-665-2195; 800-994-8849

Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM website for information on updates.

Note to readers: These guidelines are for field production and not greenhouse. They represent the best information currently available to the authors and are intended to help you make the best choices for an IPM program. Not all formulations or registered pesticides are mentioned. Always check the label and with local authorities for the most up-to-date information regarding registration and restrictions on pesticide use. Check with your agricultural commissioner for the latest restricted entry intervals.

http://ipm.ucdavis.edu

Cucurbits Year-Round IPM Program

(Reviewed 10/11)

ANNUAL CHECKLIST

Supplement to UC IPM Pest Management Guidelines

These practices are recommended for a monitoring-based IPM program that enhances pest control and reduces environmental quality problems related to pesticide use.

Water quality becomes impaired when pesticides and sediments move off-site and into water. Air quality becomes impaired when volatile organic compounds (VOCs) move into the atmosphere. Each time a pesticide application is considered, review the Pesticide Application Checklist at the bottom of this page for information on how to minimize water and air quality problems.

This year-round IPM program covers the major pests of cucurbits in the Sacramento, San Joaquin, Coachella, Palos Verde and Imperial valleys, as well as Riverside County. Details on carrying out each practice, example monitoring forms, and information on additional pests can be found in the Cucurbit Pest Management Guidelines (PMG) at http://ipm.ucdavis.edu/PMG. Track your progress through the year with the annual checklist form.

✓ Done	**Preplant** **Special issues of concern related to environmental quality:** runoff, drift, volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**

	Select the field:
	• Consider soil type, cropping and pest history, and plantback restrictions from the previous crop
	• Consider crop rotation for fields with high populations of problematic weeds and difficult pathogens/diseases such as:
	  ◦ Fusarium crown and foot rot
	  ◦ Fusarium wilt (cantaloupe)
	  ◦ Fusarium wilt (watermelon)
	  ◦ Vine disease decline
	  ◦ Vine disease decline (Monosporascus cannonballus)
	  ◦ Root knot nematodes

	Take a soil sample for: • Nutrient, salinity, and pH analysis to determine field suitability and soil nutrient management. Manage salty soils to reduce risk of charcoal rot. • Root knot nematode if there is a history of galls on roots of previous crops. If soil sampling indicates the presence of root knot nematodes, the soil should be treated according to the PMG.
	Clean equipment and tractors between fields to prevent the spread of some soilborne pathogens and weed seeds.
	Identify a planting date that permits harvesting before frost. Consider the following: • If planting into cover crops or no-till fields with heavy residue, additional germination time may be required, as these soils tend to be cooler. • Early-planted melons often avoid competition from barnyardgrass. Late plantings in the San Joaquin Valley for fall harvest and fall-planted melons in desert areas have higher insect and disease pressure, especially viruses.

✓ Done	**Preplant** **Special issues of concern related to environmental quality:** runoff, drift, volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**

	Prepare the field in the fall if a spring planting is planned.
	• Cultivate crop residues.
	• Manage weeds.
	  ◦ Preirrigate the field to germinate weed seeds and cultivate, or apply an herbicide, or in special situations, a soil fumigant according to the Cucurbits Pest Management Guidelines.
	  ◦ Consider a fallow bed herbicide treatment on pre-formed beds to prevent winter weed growth and allow early spring melon planting.
	  ◦ If planting into a cover crop or utilizing conservation tillage or no-till systems, apply a burn-down herbicide prior to planting and before cover crop reaches 1 ft. tall.
	• If using soil fumigants, for weeds or other pests, check the label for details on the minimum time required between application and planting to prevent crop damage.
	• Apply fertilizer, lime, gypsum, or other soil amendments based on soil test results.
	• Most cucurbits grow best at soil pH of 6.0 to 7.0.
	  ◦ If liming is required, applications should be made well in advance of planting to give soil acidity time to adjust.
	• Determine bed size and planting configuration.
	• Prepare planting beds with proper drainage.
	• Choose an irrigation system and schedule.
	• Consider the use of solarization or plastic mulches for pest suppression.

	Consider selecting a hybrid based on pest history. Purchase seed or transplants from a reliable source to ensure quality, indexed, pathogen-negative seed or pest- and disease-free plants.
	Use treated seed: • If seedling root rots (damping-off), seedcorn maggots, or wireworms were problematic in the previous crop. • In no-till, conservation-till, and when planting through cover crops to reduce the potential for seedling disease and insect problems.
	Set out sticky traps for silverleaf whiteflies, green peach aphid, and melon aphid.

✓ Done	**Planting** **Special issues of concern related to environmental quality: drift.** **Mitigate pesticide usage to minimize air and water contamination.**
	Plant seeds or transplants considering: • Soil temperature, depth, moisture level, and seed rate or transplant density to reduce incidence of seedling root rots (damping-off). • Precision planting to promote crop uniformity and close-to-seedline cultivation.
	Check sticky traps for silverleaf whiteflies, green peach aphid, and melon aphid according to the Cucurbits Pest Management Guidelines.
	In the desert production areas of southern California, use row covers over fall planting beds to exclude: • Leafhoppers • Squash bugs • Silverleaf whiteflies • Virus-transmitting green peach and melon aphid. Alternatively, consider applying reflective mulch to repel melon aphids and whiteflies. Silver reflecting mulches have been found to be the most effective. In the desert remove when temperatures are excessive.
	Clean equipment and tractors between fields to prevent the spread of some soilborne diseases and weed seeds.

✓ Done	**Planting** **Special issues of concern related to environmental quality: drift.** **Mitigate pesticide usage to minimize air and water contamination.**
	After planting but before hand weeding or cultivation, survey and identify germinated weeds. • Keep records, noting the presence of problematic weeds. (See example form online.) • Manage according to the Cucurbits Pest Management Guidelines • If herbicides will be used, customize the susceptibility to herbicide table for the weed complex in your field. Learn how.
	If root knot nematodes (*M. incognita*, *M. javanica, M. arenaria*) are a problem, and the soil was not fumigated before planting, treat according to the Cucurbits Pest Management Guidelines.

✓ Done	**Seedlings (cotyledons to 4 leaves)** **Special issues of concern related to environmental quality:** runoff, drift, risk to bees and native pollinators, and volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**
	Look for the following pests or their damage and manage as needed according to the Cucurbits Pest Management Guidelines: • Aphids (green peach and melon) • Beet armyworm • Cabbage looper • Cucumber beetle (adults) • Cutworms • Flea beetles • Squash bugs (in squash, pumpkin, and melon) • Whiteflies
	If needed, manage weeds when small according to the Cucurbits Pest Management Guidelines. Selective herbicides can be used to control emerged grasses and nutsedges. Customize the susceptibility to herbicide table for the weed complex in your field. Learn how.
	Other pests or damage you may see: **Arthropods** • Darkling beetles (not in desert) • Leafminers • Seedcorn maggot • Wireworms (especially on transplants) • Yellowstriped armyworm **Diseases/Nematodes** • Seedling root rots (usually more prevalent in cool, wet soils) • Stunted seedlings, galled roots (root knot nematodes)

✓ Done	**Vegetative growth** **Special issues of concern related to environmental quality:** runoff, drift, risk to bees and native pollinators, and volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**
	Monitor for the following pests or their damage and treat if needed according to the Cucurbits Pest Management Guidelines: **Arthropods** • Aphids (green peach and melon) • Cabbage looper • Cucumber beetles (adults) • Cutworm (in honeydew, crenshaw, and casaba melon) • Leafminers • Spider mites • Squash bugs (in squash, pumpkin, and melon) • Whiteflies **Diseases** • Downy mildew • Powdery mildew

✓ Done	**Vegetative growth** **Special issues of concern related to environmental quality:** runoff, drift, risk to bees and native pollinators, and volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**
	Note symptoms or damage from the following and manage prior to future planting: • Charcoal rot • Fusarium wilt (in cantaloupe, watermelon) • Root knot nematodes • Root rots • Sudden wilt • Verticillium wilt • Vine decline-like symptoms caused by *Pythium* • Viruses (Cucumber mosaic, Cucurbit aphid-borne yellows, Potyviruses, *Squash mosaic virus*)
	If needed, manage weeds with cultivation or herbicide applications according to the Cucurbits Pest Management Guidelines. Controlling weeds prior to vining has the most potential to minimize yield impacts. During cooler seasons or for crops with a long growing season, a layby herbicide can be beneficial. If herbicides will be used, customize the susceptibility to herbicides table for the weed complex in your field. Learn how.
	Take leaf tissue samples for nutrient analysis and apply nutrients as necessary.
	Other pests or damage you may see: **Arthropods** • Darkling beetle • Flea beetles • Grasshoppers and crickets • Leafhopper • Seedcorn maggot • Thrips **Diseases** • *Cucurbit yellow stunting disorder virus*

✓ Done	**Bloom** **Special issues of concern related to environmental quality:** runoff, drift, risk to bees and native pollinators, and volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**
	Remove row covers before first bloom.
	Look for the following pests or their damage and manage if needed according to the Cucurbits Pest Management Guidelines. **Arthropods** • Aphids (green peach and melon) • Beet armyworm • Cabbage looper • Cucumber beetle • Cutworm (in honeydew, crenshaw, and casaba melon) • Spider mites • Squash bug (in squash, pumpkin, and melon) • Yellowstriped armyworm • Whiteflies **Diseases** • Downy mildew • Powdery mildew

✓ Done	**Bloom** **Special issues of concern related to environmental quality:** runoff, drift, risk to bees and native pollinators, and volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**
	Note symptoms or damage from the following and manage prior to future planting: • Charcoal rot • Fusarium wilt (in cantaloupe and watermelon) • Root knot nematodes • Root rots • Sudden wilt • Verticillium wilt • Vine decline-like symptoms caused by *Pythium* • Viruses (Cucumber mosaic, Cucurbit aphid-borne yellows, Potyviruses, *Squash mosaic virus*)
	Other pests or damage you may see: **Arthropods** • Darkling ground beetles • Flea beetles • Leafhoppers • Leafminer • Thrips

✓ Done	**Fruit development** **Special issues of concern related to environmental quality:** runoff, drift, risk to bees and native pollinators, and volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**
	Look for the following pests or their damage and treat if needed according to the Cucurbits Pest Management Guidelines: **Arthropods** • Cabbage looper • Cucumber beetle • Cutworms (in honeydew, crenshaw, and casaba melons) • Darkling beetles • European earwig • Stink bugs • Squash bug (in squash, pumpkin, and melon) • Whiteflies • Yellowstriped armyworm **Diseases** • Downy mildew • Powdery mildew
	Note symptoms or damage from the following and manage prior to future planting: • Charcoal rot • Fusarium wilt (in cantaloupe, watermelon) • Root knot nematodes • Root rots • Sudden wilt (*Pythium*) • Verticillium wilt • Vine decline-like symptoms caused by *Monosporascus* (melons) *Macrophomina, Pythium* • Viruses (Cucumber mosaic, Cucurbit aphid-borne yellows, Potyviruses, *Squash mosaic virus*)
	Just before harvest survey weeds and record their location for future management. (See example form online.)

	Other pests or damage you may see: **Arthropods** • Aphids (green peach and melon) • Darkling beetles • Flea beetles • Grasshoppers and crickets • Leafminer • Thrips

✓ Done	**Harvest and postharvest** **Special issues of concern related to environmental quality:** drift and volatile organic compounds (VOCs). **Mitigate pesticide usage to minimize air and water contamination.**
	Harvest rapidly to reduce exposure of fruit to pest infestations such as pathogens and vinegar flies.
	Clean equipment and tractors between fields to prevent the spread of soil borne pathogens and weed seeds.
	During harvest, note or record the type of damage on fruit to assess this year's pest management results and to plan for next year.
	Check for root galling if root rot nematode damage is suspected. If galls are present dig up a series of plants to determine distribution and severity. If action is warranted, consider choosing a resistant or non-host crop, or treat the soil according to the Cucurbits Pest Management Guidelines next season.
	Carry out sanitation practices in the field to reduce the spread of: • Aphids (green peach and melon) • Cutworms • Driedfruit beetles • Leafhoppers • Leafminers • Silverleaf whitefly • Squash bug • Vine disease decline (in melons) • Vinegar flies • Wireworms • Yellowstriped armyworm
	Consider fall bed herbicide applications as part of a weed management program. See Cucurbits Pest Management Guidelines for details. If herbicides will be used, customize the susceptibility to herbicide table for the weed complex in your field. Learn how.
	Consider crop rotation next season to reduce pathogen and weed problems.

✓ Done	**Pesticide application checklist** When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, and review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	✓ Choose a pesticide from the Pest Management Guidelines for the target pest, considering:
	• Impact on natural enemies and pollinators. For more information see Protecting Natural Enemies and Pollinators at http://ipm.ucdavis.edu/mitigation/protect_beneficials.html.
	• Potential for water quality problems using the UC IPM WaterTox database. See http://ipm.ucdavis.edu/TOX/simplewatertox.html.
	• Impact on aquatic invertebrates. For more information, see *Pesticide Choice*, UC ANR Publication 8161 (PDF), http://anrcatalog.ucdavis.edu/pdf/8161.pdf.
	• Chemical mode of action, if pesticide resistance is an issue. For more information, see *Herbicide Resistance: Definition and Management Strategies*, UC ANR Publication 8012 (PDF), http://anrcatalog.ucdavis.edu/pdf/8012.pdf.
	• Endangered species that may be near your site. Find out using the Department of Pesticide Regulation's PRESCRIBE program. (http://cdpr.ca.gov/docs/endspec/prescint.htm)
	✓ Before an application
	Ensure that spray equipment is properly calibrated to deliver the desired pesticide amount for optimal coverage. (See http://ipm.ucdavis.edu/training/incorporating-calibration.html)
	Use appropriate spray nozzles and pressure to minimize off-site movement of pesticides.
	Avoid spraying during these conditions to avoid off-site movement of pesticides. • Wind speed over 5 mph • Temperature inversions • Just prior to rain or irrigation (unless it is an appropriate amount, such as when incorporating a soil-applied pesticide) • At tractor speeds over 2 mph
	Identify and take special care to protect sensitive areas (for example, waterways or riparian areas) surrounding your application site.
	Review and follow labeling for pesticide handling, personal protection equipment (PPE) requirements, storage, and disposal guidelines.
	Check and follow restricted entry intervals (REI) and preharvest intervals (PHI).
	✓ After an application
	Record application date, product used, rate, and location of application.
	Follow up to confirm that treatment was effective.
	✓ Consider water management practices that reduce pesticide movement off-site.
	Consult relevant publications • *Reducing Runoff from Irrigated Lands: Orchard Floor Management Practices to Reduce Erosion and Protect Water Quality*, UC ANR Publication 8202 (PDF), http://anrcatalog.ucdavis.edu/pdf/8202.pdf. • *Reducing Runoff from Irrigated Lands: Causes and Management of Runoff from Surface Irrigation in Orchards,* UC ANR Publication 8214 (PDF), http://anrcatalog.ucdavis.edu/pdf/8214.pdf. • *Protecting Surface Water from Sediment-Associated Pesticides in Furrow-Irrigated Crops*, UC ANR Publication 8403 (PDF), http://anrcatalog.ucdavis.edu/pdf/8403.pdf.
	Consult the Department of Pesticide Regulation Groundwater Protection Program (GWPA) website for pesticide information and mitigation measures. (http://cdpr.ca.gov)
	Install an irrigation recirculation or storage and reuse system. Redesign inlets into tailwater ditches to reduce erosion.
	Use drip rather than sprinkler or flood irrigation.
	Limit irrigation to amount required using soil moisture monitoring and evapotranspiration (ET). (For more information, see *Reducing Runoff from Irrigated Lands: Understanding Your Orchard's Water Requirements*, UC ANR Publication 8212 (PDF), http://anrcatalog.ucdavis.edu/pdf/8212.pdf.)

✓ Done	Pesticide application checklist
	Consider using cover crops.
	Consider vegetative filter strips or ditches. (For more information, see *Vegetative Filter Strips,* UC ANR Publication 8195 (PDF), http://anrcatalog.ucdavis.edu/pdf/8195.pdf.)
	Apply polyacrylamides in furrow and sprinkler irrigation systems to prevent off-site movement of sediments.
	Redesign inlets and outlets into tailwater ditches to reduce erosion. (For more information, see *Reducing Runoff from Irrigated Lands: Tailwater Return Systems*, http://anrcatalog.ucdavis.edu/pdf/8225.pdf.)
	✓ **Consider practices that reduce air quality problems.**
	When possible, reduce volatile organic compound (VOC) emissions by decreasing the amount of pesticide applied, choosing low-emission management methods, and avoiding fumigants and emulsifiable concentrate (EC) formulations.

For more about mitigating the effects of pesticides, see the Mitigation page: http://ipm.ucdavis.edu/mitigation/.

General Information

(Section reviewed 12/09)

BIOLOGICAL CONTROL (12/09)

Cucurbits are relatively fast growing, annual crops; consequently, beneficial insects and mites may not have adequate time to develop high populations in the early stages of crop development. If natural enemies are to provide control in cucurbits, they must either come from adjacent crops (alfalfa, orchards, etc.), noncultivated areas, or be released throughout the cucurbit field. Be aware, however, that control by natural enemies is not always adequate to prevent economic losses and it may be difficult to establish populations of introduced beneficials. For example, if lady beetles are released, they generally fly away before significant feeding occurs, but naturally occurring populations can sometimes effectively control insects such as aphids.

PESTICIDE REGISTRATIONS (12/09)

The cucurbit group is a large one that includes crops such as melons, cucumbers, squash, and pumpkins. Some varieties of each crop may be more susceptible to certain pests or pesticide injury than others. Therefore, not all of the chemicals listed in the treatment tables can be used on all varieties of cucurbit crops, especially melons. The comments in the treatment tables indicate which crops are listed or not listed on the label, but always read the label before applying a material to check for further restrictions. Also, check with local farm advisors or pest control advisors regarding any phytotoxicity problems associated with a specific crop and chemical combination. Local use permits may be available for certain materials in specific situations; contact your county agricultural commissioner regarding these permits.

These guidelines are written for field crop production and not for greenhouse production. Also, not all products that are registered are listed, especially pyrethroids for caterpillar control. While pyrethroids can effectively control these pests, they are also quite disruptive of beneficial insects and mites. Because there are many other insecticides that are equally effective at controlling these pest but not as destructive to beneficials, these products are listed instead of the pyrethroids.

RELATIVE TOXICITIES OF PESTICIDES USED IN CUCURBITS TO NATURAL ENEMIES and HONEY BEES (5/16)

Cucurbits depend on bees for successful pollination. In addition, beneficial insects and mites play a key role in maintaining populations of aphids, leafminers, and spider mites below economically damaging levels. They also are instrumental in controlling populations of whiteflies, armyworms, and loopers. Some insecticides and miticides used in cucurbits are toxic to these beneficials and must be used with extreme care to minimize destruction of natural enemy populations. To ensure survival of natural enemies, use *Bacillus thuringiensis* (Dipel, Javelin, Biobit, etc.) or soft contact chemicals such as soaps and oils in the early plant stages, if needed, rather than harsh disruptive materials (pyrethroids, organophosphates, and carbamates). To protect honey bees, do not use moderate-to-highly toxic materials when the crop is in bloom and bees are in the field. The following table outlines the general toxicity of cucurbit pesticides to beneficial organisms.

Common name (Example trade name)	Mode of Action[1]	Selectivity[2] (affected groups)	Predatory Mites[3]	General Predators[4]	Parasites[4]	Honey bees[5]	Duration of impact to natural enemies[6]
abamectin (Agri-Mek SC)	6	moderate (mites, leafminers)	M	L	M/H	I	moderate to predatory mites and affected insects
acetamiprid (Assail)	4A	moderate (sucking insects, larvae)	—[7]	—	—	II	moderate
Bacillus thuringiensis ssp. *aizawai*	11A	narrow (caterpillars)	L	L	L	II	short
Bacillus thuringiensis ssp. *kurstaki*	11A	narrow (caterpillars)	L	L	L	III	short
bifenazate (Acramite)	un	narrow (spider mites)	L	L	L	II	short
bifenthrin (Capture)	3A	broad (insects, mites)	H	H	H	I	long
buprofezin (Courier)	16	narrow (sucking insects, beetles)	L	H[8]	L	II	long
carbaryl (Sevin) bait	1A	narrow (cutworms, army-worms, grasshoppers, etc.)	L	L	L	III	short
carbaryl (Sevin 4F)	1A	broad (insects, mites)	M/H	H	H	I	long
carbaryl (Sevin XLR Plus)	1A	broad (insects, mites)	L	H	H	I	long
chlorantraniliprole (Coragen)	28	*narrow (primarily caterpillars)*	L	L	L/M	III	short
chlorantraniliprole / lambda-cyhalothrin (Voliam Xpress)	28 / 3A	broad (plant bugs, beetles, caterpillars)	H	H	H	—	moderate
clothianidin (Belay)	4A	—	—	M/H	M/H	I	long
cryolite (Kryocide)	un	narrow (foliage chewing insects)	L	L	L	III	short
cyantraniliprole (Exirel,Verimark)	28	narrow (whiteflies, worms, cabbage loopers)	—	—	—	—	short
cyromazine (Trigard)	17	narrow (leafminers)	L	L	L	II	short
diazinon (WP, EC)	1B	broad (insects, mites)	L	H	H	I	moderate to long
dimethoate	1B	broad (insects, mites)	H	H	H	I	long
dinotefuran (Venom)	4A	narrow (sucking	L	—	L	I	short

		insects)					
esfenvalerate (Asana)	3A	broad (insects, mites)	H	M	H	I	moderate
fenpropathrin (Danitol)	3A	broad (insects, mites)				I	
imidacloprid (Admire)	4A	narrow (sucking insects, beet armyworm, cutworms)	—	L	—	III	—
indoxacarb (Avaunt)	22A	narrow (caterpillars)	L	L	L	I	moderate
insecticidal soaps	—	broad (exposed insects, mites)	M	M	M	III	short
lambda-cyhalothrin (Warrior)	3A	broad (plant bugs, beetles, caterpillars)	H	H	H	I	moderate
malathion (EC)	1B	broad (insects, mites)	M	H	H	I	moderate
methomyl (Lannate)	1A	broad (insects, mites)	H	H	H	I	moderate
methoxyfenozide (Intrepid)	18	narrow (caterpillars)	L	L	L	II	short
oxamyl (Vydate)	1A	broad (insects, mites)	H	H	H	I	moderate
paraffinic oil (JMS Stylet Oil)	—	broad (exposed insects, mites)	L	L	L	II	short
pyrethrin (PyGanic)	3A	broad (insects)	—	M	M	I	short
petroleum oil	—	broad (exposed insects, mites)	L[8]	L	L	II	short
pymetrozine (Fulfill)	9B	narrow (aphids, whiteflies)	L	L	L	II	short
pyriproxifen (Knack)	7C	narrow (aphids, whiteflies)	L	H[9]	L	II	short
rosemary oil (Hexacide)	—	broad (exposed insects, mites)	L	L	L	III	—
spinetoram (Radiant)	5	narrow (caterpillars, thrips, whiteflies, aphids, leafminers)	L/M	M[10]	L/M	II	moderate[11]
spinosad (Entrust, Success)	5	narrow (caterpillars, thrips, whiteflies, aphids, leafminers)	L/H	M[10]	L/M	II	short to moderate
spiromesifen (Oberon SC)	23	narrow (whiteflies)	—	—	—	II	—
sulfur	—	narrow (mites, thrips)	L/H	M/L	H	III	short
thiamethoxam (Actara)	4A	narrow (sucking insects)	—[12]	—	M	I	moderate

H = high M = moderate L = low — = no information

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number morethan twice per season to help prevent development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

2 Selectivity: broad means it affects most groups of insects and mites; narrow means it affects only a few specific groups.

3 Generally, toxicities are to western predatory mite, Galendromus occidentalis. Where differences have been measured in toxicity of the pesticide-resistant strain versus the native strain, these are listed as pesticide-resistant strain/native strain.

4 Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific chemical depends on the species of predator or parasite, environmental conditions, and application rate.

5 Ratings are as follows: I–Do not apply or allow to drift to plants that are flowering; II–Do not apply or allow to drift to plants that are flowering, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations; III–No bee precaution, except when required by the pesticide

label or regulations. For more information about pesticide synergistic effects, see Bee Precaution Pesticide Rating *(available online at http://ipm.ucanr.edu/beeprecaution/)*.

6 Duration: short means hours to days; moderate means days to 2 weeks; and long means many weeks or months.

7 May cause flare-ups of spider mite populations.

8 Rating depends on rate used.

9 Kills lady beetles.

10 Toxic against some natural enemies (predatory thrips, syrphid fly and lacewing larvae, beetles) when sprayed and up to 5-7 days after, especially for syrphid fly larvae.

11 Residual is moderate if solution is between pH of 7 to 8.

12 May cause increase in spider mite populations.

Acknowledgements: This table was compiled based on research data and experience of University of California scientists who work on a variety of crops and contribute to the Pest Management Guideline database, and from Flint, M. L. and S. H. Dreistadt. 1998. Natural Enemies Handbook: An Illustrated Guide to Biological Pest Control, ANR Publication 3386.

Insects and Mites

(Section reviewed 12/09)

ARMYWORMS (5/16)

Scientific Name: Beet Armyworm: *Spodoptera exigua*
Western Yellowstriped Armyworm: *Spodoptera praefica*
Yellowstriped Armyworm: *Spodoptera ornithogalli*

DESCRIPTION OF THE PEST

Beet Armyworm

Larvae are usually dull green and have wavy, light-colored stripes running lengthwise down the back and broader stripes on each side. Eggs are laid in a mass covered with hairlike scales.

Western Yellowstriped Armyworm

Females lay eggs in clusters covered with a gray, cottony material. Larvae measure about 1.5 inches (3.8 cm) long when fully grown. They are usually black with one prominent stripe over many narrow bright ones on each side of its body. The head is brown with a netted pattern. There is also a large black spot above the first abdominal spiracle.

Yellowstriped Armyworm

Larvae of the yellowstriped armyworm are almost black, with two prominent and many fine, bright yellow stripes on the side.

DAMAGE

Primarily a foliage feeder, armyworms will also attack fruit, creating single or closely grouped circular or irregular holes on the surface. In many cases, feeding is superficial and little loss would result if not for decay organisms that enter wounds and rot fruit. The beet armyworm caterpillars occasionally develop inside the fruit. Yellowstriped armyworm does not enter the fruit and infestations are most severe from July to mid-September.

MANAGEMENT

Yellowstriped armyworm is not a serious pest every year but is very destructive on occasion. Armyworms tend to build up in alfalfa and weedy areas around the field and migrate from these areas when cut. Armyworms only need to be controlled if it is feeding on the crop. Keep crop residue and weeds in field and surrounding areas to a minimum to lessen the attraction of the field.

Biological Control

Many natural enemies attack armyworms. Among the most common parasites are the wasps, *Hyposoter exiguae* and *Chelonus insularis*, and the tachinid fly, *Lespesia archippivora*. Armyworms can easily be checked for the presence of *Hyposoter exiguae* by pulling the larva apart and looking for the parasite larvae. Viral diseases also kill significant numbers.

Organically Acceptable Methods

Sanitation in the field and surrounding areas along with biological control and sprays of *Bacillus thuringiensis* or the Entrust formulation of spinosad are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

Beet armyworm may be present in and around the field feeding on bindweed and little mallow (malva).

- Start monitoring weeds and crop foliage for larvae just after transplanting or when seedlings emerge.
- If young instars are found, consider treating with low-impact product such as *Bacillus thuringiensis*, methoxyfenozide (Intrepid), or spinosad (Entrust). For yellowstriped armyworm, the older stages can be treated with methomyl. Treat the crop only if there is severe defoliation prior to fruiting. No thresholds have been established.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

A.	SPINETORAM			
	(Radiant SC)	5–10 fl oz	4	See comments
	MODE-OF-ACTION GROUP NUMBER[1]: 5			
	COMMENTS: PHI for cucumbers is 1 day and for other cucurbits 3 days.			
B.	SPINOSAD			
	(Entrust)#	1.25–2.5 oz	4	See comments
	(Success)	4–8 fl oz	4	See comments
	MODE-OF-ACTION GROUP NUMBER[1]: 5			
	COMMENTS: Time spray to target eggs at hatch or small larvae. Do not apply more than 9 oz Entrust or 29 fl oz of Success per acre per season. PHI for cucumbers is 1 day and for other cucurbits 3 days.			
C.	CYANTRANILIPROLE			
	(Exirel - foliar)	7–13.5 fl oz	12	1
	(Verimark - soil)	6.75–13.5 fl oz	4	1
	MODE-OF-ACTION GROUP NUMBER[1]: 28			
D.	CHLORANTRANILIPROLE/LAMBDA-CYHALOTHRIN			
	(Voliam Xpress)*	6–9 fl oz	24	1
	MODE-OF-ACTION GROUP NUMBER[1]: 28 / 3A			
E.	CHLORANTRANILIPROLE			
	(Coragen)	3.5–5 fl oz	4	1
	MODE-OF-ACTION GROUP NUMBER[1]: 28			
F.	METHOXYFENOZIDE			
	(Intrepid 2F)	4–10 fl oz	4	3
	MODE-OF-ACTION GROUP NUMBER[1]: 18			
	COMMENTS: Time spray to target eggs and small larvae.			
G.	BACILLUS THURINGIENSIS ssp. AIZAWAI#			
	(various products)	Label rates	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: 11.A			
	COMMENTS: Use to control small armyworms only (first and second instar) when populations are light and full coverage sprays are applied. Repeat treatment as necessary. If mature larvae or heavy populations are present, use another material.			
H.	INDOXACARB			
	(Avaunt)	3.5-6.0 oz	12	3
	MODE-OF-ACTION GROUP NUMBER[1]: 22A			
I.	METHOMYL*			
	(Lannate SP)	0.5–1 lb	48	See comments
	(Lannate LV)	1.5–3 pt	48	See comments
	MODE-OF-ACTION GROUP NUMBER[1]: 1A			
	COMMENTS: For use on cucumbers, melons and summer squash only. PHI is 1 day when 0.5 lb or less for 90SP or 1.5 pt or less for LV formulations is used; when more than 0.5 lb (90SP) or 1.5 pt (LV) is used, PHI is 3 days.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.

CABBAGE LOOPER (5/16)

Scientific Name: *Trichoplusia ni*

DESCRIPTION OF THE PEST

Cabbage loopers are green caterpillars with a narrow, white stripe along each side and several narrow lines down the back; they have a characteristic arch to their back as they crawl. Eggs are similar in appearance to corn earworm eggs, but flatter, and laid singly on the underside of leaves. Adult moths have brown, mottled forewings marked in the center with a small, silver figure eight.

DAMAGE

The cabbage looper can be a very damaging pest. Young larvae feed primarily on the underside of leaves, skeletonizing them. High populations may move to the fruit and feed on the fruit surface.

MANAGEMENT

Encourage biological control agents by using least-toxic pesticides to control other pests. Treatments may be warranted if loopers are numerous.

Biological Control

Cabbage looper has many natural enemies that frequently keep it below economic levels, unless they are killed by insecticide applications. Important parasitic wasps include the tiny egg parasite, *Trichogramma pretiosum*, and three wasps that attack the caterpillars (*Hyposoter exiguae, Copidosoma truncatellum*, and *Microplitis brassicae*). The tachinid fly, *Voria ruralis*, also attacks the caterpillar. In some areas, the *nuclear polyhedrosis virus*, an important biological control agent, occurs naturally in fields and kills loopers that it infects.

Organically Acceptable Methods

Biological control and sprays of *Bacillus thuringiensis* are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

Monitor adult flights throughout the season with pheromone traps to determine when to begin looking for loopers and if a pesticide application should be considered.

1. Set out first traps when seedlings emerge or just before transplanting. Replace trap bottoms monthly or when they become covered with debris.
2. When increasing numbers of moths are found in the traps, indicating a flight peak, it is time to start monitoring crop foliage for eggs and small larvae. Continue to monitor through fruit development.
3. Treatments are generally warranted if there are sufficient numbers of loopers that are easily found feeding on leaves.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. SPINETORAM			
(Radiant SC)	5–10 fl oz	4	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: PHI for cucumbers is 1 day and for other cucurbits 3 days.			
B. SPINOSAD			
(Entrust)#	1.25–2.5 oz	4	See comments
(Success)	4–8 fl oz	4	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Time spray to target eggs at hatch or small larvae. Do not apply more than 9 oz Entrust or 29 fl oz of Success per acre per season. PHI for cucumbers is 1 day and for other cucurbits 3 days.			
C. CHLORANTRANILIPROLE			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
(Coragen)	3.5–5 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 28			
D. CYANTRANILIPROLE			
(Exirel - foliar)	10–17 fl oz	12	1
(Verimark - soil)	6.75–13.5 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 28			
E. CHLORANTRANILIPROLE/LAMBDA-CYHALOTHRIN			
(Voliam Xpress)*	6–9 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER[1]:28 / 3A			
F. CHLORANTRANILIPROLE / THIAMETHOXAM			
(Voliam Flexi)	4–7 oz	12	1
MODE-OF-ACTION GROUP NUMBER[1]: 28 / 4A			
G. METHOXYFENOZIDE			
(Intrepid 2F)	4–10 fl oz	4	3
MODE-OF-ACTION GROUP NUMBER[1]: 18			
COMMENTS: Time spray to target eggs and small larvae. Do not apply more than 4 applications per acre per season or spray at less than 7-day intervals.			
H. BACILLUS THURINGIENSIS ssp. KURSTAKI#			
(various products)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 11A			
COMMENTS: Apply when eggs start to hatch and larvae are small (early instars) and before significant crop damage occurs. To be effective, *Bacillus thuringiensis* must be applied to young larva in the 1st or 2nd instar. Choose one of the other materials listed if larger larvae are present. Larvae must be actively feeding to be affected. Repeat as necessary to maintain control.			
I. INDOXACARB			
(Avaunt)	2.5–6.0 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 22A			
J. CRYOLITE			
(Kryocide)	8–12 lb	12	See comments
MODE-OF-ACTION GROUP NUMBER[1]: un			
COMMENTS: Labeled for use on cucumber, squash, melons, and pumpkins. Can be applied as a spray or dust. Thorough coverage using ground equipment is necessary for adequate control. Do not apply immediately before harvest. Remove excess residues on edible portions by washing, brushing, or other effective means. Effectiveness of this material is lower than materials listed above. PHI is 7 days for summer squash and 14 days for winter squash, cucumber, melons, and pumpkins.			
. . . *or* . . .			
(Prokil Cryolite 96)	10–16 lb	12	See comments
COMMENTS: Labeled for use on cantaloupe, squash, and watermelon. Applied as a spray. Thorough coverage using ground equipment is necessary for adequate control. Do not apply immediately before harvest. Remove excess residues on edible portions by washing, brushing, or other effective means. Effectiveness of this material is lower than materials listed above. PHI is 7 days for summer squash and 14 days for winter squash, cantaloupe, and watermelon.			
K. METHOMYL*			
(Lannate SP)	0.5–1 lb	48	See comments
(Lannate LV)	1.5–3 pt	48	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Labeled for use on cucumbers, melons, and summer squash. Highly toxic to bees. PHI is 1 day when 0.5 lb or less for 90SP or 1.5pt or less for LV formulations is used; when more than 0.5 lb (90SP) or 1.5 pt (LV) is used, PHI is 3 days.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

Acceptable for organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.

CRICKETS (5/16)

Scientific Names: Many species in the Gryllid family

DESCRIPTION OF THE PESTS

Adult crickets are black or brown, and are 0.6 to 1 inch in length. Eggs are laid in the ground, mostly in damp places. Crickets are present in all stages all year round.

DAMAGE

Crickets generally do not cause economic losses in cucurbits. Crickets can cause some damage initially by eating flower parts and causing poor or incomplete pollination. Also, as fruit reaches the full slip stage, this pest can enter the stem end and feed internally on the fruit. Excrement of crickets can spot melons, resulting in exterior dark stains that may affect marketing value.

MANAGEMENT

Crickets are usually more of a problem in areas of the field near weedy areas during stand establishment. Clear weeds early in spring before crickets mature and begin to migrate. Treat if damaging numbers of insects are observed during field inspection.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. CARBARYL (Sevin 5 bait)	20 lb	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Apple pumice baits work better for crickets and grasshoppers than bran baits. Baits lose their attractiveness as they dry out. Apply in early evening to avoid drying out too soon from sun exposure. Use suitable ground or aircraft equipment that provides good distribution. A repeat application is usually necessary for effective control.			
B. BIFENTHRIN* (Capture 2EC-CAL)	2.6–6.4 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Repeated use of this material is very disruptive to beneficials.			
C. LAMBDA CYHALOTHRIN (Warrior II with Zeon)*	1.28–1.92 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
D. FENPROPATHRIN (Danitol)*	10.67–16 fl oz	24	7
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
E. ESFENVALERATE* (Asana XL)	5.8–9.6 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Do not exceed 0.25 lb a.i./acre per season. Highly toxic to honey bees.			
F. PYRETHRIN# (PyGanic EC 1.4)	16–64 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Buffer final spray to a pH of 5.5 to 7.0.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

CUCUMBER BEETLES (5/16)

Scientific Names: Western spotted cucumber beetle: *Diabrotica undecimpunctata undecimpunctata*
Western striped cucumber beetle: *Acalymma trivittatum*
Banded cucumber beetle: *Diabrotica balteata*

DESCRIPTION OF THE PESTS

The western spotted and the western striped cucumber beetles occur throughout California and are major pests of cucurbits; the banded cucumber beetle occurs primarily in southern California. Cucumber beetles overwinter as adults and are active by the time the earliest melons are planted in spring. Adults lay eggs at the base of plants. As soon as they hatch, larvae begin to feed on plant roots. They complete their development in the soil. There are about three generations a year.

Cucumber beetles are about 0.36 inch (9 mm) long and either have a greenish yellow background with black spots or alternating black and yellow stripes. They fly readily and migrate into cultivated areas from alfalfa and other crops, and from uncultivated lands. Cucumber beetles like moisture and dislike heat; consequently, melon fields are especially attractive in hot weather during and after an irrigation.

Western striped cucumber beetle larvae feed exclusively on cucurbit roots, whereas western spotted cucumber beetle larvae feed on a wide variety of plants including grasses, corn, legumes, and cucurbits.

DAMAGE

Cucumber beetles are serious pests of smooth-skinned cucurbits, especially melon varieties such as honeydew, crenshaw, and casaba. While the adults prefer tender, succulent portions of plants, including the flowers and leaves, which they may destroy with their feeding, it is the damage to the surface of the melon that reduces marketable yield. When temperatures are high, adults especially feed on the undersides of young melons, scarring them. After the skin hardens, melons are much less subject to attack. Scarring in the crown of the plant is also typical of adult damage. Feeding on stems of young plants, followed by sustained winds, may result in severe stand reductions making replanting necessary. In some situations, larvae may cause serious injury by feeding on roots, and young plants can be killed. Cucumber beetles also spread squash mosaic virus.

MANAGEMENT

Damaging populations of cucumber beetles are usually treated with insecticides.

Biological Control

Cucumber beetles are attacked by a variety of natural enemies, the most important being a parasitic tachinid fly, *Celatoria diabroticae*. Natural enemies are rarely effective enough, however, to reduce populations below economically damaging levels.

Cultural Control

There are no effective cultural controls for these pests. Because spotted cucumber beetle larvae also feed on corn, avoiding planting cucurbits next to corn may help.

Monitoring and Treatment Decisions

Cucumber beetles are difficult to control. Pesticide sprays must be directed at adult beetles. Larvae of western spotted cucumber beetle develop outside of cucurbit fields and striped cucumber beetle larvae are located on roots where they cannot be controlled.

Start monitoring for cucumber beetles after transplanting or when seedlings emerge, through the fruiting stage. Pesticide applications for adults may be necessary if there is an average of one beetle per plant during the seedling-to-4-inch-tall stage. Infestations that develop late in the season are usually not as damaging as those that begin earlier because numbers tend to be lower. Apply insecticides before beehives are introduced into the field; typically, an application is often made the day before bees are put in the field.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

A.	ACETAMIPRID			
	(Assail 30SG)	2.5–5.3 oz	12	0
	(Assail 70WP)	1.1–2.3 oz	12	0
	MODE-OF-ACTION GROUP NUMBER[1]: 4A			
B.	CARBARYL*			
	(Sevin 4F)	1 qt	12	3
	(Sevin XLR Plus)	1 qt	12	3
	MODE-OF-ACTION GROUP NUMBER[1]: 1A			
	COMMENTS: To avoid plant injury, do not apply when foliage is wet or when rain or excessive humidity is expected during the 2 days after application. May cause increased spider mite problems. The XLR Plus formulation is less hazardous to honey bees than other formulations if applied from late evening to early morning when bees are not foraging.			
C.	FENPROPATHRIN			
	(Danitol)*	10.67–16 fl oz	24	7
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
D.	ESFENVALERATE*			
	(Asana XL)	5.8–9.6 oz	12	3
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
	COMMENTS: Use to control adults; repeat as necessary to maintain control. Do not exceed 0.25 lb a.i./acre per season. Highly toxic to honey bees.			
E.	CRYOLITE			
	(Kryocide)	8–12 lb	12	See comments
	MODE-OF-ACTION GROUP NUMBER[1]: un			
	COMMENTS: Labeled for use on cucumber, squash, melons, and pumpkins. Can be applied as a spray or dust. Thorough coverage using ground equipment is necessary for adequate control. Do not apply immediately before harvest. Remove excess residues on edible portions by washing, brushing, or other effective means. Effectiveness of this material is lower than materials listed above. PHI is 7 days for summer squash and 14 days for winter squash, cucumber, melons, and pumpkins.			
	. . . or . . .			
	(Prokil Cryolite 96)	10–16 lb	12	See comments
	COMMENTS: Labeled for use on cantaloupe, squash, and watermelon. Applied as a spray. Thorough coverage using ground equipment is necessary for adequate control. Do not apply immediately before harvest. Remove excess residues on edible portions by washing, brushing, or other effective means. Effectiveness of this material is lower than materials listed above. PHI is 7 days for summer squash and 14 days for winter squash, cantaloupe, and watermelon.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers .(un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

CUTWORMS (5/16)

Scientific Names: species in the Noctuid family

DESCRIPTION OF THE PESTS

Cutworm adults are medium-sized moths, usually brown or gray, about 1 inch long. Mature larvae are robust, nearly 1.5 inches (3.7 cm) long, and their skin is either mottled brown or gray. Larvae tend to curl up into a C-shape when they are disturbed.

DAMAGE

Young plants are often damaged or killed by cutworms. These caterpillars usually hide in the soil under debris, or under clods during the day. At night they come out to feed, cutting off the plants at or just below the crown level. Several different species of cutworms may cause damage. The roughskinned cutworm is a serious pest of cantaloupes and honeydew, crenshaw and casaba melons, in certain localities, causing scarring to the underside of melons.

MANAGEMENT

Management of cutworm populations begins with the destruction of plant residues from previous crops and avoiding planting in fields that are coming out of pasture. At least 2 weeks before planting eliminate weeds both within and around the field. Irrigate to speed germination and emergence of the crop. Often cutworm infestations occur in localized areas and spot treatments are adequate.

Organically Acceptable Methods

Cultural controls such as weed management by cultivation, irrigation management, and field sanitation are acceptable to use for an organically grown crop.

Monitoring and Treatment Decisions

Monitor for cutworm injury by walking through the field when plants are in the seedling stage, especially after first weeding and thinning, which concentrates the cutworms on the remaining stand. In honeydew, crenshaw, and casaba melons, continue to monitor through fruiting. Pay particular attention to cucurbit crops that follow barley or corn, especially in fields with heavy soils.

If an infestation is localized and only a few plants are damaged, taking the loss or replanting may be sensible. Frequently, damage is most serious at the edges of the field, but stand loss can occur in a clumped pattern throughout the field; spot treatments may be effective in these situations. If a large area is infested, treat with insecticides when problems are first observed before stands are severely reduced or fruit is damaged.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. INDOXACARB			
(Avaunt)	3.5–6 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 22A			
B. CHLORANTRANILIPROLE / LAMBDA-CYHALOTHRIN			
(Voliam Xpress)*	6–9 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER[1]: 28 / 3A			
C. DIAZINON*			
(Diazinon 50W)	4–8 lb	72	3
(Diazinon AG500)	2–4 qt	72	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Only labeled for melons. Broadcast just before planting. Work into the soil immediately, 2 to 3 inches for surface cutworms, 3 to 6 inches for subterranean cutworms.			
D. CARBARYL			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
(Sevin 5 bait)	20 lb	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Labeled for use on cucumbers, squash, and melons. Use suitable ground or aircraft equipment that provides good distribution.			
E. ESFENVALERATE*			
(Asana XL)	5.8–9.6 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS Not labeled for use on casaba, crenshaw, or Persian melons. Apply as a seedling spray; repeat as necessary to maintain control. Do not exceed 0.25 lb a.i./acre per season.			
F. METHOMYL*			
(Lannate SP)	0.5–1 lb	48	See comments
(Lannate LV)	1.5–3 pt	48	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Labeled for use on cucumbers, melons, and summer squash. Highly toxic to bees. PHI is 1 day when 0.5 lb or less for 90SP or 1.5 pt or less for LV formulations is used; when more than 0.5 lb (90SP) or 1.5 pt (LV) is used, PHI is 3 days.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

* Permit required from county agricultural commissioner for purchase or use.

DARKLING BEETLES (5/16)

Scientific Names: *Blapstinus* spp., *Coelus* spp., and others

DESCRIPTION OF THE PESTS

Darkling beetle adults are from 0.13 to 0.25 inch long (3 to 6 mm) and vary from black or bluish black to rusty brown. Do not confuse beetles (Tenebrionidae) with predatory ground beetles (Carabidae), which prey on various soil dwelling pests. Darkling beetles generally have clubbed antennae whereas carabids do not. Darkling beetles may be hidden by dust or a thin layer of soil. Larvae are cylindrical, wireworm-like, soil-inhabiting worms that are light yellow to dark brown and range from 0.03 to 0.33 inch (1–8 mm) in length. They are often referred to as false wireworms.

DAMAGE

Darkling beetles are generally not a problem unless large populations build up when the plants are in the seedling stage. Young plants may be girdled or cut off at or below the soil surface. After the plants reach a height of 5 to 6 inches, darkling beetles are usually not a problem. However, further feeding may occur on flower blossoms during bloom, on the undersides of leaves, and on the netting of mature melons. They can also bore into fruit where it rests on the ground.

MANAGEMENT

There are cultural control methods that can reduce darkling beetle damage.

- Keep fields and ditches free of weeds.
- Water barriers can aid in stopping migrating populations.
- Reduce organic matter in soil by fallowing.

Start monitoring for darkling beetles at fruiting. Treat whenever beetles are observed feeding on plants, flowers, or fruit. Also treat when beetles are observed moving into cucurbits or melons from fallow or alfalfa hay fields.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. CARBARYL (Sevin 5 bait)	20 lb	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Use suitable ground or aircraft equipment that provides good distribution. Repeat application of bait may be necessary.			
B. MALATHION (Malathion 8-E)	1.75 pt	24	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Do not apply unless plants are dry. PHI on cucumber and squash is 1 day.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

DRIEDFRUIT BEETLES (11/05)

Scientific Names: Driedfruit beetle: *Carpophilus hemipterus*
Freeman sap beetle: *Carpophilus freemani*
Confused sap beetle: *Carpophilus mutilatus*

DESCRIPTION OF THE PESTS

Driedfruit beetles, also known as sap beetles, are a complex of several closely related species in the family Nitidulidae that have similar life histories and resemble each other in appearance. The driedfruit beetle is the most common species, but the other two are also common and can be the most abundant in some fields. Other species are sometimes present in lesser numbers.

Adults are small brown or black beetles with or without lighter spots on the wings, depending on species. They range in size from 0.1 to 0.2 inch (3–5 mm) long and have clubbed antennae. The wings do not cover the last two to three abdominal segments. Eggs are laid in fruit, where larvae develop and feed; larvae are white and 0.1 to 0.2 inch (3–5 mm) long when mature. They have tan head capsules, three pairs of true legs, and two hornlike structures on the anal end. Pupation takes place in the soil.

DAMAGE

When melons are approaching maturity and are at the half-slip stage, an entry point into the soft fruit tissue develops. Driedfruit beetles can enter at this site and start feeding. They can also enter at any open site caused mechanically or by other insects.

MANAGEMENT

This pest builds up on any rotting fruit (such as citrus, stone fruit, grapes, and figs), which increases the problem as the summer season progresses. Monitor the field for the presence of these beetles. Because of the minor pest status of driedfruit beetles, nothing is presently registered for its control. These beetles are generally controlled when treatments are applied for other pests. When possible, remove or disc nearby rotting fruit, especially when it is upwind from the field; beetles can fly for some distance downwind. Multiple discs, if necessary, of infested fields promptly after final harvest.

EUROPEAN EARWIG (5/16)

Scientific Name: *Forficula auricularia*

DESCRIPTION OF THE PEST

Earwigs feed at night and can be found hidden around the crowns of the plants during the day. They are slender brown insects, about 0.5 to 0.75 inch (1.25 to 2 cm) long. They have a conspicuous pair of pincers attached to the back end of the abdomen. The adult wing covers are short and leathery. The pest becomes most destructive as nymphs approach maturity from April to July.

DAMAGE

Earwig feeding results in small deep holes in the fruit that can only be distinguished from slug damage by the absence of slime. They will also inhabit or catface open-ended fruit.

MANAGEMENT

Cultural control methods to reduce earwig damage include:

- Keeping the top of beds dry during the last irrigation, as moisture favors increased damage.
- Where practical, eliminate hiding places by removing old senescent leaves.

Check the bottom of developing fruit for damage and treat if feeding holes are present.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. CARBARYL (Sevin 5 bait)	20 lb	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Repeat as necessary using suitable ground or air equipment for proper distribution. Double treatment is usually more effective.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

FALSE CHINCH BUG (5/16)

Scientific Name: *Nysius raphanus*

DESCRIPTION OF THE PEST

The false chinch bug is a small, light or dark gray species, 0.12 to 0.16 inch long. The nymphs are pale gray with a reddish brown abdomen that matches the color of dry weeds and soil. This species normally breeds and feeds in native grasslands where it multiplies in countless numbers.

DAMAGE

False chinch bugs attack crop plants when mass ground migration begins in late spring as foothills and grassy weed areas dry. Migration occurs during cool parts of day.

MANAGEMENT

Monitor areas adjacent to the field and treat migrating populations before they enter into the crop, if possible. Some control can be achieved by burning over or cultivating the adjoining grasslands and pastures. Frequent cultivation of the infested areas when the nymphs are swarming over the ground, as well as flooding or otherwise thorough irrigation are optional practices. Otherwise, treat field borders to stop further field migration and damage. Complete crop treatment is usually not necessary if potential problems are detected early.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. ESFENVALERATE (Asana XL) MODE-OF-ACTION GROUP NUMBER[1]: 3A	5.8–9.6 0z	12	3
B. PYRETHRIN (PyGanic EC 1.4)# MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Buffer final spray to a pH of 5.5 to 7.0.	16–64 oz	12	0

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

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1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

FLEA BEETLES (5/16)

Scientific Name: *Epitrix* spp. and *Systena* spp.

DESCRIPTION OF THE PEST

Flea beetle adults are small, ranging in size from 0.06 to 0.12 inch (1.5 to 3 mm) long. These insects derive their name from their well-developed hind legs; when disturbed they jump like fleas.

DAMAGE

Adult beetles chew small holes in leaves, giving them a sievelike appearance. The small, slender, white larvae feed on underground parts of the plant. On rare occasions, flea beetles may feed directly on ripe fruit, just below the calyx. This damage is usually seen only in late-season plantings that show extreme foliar stress resulting from lack of water or powdery mildew.

MANAGEMENT

Eliminate plant stress from insufficient moisture and powdery mildew.

Start monitoring after transplanting or when seedlings emerge. During stand establishment flea beetles can damage seedlings and may require an insecticide application. If field monitoring at the time of ripening shows feeding signs on fruit, base treatment decisions on the severity of damage.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. ACETAMIPRID			
(Assail 30SG)	2.5–5.3 oz	12	0
(Assail 70WP)	1.1–2.3 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
B. CLOTHIANIDIN			
(Belay)	9–12 oz	12	21
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
C. CARBARYL*			
(Sevin XLR Plus)	1 qt	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Observe plant response precautions listed on label. Avoid excessive applications.			
D. LAMBDA CYHALOTHRIN			
(Warrior II with Zeon)*	1.28–1.92 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
E. METHOMYL*			
(Lannate SP)	0.5–1 lb	48	See comments
(Lannate LV)	1.5–3 pt	48	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Labeled for use on cucumbers, melons, and summer squash. Highly toxic to bees. PHI is 1 day when 0.5 lb or less for 90SP or 1.5 pt or less for LV formulations is used; when more than 0.5 lb (90SP) or 1.5 pt (LV) is used, PHI is 3 days.			
F. CRYOLITE			
(Kryocide)	8–12 lb	12	See comments
MODE-OF-ACTION GROUP NUMBER[1]: un			
COMMENTS: Labeled for use on cucumber, squash, melons, and pumpkins. Can be applied as a spray or dust. Thorough coverage using ground equipment is necessary for adequate control. Do not apply immediately before harvest. Remove excess residues on edible portions by washing, brushing, or other effective means. Effectiveness of this material is lower than materials listed above. PHI is 7 days for summer squash and 14 days for winter squash, cucumber, melons, and pumpkins.			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
. . . or . . .			
(Prokil Cryolite 96)	10–16 lb	12	See comments
COMMENTS: Labeled for use on cantaloupe, squash, and watermelon. Applied as a spray. Thorough coverage using ground equipment is necessary for adequate control. Do not apply immediately before harvest. Remove excess residues on edible portions by washing, brushing, or other effective means. Effectiveness of this material is lower than materials listed above. PHI is 7 days for summer squash and 14 days for winter squash, cantaloupe, and watermelon.			
G. PYRETHRIN#			
(PyGanic EC 1.4)	16–64 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Buffer final spray to a pH of 5.5 to 7.0.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

* Permit required from county agricultural commissioner for purchase or use.

\# Acceptable for organically grown produce.

GRASSHOPPERS (5/16)

Scientific Name: *Melanoplus* spp.

DESCRIPTION OF THE PEST

Grasshoppers may occasionally attack cucurbit crops, particularly if planted adjacent to foothill rangeland. They normally migrate from the range into cultivated areas as vegetation on the rangeland dries up.

DAMAGE

Grasshoppers destroy leaf tissue and, if present in extremely large numbers, will consume the entire plant. They may also chew on fruit, scarring the surface and netting of cantaloupes.

MANAGEMENT

Keep fields and surrounding areas weed-free. Grasshopper problems usually occur when a migrating population from a foothill range area is attracted to the crop. Plant a trap crop between the crop and the direction that the grasshoppers might migrate from. The trap crop can be treated with cryolite, if allowed by the label. Treat the crop if feeding damage warrants control action.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. CARBARYL			
(Sevin 5 bait)	20 lb	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Apple pumice baits work better for crickets and grasshoppers than bran baits. Baits lose their attractiveness as they dry out. Apply in early evening to avoid drying out too soon from sun exposure. Use suitable ground or aircraft equipment that provides good distribution. Repeat application probably necessary.			
. . . or . . .			
(Sevin XLR Plus)*	0.5–1.5 pt	12	3
COMMENTS: Observe plant response precautions listed on the label. Avoid excessive applications. Be certain spray volumes are appropriate to assure adequate coverage. Use low rate for nymphs and high rate for adults.			
B. LAMBDA CYHALOTHRIN			
(Warrior II with Zeon)*	1.28–1.92 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
C. ESFENVALERATE*			
(Asana XL)	5.8–9.6 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Repeat as necessary to maintain control. Do not exceed 0.25 lb a.i./acre per season.			
D. MALATHION			
(Malathion 8-E)	Label rates	See label	See label
MODE-OF-ACTION GROUP NUMBER[1]: 1B			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

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GREEN PEACH APHID (5/16)

Scientific Name: *Myzus persicae*

DESCRIPTION OF THE PEST

The green peach aphid is rather slender in form, light green or yellowish in color. Winged adults of the green peach aphid are pale or bright green and black, with a large dusky blotch on the dorsum of the abdomen. The immature forms are yellow, pinkish, or pale green. The mature wingless forms are pale or bright green and have no waxy covering. The tubercles at the base of the antennae grow towards each other. Populations tend to start on lower leaves and move up the plant. The green peach aphid occurs throughout California and has a wide host range.

DAMAGE

In desert areas, *Watermelon mosaic virus*, *Zucchini yellow mosaic*, and *Papaya ringspot virus* are transmitted chiefly by the green peach aphid. This aphid moves into melon fields in large numbers from surrounding vegetation, carrying viruses as it moves and feeds from one plant to another. In the San Joaquin Valley, cucumber mosaic, zucchini mosaic, and watermelon mosaic are often the most important viruses transmitted by this aphid.

MANAGEMENT

Silver reflective mulches have successfully been used to repel aphids from plants, thus reducing or delaying virus transmission. In some areas of the state, row covers have also been successfully used. Biological control can have a significant impact on aphid population, so be sure to evaluate predator and parasite populations when making treatment decisions.

Biological Control

Naturally occurring populations of the convergent lady beetle, *Hippodamia convergens*, may provide effective control in early spring. Releases of this beetle are not effective, however, because it generally does not remain in the field following release. Other general predators, such as lacewing and syrphid larvae, and parasitic wasps, including *Aphidius*, *Diaeretiella*, and *Aphelinus* species, also attack aphids. Biological control is not effective in reducing virus transmission by this aphid.

Cultural Control

- In desert production areas, exclude aphids by applying row covers at planting and removing them at first bloom or earlier. Do not apply row covers in the San Joaquin Valley.
  - Plastic row cover. Do not remove the entire cover at one time because the drastic reduction in humidity will shock plants and can lead to collapse. Instead, vent the covers and remove them piecemeal. If the air temperature under the row cover reaches 104° F remove them. Also remove the row cover before plants grow high enough to touch hot plastic.
  - Spun-bonded row cover. Covers made of spun-bonded materials do not need venting because hot air is able to escape.
- Apply silver reflective plastic mulches at planting to repel aphids from plants, thereby reducing or delaying virus infection. Reflective mulches help plants get off to a healthy start, and are effective until expanding foliage covers the reflective surface. Remove mulches in the desert areas when summer temperatures are excessive for optimal growth of plants. However, in the Central Valley and cooler areas, mulches have not caused plant damage in the summer; in fact, they improve soil moisture and nutrient retention, which may further aid plant productivity.
- Control weeds along ditch banks, roads, in farmyards, and other noncultivated areas that contribute directly to the aphid problem.
- Planting a habitat for beneficial insects, such as sweet alyssum, around the field may be helpful.
- Delay planting until warm temperatures (80° to 85°F) occur and the spring flight of aphids is over.
- Do not overfertilize with nitrogen.
- Fields infested with green peach aphid should be disced or plowed under as soon as harvest is complete.

Organically Acceptable Methods

Biological and cultural controls and applications of insecticidal soaps and certain narrow range oils are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

Before planting seed or transplants, set out yellow sticky cards at field edges to monitor the movement of aphids and whiteflies into the crop. Start checking traps after transplanting or when seedlings emerge. When aphids are observed on traps, begin monitoring crop foliage.

The decision to apply insecticides for aphids is based mainly on visual counts; measurable thresholds have not been researched. It is important to treat early to ensure that the aphids do not build up to high levels. Early treatment does not prevent virus introduction; insecticides, however, may help reduce spread of the virus if aphid colonies are present. Be aware, however, that parasites and predators, if present, may prevent an infestation from becoming established throughout a field, thus eliminating the need for insecticides.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. DINOTEFURAN			
(Venom)	See comments	12	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Rates vary depending upon whether a soil or foliar application. Soil application preferred because it has less impact on natural enemies. Preharvest intervals: foliar application—1 day; soil—21 days.			
B. IMIDACLOPRID			
(Admire Pro)	7–10.5 fl oz	12	21
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Apply at planting or transplanting and incorporate into root zone.			
C. THIAMETHOXAM			
(Platinum)	5–11 fl oz	12	30
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: At seeding or transplanting, apply in sufficient water to ensure uniform application and incorporation into the soil. Provides about 40 days of protection. Use where field has history of these pests.			
D. PYMETROZINE			
(Fulfill)	2.75 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 9B			
E. DIMETHOATE			
(Dimethoate 2.67 EC)	Label rates	48	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Labeled for use on melons and watermelons only. Highly toxic to honey bees.			
F. ROSEMARY OIL#			
(Hexacide)	0.75–1.5 qt	—	0
MODE OF ACTION: Contact including smothering and barrier effects.			
COMMENTS: Good coverage is essential for good control. Apply in a minimum of 25 gal/acre. Less disruptive of beneficials than the other organically acceptable alternatives listed.			
G. INSECTICIDAL SOAPS#			
(M-Pede)	1–2% solution	12	0
MODE OF ACTION: A contact insecticide with smothering and barrier effects.			
COMMENTS: This material will reduce populations temporarily, but has no residual and requires repeat applications and thorough coverage.			
H. NARROW RANGE OILS#			
(TriTek)	1–2 gal/100 gal	4	0
(Organic JMS Stylet Oil)	3–6 qt/100 gal	4	0
MODE OF ACTION: Contact including smothering and barrier effects.			
COMMENTS: Oil will reduce populations temporarily, but has no residual and requires repeat applications and thorough coverage. Oils may cause phytotoxicity problems; exercise care when using these materials. Check with certifier to determine which products are organically acceptable.			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
I. METHOMYL* (Lannate LV)	1.5–3 pt	48	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Labeled for use on melons, cucumbers, and summer squash only. Apply early and as needed 7 days later. Repeated use of this material is very disruptive to beneficials. PHI is 1 day if 1.5 pt or less is used/acre; if over 1.5 pt, PHI is 3 days.			

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1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

Acceptable for use on organically grown produce.

— Not recommended or not on the label.

* Permit required from county agricultural commissioner for purchase or use.

LEAFHOPPERS (5/16)

Scientific Names: Western potato leafhopper: *Empoasca abrupta*
Southern garden leafhopper: *Empoasca solana*

DESCRIPTION OF THE PESTS

Leafhoppers are small, light green, wedge-shaped insects that measure a little more than 0.12 inch (3 mm) in length. The western potato leafhopper is a pest throughout California whereas the southern garden leafhopper occurs mostly in the southern California desert areas. Adult females insert kidney-shaped eggs singly in the plant just below the surface. Eggs hatch and the nymphs pass through five instars. Nymphs are whitish to pale green and move rapidly (often sideways) when disturbed. They are found mainly on the underside of leaves.

DAMAGE

The leafhopper has sucking mouthparts and can cause severe white stippling and yellowing of the leaves, green spotting of the fruit, and premature leaf drop. Large populations can reduce quality as well as yield.

MANAGEMENT

Generally good field sanitation and crop growing practices are adequate for preventing damage by these pests.

Cultural Control

Melons and other cucurbits can tolerate fairly heavy feeding provided they are not stressed for moisture and possess six to eight healthy noninfested terminal leaves. After harvest, destroy crop residue as soon as possible to eliminate breeding areas.

In desert production areas, exclude leafhoppers by applying row covers (plastic and spun-bonded materials) at planting and gradually removing them at first bloom or earlier if needed. Row covers are not recommended for the San Joaquin Valley.

- Do not remove the entire plastic row cover at one time because a drastic reduction in humidity will shock plants and can lead to collapse. Instead vent the covers and remove them gradually. Covers made of spun-bonded materials do not need venting because hot air is able to escape.
- Remove row covers if the air temperature underneath reaches 104° F before bloom.
- Remove row covers before plants grow high enough to touch hot plastic.

Organically Acceptable Methods

Cultural controls are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

Treatment thresholds have not been established, but pesticide sprays are not usually required. If leafburn occurs, or if leafhoppers are moving into an immature field from nearby harvested sugarbeet, potato, or other crops, a treatment may be needed.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. DINOTEFURAN (Venom)	See comments	12	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Rates vary depending upon whether a soil or foliar application. Soil application preferred because it has less impact on beneficials.			
B. THIAMETHOXAM (Platinum)	5–11 fl oz	12	30
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: At seeding or transplanting, apply in sufficient water to ensure uniform application and incorporation into the soil. Provides about 40 days of protection. Use where field has history of these pests.			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
C. IMIDACLOPRID			
(Admire Pro)	7–10.5 fl oz	12	21
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: At seeding or transplanting, apply in sufficient water to ensure uniform application and incorporation into the soil. Use where field has history of these pests.			
D. ESFENVALERATE*			
(Asana XL)	5.8–9.6 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Repeat as necessary to maintain control. Do not exceed 0.25 lb a.i./acre per season. Highly toxic to honey bees.			
E. ACETAMIPRID			
(Assail 30SG)	2.5–4 oz	12	0
(Assail 70WP)	1.1–1.7 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
F. METHOMYL*			
(Lannate LV)	1.5–3 pt	48	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Labeled for use on cucumbers, melons and summer squash only. Use sufficient water for thorough coverage. Highly toxic to honey bees. PHI is 1 day if 1.5 pt or less is used per acre; if over 1.5 pt, PHI is 3 days.			
G. DIMETHOATE			
(Dimethoate 2.67 EC)	Label rates	48	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Labeled for use on melons and watermelons only. Highly toxic to honey bees.			
H. DIAZINON*			
(Diazinon 50W)	Label rates	72 (3 days)	3
(Diazinon AG500)	Label rates	72 (3 days)	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Not labeled for pumpkins and squash. Highly toxic to honey bees.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

* Permit required from county agricultural commissioner for purchase or use.

LEAFMINERS (5/16)

Scientific Names: Vegetable leafminer: *Liriomyza sativa*
Serpentine leafminer: *Liriomyza trifolii*, and other *Liriomyza* spp.

DESCRIPTION OF THE PESTS

Liromyzid leafminer adults are small (0.06 inch or 1.5 mm) black and yellow flies having a bright yellow scutellum, a triangular spot on the top rear of the thorax. In the San Joaquin Valley, it is important to distinguish between *L. trifolii* and *L. sativae*, which can occur in the same areas, because *L. trifolii* is much more resistant to most chemical controls. Using a strong hand lens, observe the compound eye of the adult. The eye of *L. trifolii* is nearly completely surrounded by yellow with only a small portion of black touching the rear of the eye. *Liriomyza sativa* has approximately one-fourth to one-third of the eye bordered in black at the rear. The top of the thorax of *L. sativa* is shiny black whereas on *L. trifolii* it is more dull dark gray colored. The larvae of leafminers are tiny bright yellow maggots about 2 mm long when they emerge from the leaves to pupate. Pupae look like tiny brown grains of rice. There can be many generations a year.

Females insert the white, oval eggs into the leaf tissue by puncturing the leaf at the tip and along the edges. Numerous punctures are made, but only a small percentage contain eggs: the majority serve as feeding sites for the adults who lap up the exudate.

DAMAGE

Larvae mine between upper and lower leaf surfaces, creating winding, whitish tunnels that are initially narrow, but then widen as the larvae grow. They may cause leaves to dry, resulting in sunburning of fruit and reduction in yield and fruit quality. In severe infestations, the leafmining may reduce yields or cause plant death. The most serious infestations usually appear late in the season.

MANAGEMENT

Biological control, unless destroyed by treatment for other pests, is often adequate to control leafminers. Good field sanitation can also greatly reduce the numbers of this pest. Evaluate levels of parasitism before making treatment decisions. Also, avoid summer plantings, if possible, in the San Joaquin Valley where leafminers usually do not reach damaging levels until mid-July to early August.

Biological Control

Because of numerous parasites, leafminers are generally not serious pests, but can be sporadic in their attacks. The destruction of beneficials by frequent applications of organophosphates, carbamates, and pyrethroids applied to control other pests can result in leafminer outbreaks. Of the numerous parasites that attack the leafminer in California, the most abundant is the parasitic eulophid wasp, *Solenotus intermedius*, but *Diglyphus* spp. and *Chrysocharis* spp. are probably the most important for controlling leafminers.

Cultural Control

Cutting forage crops and deep plowing after harvesting crops aid greatly in reducing leafminer numbers.

In desert production areas, exclude leafminers by applying row covers (plastic and spun-bonded materials) at planting and gradually removing them at first bloom or earlier if needed. Row covers are not recommended for the San Joaquin Valley.

- Do not remove the entire plastic row cover at one time because a drastic reduction in humidity will shock plants and can lead to collapse. Instead vent the covers and remove them gradually. Covers made of spun-bonded materials do not need venting because hot air is able to escape.
- Remove row covers if the air temperature underneath reaches 104° F before bloom.
- Remove row covers before plants grow high enough to touch hot plastic.

Plants that are not stressed for moisture can better tolerate this pest. In the San Joaquin Valley, plant in early spring and avoid summer plantings because leafminers often occur in damaging numbers beginning in mid-July.

Organically Acceptable Methods

Biological and cultural controls are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

Start monitoring leaves for mines during the vegetative growth stage. Early season infestations are common, but in most cases are controlled by natural enemies. However, if leafminer populations build to high levels and parasitism is low, an insecticide application may be necessary when seedlings have four to five leaves. In desert areas treatment may be required 2 to 4 weeks after planting and then repeated as needed. Use 3-by-5-inch yellow sticky cards to monitor adults moving into the fields from surrounding crops being harvested. Plastic trays can be used to monitor pupating larvae emerging from the leaves by placing the trays under the plant to catch the larvae as they drop to the ground. No economic threshold values are available yet, however.

If parasitism approaches 50% or more, the chances of the leafminer population being kept below economic levels are excellent. Once larvae have entered the leaf, they are difficult to control with insecticides.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. ABAMECTIN* (Agri-Mek SC)	1.75–3.5 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 6			
COMMENTS: Controls serpentine leafminer, *L. trifolii.* Apply by ground only. In heavy infestations, apply a second treatment 7–10 days following the first. Under severe, continuous pressure, a second set of treatments may be needed 3 weeks following the first set. Highly toxic to honey bees.			
B. CYROMAZINE (Trigard)	2.66 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 17			
COMMENTS: Apply as a foliar spray when leafminers first appear. Do not make more than six applications per growing season.			
C. CHLORANTRANILIPROLE (Coragen)	3.5–5 oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 28			
D. SPINETORAM (Radiant SC)	5–10 fl oz	4	1–cucumbers 3–other cucurbits
MODE-OF-ACTION GROUP NUMBER[1]: 5			
CAUTION: Be aware that the following chemicals are harsh on predators and parasites, especially at high label rates and should not be used if natural enemies are present.			
E. ESFENVALERATE* (Asana XL)	5.8–9.6 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Repeat as necessary to maintain control. Do not exceed 0.25 lb a.i./acre per season. Provides only sporadic control of *L. trifolii*. Highly toxic to honey bees.			
F. OXAMYL* (Vydate L)	2–4 pt	48	1
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Labeled for use on cucumber, cantaloupe, honeydew melon, watermelon, squash, and pumpkin only. Apply low rate for light infestations. Not effective on *L. trifolii.* Highly toxic to honey bees.			
G. DIMETHOATE (Dimethoate 2.67 EC)	Melons: 1.5 pt Watermelons: 0.75–1.5 pt	48 48	3 3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Labeled for use on melons and watermelons only. Pest has developed tolerance to this material in some areas; not effective on *L. trifolii.* Highly toxic to honey bees.			
H. DIAZINON*			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
(Diazinon 50W)	Label rates	72	3
(Diazinon AG500)	Label rates	72	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Labeled for use on melons and watermelons only. May not be as effective as other materials because pest has developed tolerance in some areas. Highly toxic to honey bees.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

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1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

MELON APHID (5/16)

Scientific Name: *Aphis gossypii*

DESCRIPTION OF THE PEST

The melon aphid, also called cotton aphid, is a rather small aphid that ranges in color from yellowish green to greenish black. Both winged and wingless forms are produced. The winged individuals are somewhat slender and are not as robust as the wingless form. A mature individual measures about 0.06 inch (1.5 mm) in length. The melon aphid develops in colonies and prefers the underside of leaves. Unlike other aphids, melon aphid populations do not diminish with high temperatures; they can also be troublesome late in the season (September and October), particularly in the San Joaquin Valley and in northern California.

Melon aphid has an extensive host range. Some of the crops it attacks besides cucurbits are cotton and citrus. Host weeds include milkweed, jimsonweed, pigweeds, plantain, and field bindweed.

DAMAGE

These small, green aphids can be a major problem on young plants where they feed near the tips of runners or in growing points. They cluster in numbers on the underside of growing leaves, distorting and curling the leaves, and produce a large amount of honeydew. The fruits become coated with the sticky secretion, creating an environment favorable for the development of a sooty mold. In addition they vector a number of viruses. In the San Joaquin Valley, this aphid can vector cucumber mosaic, zucchini yellow, and watermelon mosaic viruses, among others. These virus diseases may be more destructive to crops than direct aphid feeding. Several other aphid species cause similar injury, as well as virus transmission. The end result of feeding by this aphid is loss of vigor, stunting, or even death of the plants. Melon aphids will feed on cantaloupe, honeydew melon, casaba, and Persian melons, watermelon, cucumber, and squash.

MANAGEMENT

Silver reflective mulches have successfully been used to repel aphids from plants, thus reducing or delaying virus transmission. In some areas of the state, row covers have also been successfully used. Biological control can have a significant impact on aphid population so be sure to evaluate predator and parasite populations when making treatment decisions.

Biological Control

Naturally occurring populations of the convergent lady beetle, *Hippodamia convergens*, may provide effective control in early spring. Releases of this beetle are not effective, however, because it generally does not remain in the field following release. Other general predators, such as lacewing and syrphid larvae, and parasitic wasps, including *Lysiphlebus*, *Aphidius*, *Diaeretiella*, and *Aphelinus* species, also attack aphids. Biological control is not effective in reducing virus transmission by this aphid.

Cultural Control

It is a good practice, where feasible, to remove and bury the few severely infested plants as they appear in spring; this helps prevent rapid spreading of the aphid population.

In desert production areas, exclude aphids by applying row covers (plastic and spun-bonded materials) at planting and gradually removing them at first bloom or earlier if needed. Row covers are not recommended for the San Joaquin Valley.

- Do not remove the entire plastic row cover at one time because a drastic reduction in humidity will shock plants and can lead to collapse. Instead vent the covers and remove them gradually. Covers made of spun-bonded materials do not need venting because hot air is able to escape.
- Remove row covers if the air temperature underneath reaches 104° F before bloom.
- Remove row covers before plants grow high enough to touch hot plastic.

Lay silver reflective plastic mulches at planting. They help plants get off to a healthy start, and are effective until expanded foliage covers the reflective surface. Reflective mulches also need to be removed in the desert areas when summer temperatures are excessive for optimal growth of plants. However, in the Central Valley and cooler areas, mulches have not caused plant damage; in fact, they improve soil moisture and nutrient retention, which may further aid plant productivity.

Preserve habitat for beneficials around the field and keep dust down to encourage parasitism and predation. If populations are high enough to produce large amounts of honeydew, the fruit will need to be washed off. Avoid overfertilizing with nitrogen. Fields infested with melon aphid should be disced or plowed under as soon as harvest is complete.

Organically Acceptable Methods

Biological and cultural controls and sprays of rosemary oil, insecticidal soaps, and certain oils are acceptable for use in an organically grown crop. Rosemary oil is less disruptive of beneficials than soaps and narrow range oils.

Monitoring and Treatment Decisions

Melon aphid is very difficult to control with insecticides. If natural enemies are not destroyed by insecticides applied for other pests, they will help keep melon aphid under control until late in the season.

1. Before planting seed or transplants, set out yellow sticky cards to monitor the movement of aphids and whiteflies.
2. Start checking traps after transplanting or when seedlings emerge.
3. When aphids are observed on traps, begin monitoring crop foliage.

If unusually large numbers of aphids build up in parts of a field early in the season and appear to be retarding growth or causing honeydew buildup on fruit, apply an insecticide to the infested portions of the field. No threshold has been established. Early treatment does not prevent virus introduction; however, treating may help reduce spread of the virus if aphid colonies are present.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. DINOTEFURAN (Venom)	1–4 oz	12	1
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Foliar application.			
B. IMIDACLOPRID (Admire Pro)	7–10.5 fl oz	12	21
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Apply at planting or transplanting and incorporate into root zone. Use where field has history of these pests.			
C. THIAMETHOXAM (Platinum)	5–11 fl oz	12	30
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: At seeding or transplanting, apply in sufficient water to ensure uniform application and incorporation into the soil. Provides about 40 days of protection. Use where field has history of these pests.			
D. PYMETROZINE (Fulfill)	2.75 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 9B			
E. DIMETHOATE (Dimethoate 2.67 EC)	Label rates	48	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Labeled for use on melons and watermelons only. Highly toxic to honey bees.			
F. ROSEMARY OIL# (Hexacide)	0.75–1.5 qt	—	0
MODE OF ACTION: Contact including smothering and barrier effects.			
COMMENTS: Good coverage is essential for good control. Apply in a minimum of 25 gal/acre. Less disruptive of natural enemies than the other organically acceptable alternatives listed.			
G. INSECTICIDAL SOAPS#			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
(M-Pede)	1–2% solution	12	0
MODE OF ACTION: A contact insecticide with smothering and barrier effects.			
COMMENTS: Thorough coverage is important. This material has no residual value and repeated applications are necessary. For plants with dense foliage the higher gallonage rate may be necessary.			
H. NARROW RANGE OILS#			
(TriTek, Organic JMS Stylet Oil)	1–2 gal/100 gal	4	0
(Organic JMS Stylet Oil)	3–6 qt/100 gal	4	0
MODE OF ACTION: Contact including smothering and barrier effects.			
COMMENTS: Oil will reduce populations temporarily, but has no residual and requires repeat applications and thorough coverage. Oils may cause phytotoxicity problems; exercise care when using these materials. Check with certifier to determine which products are organically acceptable.			
I. BIFENTHRIN*			
(Capture 2EC-CAL)	2.6–6.4 oz	12	3
(Brigade 2EC)	2.6–6.4 fl oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Also will control mites. Repeated use of this material is very disruptive to beneficials. Do not apply more than 19.2 oz/acre per season. Do not make more than 2 applications after bloom.			
J. METHOMYL*			
(Lannate LV)	1.5–3 pt	48	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Labeled for use on cucumbers, melons, and summer squash only. Repeated use of this material is very disruptive to natural enemies. PHI is 1 day if 1.5 pt or less is used per acre; if over 1.5 pt, PHI is 3 days.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

Acceptable for use on organically grown produce.

— Not recommended or not on the label.

* Permit required from county agricultural commissioner for purchase or use.

SEEDCORN MAGGOT (5/16)

Scientific Name: *Delia platura*

DESCRIPTION OF THE PEST

The seedcorn maggot is the larva of a small, light gray fly that is about 0.15 inch (4 mm) long. The whitish, legless maggots are about 0.3 inch (8 mm) long and attack the planted seed of a number of crops during the winter and early spring months, particularly if there is a cold period that prevents quick germination of the seed. Maggots may overwinter in the soil or hatch from eggs laid in spring.

DAMAGE

The maggot attacks germinating seeds or transplants, but is only a pest early in the season before the soil warms up. Little damage is likely to occur once favorable growing conditions set in. Seed corn maggots are particularly damaging when residues of the previous crop have not thoroughly decayed before planting cucurbits.

MANAGEMENT

A preventive seed treatment is particularly important when planting in no-till, conservation-till, and when planting through cover crops to prevent seed corn maggot damage. Additionally, good field sanitation, and production measures that ensure rapid seed germination are important in controlling seed corn maggots.

Cultural Control

Fields with moist, heavy-textured soil usually have the worst problem with this pest. To reduce attractiveness of the field to egg-laying adults, disc or plow early in the season to incorporate residues from the previous crop and allow time for residues to completely decompose before planting. Destroy weed growth. Avoid planting cucurbits after root crops or cole crops, including cabbage, cauliflower, broccoli, and Brussels sprouts, and after fall tomatoes. Assure rapid seed germination by planting in moist soil and not too deep (1.25 to 1.5 inch depth is ideal for melons) when weather conditions are ideal. The longer the germination the greater the risk of infestation. Late-season planting may avoid the early season infestation of this pest.

Organically Acceptable Methods

Cultural controls are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

A preventive seed treatment is the best method of control.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
CAUTION: Do not use treated seed for human consumption, for livestock or poultry, or for oil purposes. Label treated seed as follows: TREATED SEED. DO NOT USE FOR FOOD, FEED, OR OIL.			
PREHARVEST			
A. DIAZINON* (Diazinon AG 500)	3–4 qt	72	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: For use in melon fields only; broadcast just before planting and incorporate. Avid drift and tail water runoff into surface waters.			
PREPLANT FUMIGATION			
A. METAM SODIUM* (Vapam)	75 gal	See label	NA

COMMENTS: Wait at least 14 days after fumigation before planting. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

SEED TREATMENT

A.	THIAMETHOXAM (Farmore FI400) MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: Seed treatment. Farmore FI400 is not labeled for use in California, but seed treated in and obtained from another state can be legally used in California even for a chemical not registered on cucurbits in California. Contact your retail seed dealer for information and availability.	Label rates	See label	NA

AT PLANTING

A.	DIAZINON* (Diazinon AG 500) MODE-OF-ACTION GROUP NUMBER[1]: 1B COMMENTS: Broadcast apply just before planting and immediately incorporate into the top 4 inches of the soil.	9–12 oz	72	3
B.	BIFENTHRIN (Capture LFR) MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Apply as an in-furrow spray directly with the seed during planting; soil surface band directly over the seedline. Sprinkler incorporation is an alternative method.	6–8 oz		
C.	CLOTHIANIDIN (Belay) MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: Apply as an in-furrow spray directly with the seed during planting; can also be applied as a transplant water drench for watermelons.	9–12 oz	12	21
D.	CHLORANTRANILIPROLE (Coragen) MODE-OF-ACTION GROUP NUMBER[1]: 28 COMMENTS: Apply as an in-furrow spray directly with the seed during planting; can also be applied as a transplant water drench for watermelons.	3.5–5 oz	4	1
E.	CHLORANTRANILIPROLE / THIAMETHOXAM (Durivo) MODE-OF-ACTION GROUP NUMBER[1]: 28 / 4A COMMENTS: Apply as an in-furrow spray directly with the seed during planting; can also be applied as a transplant water drench for watermelons.	10–13 fl oz	12	30

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

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NA Not applicable.

SPIDER MITES (5/16)

Scientific Names: Twospotted spider mite: *Tetranychus urticae*
Pacific spider mite: *Tetranychus pacificus*
Strawberry spider mite: *Tetranychus turkestani*
Desert spider mite: *Tetranychus desertorum*
Carmine spider mite: *Tetranychus cinnabarinus*
Brown wheat mite: *Petrobia latens*

DESCRIPTION OF THE PESTS

Examine leaves with a hand lens for spider mites. Frequently, infestations include a mixture of spider mite species. Adult mites are about 0.06 inch in length, have four pairs of legs, are greenish to pink or cream colored, and have various sized black spots on the body. Under warm conditions spider mites move rapidly within the colony area. Spider mites have four stages of development: (1) the oval, somewhat translucent egg; (2) a six-legged translucent immature stage; (3) an eight-legged immature stage; and (4) the eight-legged adult stage. A generation may pass in as few as 5 to 7 days in mid-summer, or in a month during cool periods. Spider mites produce webbing that is often filled with cast skins, dust, and other debris.

DAMAGE

Mite feeding results in the destruction of chlorophyll; leaves become pale, stippled, and in later stages of infestation dry up and die. Loss of color is pronounced on the under surface of leaves before it becomes apparent on the upper side. Light infestations can be tolerated, but when heavy, can result in lowered yield and reduced quality of fruit.

MANAGEMENT

Biological control is an important component of mite management. Take measures to ensure the survival of predators and parasites.

Biological Control

Several predators play an important role in regulating spider mite populations, including the western predatory mite (*Galendromus* [*Metaseiulus*] *occidentalis*), sixspotted thrips (*Scolothrips sexmaculatus*), western flower thrips (*Frankliniella occidentalis*), lady beetles (*Stethorus* sp.), minute pirate bug (*Orius tristicolor*), and lacewing larvae (*Chrysoperla carnea*). The western predatory mite is the same size as spider mites but lacks spots and ranges in color from cream to amber red. It is available commercially, but research has not been done on the effectiveness of releasing these predators in cucurbits. Sixspotted thrips and western flower thrips are also effective predators, but naturally occurring populations of these insects generally do not develop to high enough levels that they can provide significant control until damage has already taken place. Both species are tiny, slender insects about1 mm or less in length. Sixspotted thrips has three dark spots on each forewing; western flower thrips ranges in color from clear lemon yellow to dark brown. Monitor western predatory mites and the two species of thrips to determine if they are present in the field and their relative population density in comparison with pest mites.

Cultural Control

Minimize dust and encourage naturally occurring predators and parasites by limiting chemical rates and the number of applications. Control field bindweed growing in or at the edges of a cucurbit field. Good water management increases plant tolerance to these pests. After runners are 14 inches long, natural enemies such as sixspotted thrips or predaceous mites usually control pest mite populations.

Organically Acceptable Methods

Biological and cultural controls and sulfur sprays (not for use on sulfur sensitive varieties) are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

Start monitoring for spider mites during the vegetative growth stage. No threshold is established, but when buildup is observed, either spot or completely treat the field before webbing occurs or before runners are 14 inches in length, providing no predatory thrips or predaceous mites are present. After the rows close over, ground equipment cannot get in the field, and chemical treatment must be applied by aircraft. Such treatments are less effective because it is difficult to obtain good coverage by aircraft.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. BIFENAZATE (Acramite 50WS) MODE-OF-ACTION GROUP NUMBER[1]: un	0.75–1 lb	12	3
B. ABAMECTIN* (Agri-Mek SC) MODE-OF-ACTION GROUP NUMBER[1]: 6	1.75–3.5 fl oz	12	7
C. SULFUR# MODE OF ACTION: Unknown. An inorganic insecticide. COMMENTS: Do not apply when temperature exceeds 95°F or use on sulfur-sensitive varieties. Not effective on Pacific mites.	15–20 lb	24	0

‡ Restricted entry interval (REI) is the number of hours(unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

* Permit required from county agricultural commissioner for purchase or use.

\# Acceptable for use on organically grown produce.

SQUASH BUG (5/16)

Scientific Name: *Anasa tristis*

DESCRIPTION OF THE PEST

The adult squash bug is 0.65 inch (1.5 cm) in length. It is brownish yellow but appears black because of a dense covering of black hairs. Protruding margins of the abdomen are orange or orange and brown striped, and the margins of the pronotum are yellow. Shiny, elliptical reddish brown eggs are laid singly or in groups of 15 to 40 on the underside of leaves or on stems. Young nymphs are pale green, while later instars have a blackish thorax and brownish abdomen; they are often covered with white powder.

DAMAGE

Injury occurs on squash, pumpkins, and melons. Adults and nymphs cause damage by sucking plant juices. Leaves lose nutrients and water and become speckled, later turning yellow to brown. Under heavy feeding, plants begin to wilt, and the point of attack becomes black and brittle. Small plants can be killed completely, while larger cucurbits begin to lose runners. The wilting resembles bacterial wilt, which is a disease spread by another pest of squash, the cucumber beetle. The wilting caused by squash bugs is not a true disease. Squash bugs may feed on developing fruits, causing scarring and death of young fruit.

MANAGEMENT

Good field sanitation and other cultural practices help to prevent damage by this pest. Treatments may be warranted if the insect is causing damage in the field.

Cultural Control

Destroy crop residues and reduce overwintering hiding places.

In desert production areas, exclude squash bugs by applying row covers (plastic and spun-bonded materials) at planting and gradually removing them at first bloom or earlier if needed. Row covers are not recommended for the San Joaquin Valley.

- Do not remove the entire plastic row cover at one time because a drastic reduction in humidity will shock plants and can lead to collapse. Instead vent the covers and remove them gradually. Covers made of spun-bonded materials do not need venting because hot air is able to escape.
- Remove row covers if the air temperature underneath reaches 104° F before bloom.
- Remove row covers before plants grow high enough to touch hot plastic.

Some plant varietal preferences occur: pumpkins, watermelons and squash are the most seriously damaged; zucchinis are less susceptible. Because squash bugs have a preference for squash, a squash planting can be used as a trap crop near other cucurbits plantings such as watermelon to concentrate an infestation. Treat the trap crop with an insecticide to control the infestation.

Organically Acceptable Methods

Cultural controls are acceptable to use in an organically certified crop along with sprays of PyGanic, insecticidal soaps, and certain oils.

Monitoring and Treatment Decisions

Squash bugs overwinter as adults under dead leaves, rocks, wood, and crop debris. In spring, search for squash bugs hidden in these places, near buildings, and in perennial plants. Inspect young plants daily for signs of egg masses. Start monitoring after transplanting or when seedlings emerge and continue monitoring through fruit development.

While no threshold has been established in California, in the Midwest one egg mass per plant is used to make treatment decisions. If the squash population exceeds the threshold, apply an insecticide early when most eggs are hatching because young nymphs are more susceptible to pesticides than older nymphs or adults. Squash bugs will feed on and damage young and mature fruit, therefore, control may be needed later as the crop matures.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

A.	DINOTEFURAN			
	(Venom)	1–4 oz	12	1
	MODE-OF-ACTION GROUP NUMBER[1]: 4A			
	COMMENTS: An earlier season soil application that targets aphids and whiteflies can provide protection for about 40 days. Make a foliar application later in season after soil application has lost its effectiveness.			
B.	LAMBDA CYHALOTHRIN			
	(Warrior II with Zeon)*	1.28–1.92 fl oz	24	1
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
C.	ESFENVALERATE*			
	(Asana XL)	5.8–9.6 oz	12	3
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
	COMMENTS: Repeat as necessary to maintain control. Do not exceed 0.25 lb a.i./acre per season. May encourage the buildup of pest mite populations. Highly toxic to honey bees.			
D.	PYRETHRIN#			
	(PyGanic EC 1.4)	16–64 oz	12	0
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
	COMMENTS: Apply round the base of plants a few days after eggs are first laid and nymphs are beginning to hatch. Follow with a second application 10 days later. Buffer final spray to a pH of 5.5 to 7.0.			
E.	INSECTICIDAL SOAPS#			
	(M-Pede)	1–2% solution	12	0
	MODE OF ACTION: A contact insecticide with smothering and barrier effects.			
	COMMENTS: Thorough coverage is important. Can control small nymphs; not as effective on older nymphs or adults.			
F.	NARROW RANGE OILS#			
	(TriTek)	1–2 gal/100 gal	4	0
	(Organic JMS Stylet Oil)	3–6 qt/100 gal	4	0
	MODE OF ACTION: Contact including smothering and barrier effects.			
	COMMENTS: Thorough coverage is important. Can control small nymphs; not as effective on older nymphs or adults. Oils may cause phytotoxicity problems; exercise care when using these materials. Check with certifier to determine which products are organically acceptable.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

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\# Acceptable for use on organically grown produce.

STINK BUGS (5/16)

Scientific Name: Consperse stink bug: *Euschistus conspersus*
Green stink bug: *Acrosternum hilare*
Say's stink bug complex: *Chlorochroa sayi, C. uhleri*

DESCRIPTION OF THE PEST

Several kinds of stink bugs feed on cucurbits, but all are similar in life history and damage. Adult stink bugs are distinctly shield shaped, about 1/2 inch (1.3 cm) long and either brown or green. Some species have red, pink, or yellow markings. Eggs are laid in about fourteen to a cluster and are barrel-shaped with circular lids. Initially they are pearly white and later turn cream colored or pinkish just before hatching. For consperse stink bugs, a row of spines encircle the top of the eggs; the other species have concentric black rings on top of the eggs. Early nymphal stages resemble the adults in shape, but have various markings and patterns and no wings. Nymphs develop prominent wing pads as fourth and fifth instars.

The green stink bug is bright green with the entire lateral margin lined yellow, orange, or reddish. They are slightly larger (0.6–0.9 inch or 1.5–2.2 cm in length) and less common than the redshouldered stink bug which is predominantly green with a narrow red band across the shoulder, although sometimes the band is absent. Consperse stink bugs have gray brown to green bodies with yellow to orange legs and antennae with darkened tips. The body and legs are covered with small, black specks and the undersurface of the body varies from gray to green. Say's stink bugs have green and yellow colors on the head and back, are covered with tiny white flecks, have three pale spots at the base of the scutellum, and appear distinctly rounded when seen from above. These bugs develop in trees and weeds and move into green plants. Do not confuse these stink bugs with the rough stink bug, a predator that is speckled white and gray and is quite common in many crop areas throughout the year.

DAMAGE

Feeding on immature fruit can cause growth distortion as well as irregular surface and internal spots on fruit at any time.

MANAGEMENT

Stink bugs are sporadic and spotty seasonal pests. Adults overwinter on the ground under leaves, in orchards, legume crops, blackberries, or on certain weeds such as Russian thistle, mustards, and little mallow (cheeseweed). During mid- to late summer, populations can become quite high. These pests often move from undisturbed areas such as weedy fields and ditch banks as well as from riparian areas into crops. Monitor such adjacent areas to eliminate any surprise infestations. Check developing fruit for stink bugs. Time applications after the majority of eggs have hatched and nymphs are easily found. Individuals tend to hide by moving to the opposite side of the plant or fruit surface being observed.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. DINOTEFURAN (Venom) MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: Foliar application.	1–4 oz	12	1
B. LAMBDA CYHALOTHRIN (Warrior II with Zeon)* MODE-OF-ACTION GROUP NUMBER[1]: 3A	1.28–1.92 fl oz	24	1
C. ESFENVALERATE* (Asana XL) MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Repeat as necessary. Do not exceed 0.25 lb a.i./acre per season.	5.8–9.6 oz	12	3

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

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THRIPS (5/16)

Scientific Names: Western flower thrips: *Frankliniella occidentalis* and other species

DESCRIPTION OF THE PESTS

Thrips are small, slender insects with mouthparts developed primarily for sucking and rasping. The adults measure about 0.04 inch (1 mm) in length and have two pairs of fringed wings, carried lengthwise over the back.

DAMAGE

Western flower thrips is both a beneficial insect (it feeds on spider mites) and a pest (it can damage flowers and shoot tips during the early growth stages or occasionally, if populations are severe, immature fruit). Both the young and adults cause damage by rasping and puncturing surface cells. This results in a silvering, and sometimes deformation, of the leaves: edges of leaves tend to curl downward.

MANAGEMENT

Discing weeds before they flower can lessen attraction of the field to thrips. Do not disc after weeds have flowered, as thrips will move to crop plants. Monitor with yellow or blue sticky traps placed in field from seedling through flowering period to determine the magnitude of the thrips population. Be sure to determine that thrips-related damage is occurring and consider treating only if the population is causing serious damage to shoot tips, flowers, or fruit. Unnecessary treatments can cause spider mite buildup.

Organically Acceptable Methods

Weed management and sprays of the Entrust formulation of spinosad are acceptable in an organically certified crop.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. SPINETORAM			
(Radiant SC)	5–10 fl oz	4	1–cucumbers 3–other cucurbits
MODE-OF-ACTION GROUP NUMBER[1]: 5			
B. SPINOSAD			
(Entrust)#	2–2.5 oz	4	3 (1–cucumbers)
(Success)	6–8 fl oz	4	3 (1-cucumbers)
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Do not apply more than 0.45 lb a.i. spinosad/acre per season. Rotate with an insecticide that has a different mode of action.			
C. METHOMYL*			
(Lannate SP)	0.5–1 lb	48	See comments
(Lannate LV)	1.5–3 pt	48	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: For use on cucumbers, melons and summer squash only. PHI is 1 day when 0.5 lb or less for 90SP or 1.5 pt or less for LV formulations is used; when more than 0.5 lb (90SP) or 1.5 pt (LV) is used, PHI is 3 days.			
D. DIMETHOATE			
(Dimethoate) 2.67 EC	Melons: 1.5 pt	48	3
	Watermelons: 0.75–1.5 pt	48	3
(Dimethoate 400) 4EC	Melons: 1 pt	48	3
	Watermelons: 0.5–1 pt	48	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Only labeled for use on melons and watermelons. Highly toxic to honey bees.			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

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VINEGAR FLIES (11/05)

Scientific Name: *Drosophila melanogaster*

DESCRIPTION OF THE PEST

Vinegar flies, also known as fruit flies, are small, tan to amber-colored flies with red eyes, about 0.12 inch (3 mm) long. Larvae are small, white, legless maggots that get up to 0.2 inch (5 mm) long. They differ from driedfruit beetle larvae in that they do not have a hardened head capsule.

DAMAGE

Damage is similar to the driedfruit beetle in that the presence of vinegar flies in fruit causes downgrading or rejection of fruit. Vinegar flies are also responsible for transmitting spoilage organisms to sound fruit. Late ripening varieties are especially susceptible to damage as vinegar flies become widespread in tremendous numbers.

MANAGEMENT

Vinegar flies breed in any fermenting or decaying fruit but do not affect undamaged fruit. Remove or disc under damaged fruit to reduce the population. Harvest rapidly and early to reduce exposure of fruit to infestation. Sanitation is key to control.

WHITEFLIES (5/16)

Scientific Names: Greenhouse whitefly: *Trialeurodes vaporariorum*
Iris whitefly: *Aleyrodes spiraeoides*
Sweetpotato whitefly: *Bemisia tabaci*
Silverleaf whitefly: *Bemisia tabaci*, *Biotype B* (= *B. argentifolii*)

DESCRIPTION OF THE PESTS

Several species of whiteflies infest cucurbits. Proper identification of the whitefly species is important because the silverleaf whitefly, and occasionally the greenhouse whitefly, represent the greatest damage potential to cucurbits. Silverleaf whitefly is relatively new to California and has all but displaced the sweetpotato whitefly, which was a problem in cucurbits because of its ability to vector viruses. Silverleaf whitefly is a major problem in California's southern desert and an increasing problem in the southern San Joaquin Valley.

Distinguishing whitefly species is difficult; use a hand lens to examine both immatures and adults. Whiteflies are small insects that are about 0.06 inch (1.5 mm) long. The body and wings of adults are covered with a fine, whitish powdery wax that is opaque in appearance. Silverleaf whitefly adults hold their wings somewhat vertically tilted, or rooflike, over the body and generally the wings do not meet over the back but have a small space separating them. Greenhouse whitefly (*Trialeurodes vaporariorum*) adults, the species most similar in appearance to silverleaf whitefly, hold their wings flatter over the back and there is no space where the two wings meet in the center of the back.

Whiteflies colonize the underside of leaves; adults and eggs are commonly found on the lower surface of younger leaves and the scalelike nymphal stages on somewhat older leaves. The tiny, oval eggs hatch into a first larval stage that has legs and antennae and is mobile. The legs and antennae are lost after the first molt and subsequent stages remain fixed to the leaf surface. The last nymphal stage, often called the pupa or the red-eyed nymph, is the stage that is easiest to identify. Silverleaf whitefly pupae are oval, whitish, and soft. The edge of the pupa tapers down to the leaf surface and has few to no long waxy filaments around the edge. In contrast, greenhouse whitefly pupae have many long waxy filaments around the edge, and the edge is somewhat vertical where it contacts the leaf surface. Most other whiteflies found on cucurbits produce a lot of white wax in their colonies; silverleaf whitefly has almost none.

DAMAGE

Desiccation of plants occurs with moderate-to-heavy populations and the production of honeydew gives rise to sooty mold. The plant becomes unthrifty and nonproductive, and the fruit is rendered unmarketable. Sweetpotato whitefly has historically been a serious problem in cucurbits by transmitting lettuce infectious yellows virus and squash leaf curl virus. Recently, sweetpotato whitefly has all but disappeared in California, displaced by the silverleaf whitefly. The silverleaf whitefly has become especially damaging in southern California growing areas and also threatens cucurbits in northern California. In light-to-moderate infestations of silverleaf whitefly, leaves show no distinctive symptoms as a result of their feeding; however, copious quantities of honeydew are deposited on leaves, resulting in a sticky, shiny appearance. Silverleaf whitefly has become a serious pest because of its high reproductive capability, wide host range, high rate of feeding, and exudation of sticky honeydew. Its feeding on squash frequently causes crop leaves to turn whitish or silver, hence the name silverleaf whitefly.

MANAGEMENT

Whiteflies, with the exception of the silverleaf whitefly, rarely require chemical control. Natural or introduced biological controls provide the best long-term solution to keeping most of the whitefly species at low levels along with crop host absence in the areas of heavy infestations. Key cultural controls to prevent the buildup of this pest include row covers in the low deserts, silver reflective mulches, noninfested transplants, and good field sanitation.

Biological Control

Several wasps, including species in the *Encarsia* and *Eretmocerus* genera, parasitize whiteflies. Whitefly nymphs are also preyed upon by bigeyed bugs, lacewing larvae, and lady beetles. Silverleaf whitefly is an introduced pest that has escaped its natural enemies. Some indigenous native parasites and predators do attack it, but do not keep it below damaging numbers. The lady beetle, *Delphastus pusillus,* is being introduced into southern California to assist in biological control.

Cultural Control

Populations peak in late summer and begin to decrease by November. Delaying planting or using host-free periods may decrease severity of attack.

Do not plant melons during fall in the low deserts of southern California unless row covers are applied to beds at planting. Row covers are not recommended in the San Joaquin Valley.

1. Vent the row covers and remove them gradually at first bloom or before, if needed. Do not remove the entire cover at one time because a drastic reduction in humidity will shock plants and can lead to collapse. Covers made of spun-bonded materials do not need venting; hot air is able to escape.
2. Remove row covers if the air temperature underneath reaches 104° F before bloom.
3. Also remove plastic row covers before plants grow high enough to touch hot plastic.

Silver reflective plastic mulches applied at planting have been shown to be effective in reducing the number of silverleaf whiteflies landing on melon leaves. This, in turn, delays the buildup of whitefly populations on melons. They help plants off to a healthy start and are effective until expanding foliage covers the reflective surface. In desert areas, remove reflective mulches when summer temperatures are excessive for optimal growth of plants. In the Central Valley and cooler areas, mulches have not caused plant damage; in fact, they improve soil moisture and nutrient retention, which may increase plant productivity.

Avoid whitefly infested transplants; this is how the silverleaf whitefly has been transported to other areas of the state. When possible, plant cucurbits at least one-half mile upwind from other key whitefly hosts such as cole crops and cotton. Maintain good sanitation in winter/spring host plants and weeds. Remove field bindweed and other weeds in and adjacent to the crop field as well as crop residues. Attempt to produce the crop in the shortest season possible; proper management of irrigation and nitrogen will assist in this.

Organically Acceptable Methods

Biological and cultural controls, as well as soap and certain oil sprays are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

The key to management is preventing whiteflies from colonizing plants in and around the crop. This is often done by targeting the adult population to prevent them from ovipositing on the undersurface of leaves. Once oviposition takes place it is difficult and often expensive to prevent damage caused by nymph feeding. Failure to minimize the establishment of whitefly colonies can result in significant yield loss due to delayed maturity and reduced quality and fruit size.

A soil application of imidacloprid (Admire) or thiamethoxam (Platinum) at planting effectively controls whiteflies. Foliar treatments with bifenthrin (Brigade) or spiromesifen (Oberon) during the growing season effectively controls whiteflies when thresholds are reached.

Presence-absence Sampling

A presence-absence sampling method developed in Arizona provides information on whitefly distribution and economic control, particularly for spring melons. According to the research, visual observation of adults on leaves offers a more practical and accurate method to estimate whitefly populations than sticky traps. While sticky trap monitoring is used to detect initial migration into the field, evidence shows that trap catches near recently treated fields had artificially inflated whitefly numbers.

Because whitefly populations have shown a relatively even distribution in melon fields, the presence-absence sampling relates the total number of leaves with one or more adults to the average number of whiteflies per leaf throughout the field.

Set up yellow sticky traps right before planting to monitor whiteflies and aphids. Start monitoring the traps after transplanting or when seedlings emerge. Once traps begin to catch whiteflies, start presence-absence sampling.

- Monitor during early morning hours, within 2 hours of sunrise (before adults are active).
- Sample 50 leaves per field (25 leaves from 2 separate areas) by carefully turning the terminal leaf (adults tend to aggregate at terminals) of each plant and looking for adult whiteflies on each leaf.
- Count leaves with one or more whitefly adults.
- Note presence of red-eyed nymphs on the crown portion of the plant. Nymph presence can indicate a rapid increase of adult numbers in the near future.

If 50% or more of the leaves have one or more adults, the estimated infestation level in the field is at least 2 to 3 adult whiteflies per leaf.

Apply an insecticide before whitefly numbers reach more than 2 adults per leaf and honeydew contaminates fruit. Fall melon plants are usually small when adults migrate, therefore insecticide applications may be needed more frequently. Whitefly adults move between crops, so be sure to manage them in all nearby crops.

Continue presence-absence sampling after treatment to determine its success and to follow populations migrating into the field later in the season.

Nymph Monitoring
Although more complicated, nymph monitoring can be used as a supplement to adult monitoring or to manage whiteflies with an insect growth regulator (IGR).

- Collect 50 leaves per field (25 leaves from 2 separate areas).
- Place a quarter between the two major leaf veins to delineate a 1-cm^2 disc.
- Using a hand lens, look at the disc area and count visible nymphs, including 3rd and 4th instars, which look like flattened, egg-shaped scales.
- Count and record the number of nymphs for two 1-cm^2 discs per leaf.

Apply IGRs like buprofezin (Courier) when there is an average of 0.5 large nymphs or more are per disc.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
PREVENTIVE TREATMENTS (SOIL APPLICATIONS)			
A. DINOTEFURAN			
(Venom)	5–6 oz (soil)	12	21
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
B. IMIDACLOPRID			
(Admire Pro)	7–10.5 fl oz	12	21
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Apply at planting and incorporate into soil; effective against nymphs only.			
C. THIAMETHOXAM			
(Platinum)	5–11 fl oz	12	30
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Not as effective as imidacloprid but can be use at planting or injected via drip irrigation in growing season. Provides about 40 days protection. Use where field has history of these pests.			
D. CYANTRANILIPROLE			
(Verimark – soil at planting)	6.75–13.5 fl oz	4	1
(Verimark – drip chemigation)	10 fl oz	4	NA
MODE-OF-ACTION GROUP NUMBER[1]: 28			
FOLIAR SPRAYS			
A. SPIROMESIFEN			
(Oberon 2SC)	7–8.5 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 23			
COMMENTS: Effective against eggs and nymphs. Apply as a foliar treatment; thorough coverage is important. Do not make more than 3 applications per crop or apply at less than 7-day intervals.			

B.	BIFENTHRIN*			
	(Brigade 2EC)	5.12–6.4 oz	12	3
	MODE-OF-ACTION GROUP NUMBER[1]: 3A			
	COMMENTS: Apply as a foliar spray to kill adults. Apply in a minimum of 30 gal water/acre, increasing volume as plant matures. Full coverage is necessary for best control. TOXIC TO BEES.			
C.	ACETAMIPRID			
	(Assail 30SG)	2.5–5.3 oz	12	0
	(Assail 70WP)	1.1–2.3 oz	12	0
	MODE-OF-ACTION GROUP NUMBER[1]: 4A			
D.	BUPROFEZIN			
	(Courier SC)	9–13.6 fl oz	12	1
	MODE-OF-ACTION GROUP NUMBER[1]: 16			
	COMMENTS: An insect growth regulator.			
E.	CYANTRANILIPROLE			
	(Exirel - foliar)	13.5–20 fl oz	12	1
	MODE-OF-ACTION GROUP NUMBER[1]: 28			
F.	CHLORANTRANILIPROLE/THIAMETHOXAM			
	(Voliam Flexi)	4–7 oz	12	1
	MODE-OF-ACTION GROUP NUMBER[1]: 28 / 4A			
G.	PYRIPROXYFEN			
	(Knack)	8–10 fl oz	12	7
	MODE-OF-ACTION GROUP NUMBER[1]: 7C			
	COMMENTS: An insect growth regulator.			
H.	INSECTICIDAL SOAP#			
	(M-Pede)	1–2% solution	12	0
	MODE OF ACTION: A contact insecticide with smothering and barrier effects.			
	COMMENTS: This material has no residual and requires frequent applications and thorough coverage.			
I.	NARROW RANGE OILS#			
	(TriTek)	1–2 gal/100 gal	4	0
	(Organic JMS Stylet Oil)	3–6 qt/100 gal	4	0
	MODE OF ACTION: Contact including smothering and barrier effects.			
	COMMENTS: Oil requires frequent applications and thorough coverage. Check with certifier to determine which products are organically acceptable.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

* Permit required from county agricultural commissioner for purchase or use.

\# Acceptable for use on organically grown produce.

WIREWORMS (5/16)

Scientific Name: *Limonius* spp. and others

DESCRIPTION OF THE PESTS

Wireworms are shiny, slender, cylindrical, hard-bodied, yellow to brown larvae that can be found at all times of the year and in almost any kind of soil. The larval (or wireworm) stage of this insect may last several years. When fully developed, they vary in length from about 0.5 inch to 1.25 inches (12–31 mm), depending on the species. Adults of these larvae are known as click beetles. They can snap and flip their bodies into the air when turned upside down. These tan to black beetles vary from 0.25 inch (6 mm) to more than 1.0 inch (24 mm) in length, but the most common pest species are about 0.5 inch (12 mm) long.

DAMAGE

Wireworm larvae injure crops by partially or completely devouring seeds in the soil, thus reducing plant stands. On plants, they can cut off small, underground stems and roots or bore into larger ones.

MANAGEMENT

Preventive treatment may be warranted for crops planted in land that was previously pasture or planted to alfalfa, vineyards and possibly grains. Otherwise, good field sanitation and measures to ensure rapid seed germination are generally adequate for control of this pest.

Cultural Control

Destroy plant residue from previous crops. Fallow fields for several weeks to allow organic matter to decompose. Seeds planted at depths greater than 1.5 inch (3.7 mm) take longer to germinate and are at greater risk for infestation. Do not plant into cold, moist soil.

Organically Acceptable Methods

Cultural controls are acceptable to use in an organically certified crop.

Monitoring and Treatment Decisions

If wireworms have been a serious problem in the past, a preventative treatment may be necessary. Preplant or seed treatments are far superior to any postemergence practice.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. IMIDACLOPRID			
(Admire Pro)	7–10.5 fl oz	12	21
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Apply at planting or transplanting and incorporate into root zone.			
B. DIAZINON*			
(Diazinon 50)	6–8 lb	72	3
(Diazinon AG500)	3–4 qt	72	3
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Labeled for use on melons and watermelons only. Broadcast just before planting and immediately work into the soil 4 to 8 inches.			
C. METAM SODIUM*			
(Vapam)	Label rates	See label	NA
COMMENTS: Apply as a band treatment before planting. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

* Permit required from county agricultural commissioner for purchase or use.

NA Not applicable.

Diseases

(Section reviewed 12/09)

ANGULAR LEAF SPOT (5/16)

Pathogen: *Pseudomonas syringae* pv. *lachrymans*

SYMPTOMS AND SIGNS

Angular leaf spot occurs most commonly on cucumber, but is also found on melons in California. Lesions on the foliage begin as water-soaked spots that later turn gray or tan. Spots may initially develop a yellow halo. As the affected tissue dries, the internal tissue may fall out, giving the leaf a tattered appearance. The lesions are delimited by veins, giving them an angular shape. Fruit lesions are usually superficial.

COMMENTS ON THE DISEASE

The bacterium survives on infected plant debris in the soil or on seed. Humid conditions favor development of the disease. Rain or overhead irrigation leads to rapid spread. The disease is also spread by workers picking fruit or machinery passing through the field.

MANAGEMENT

Resistant cucumber varieties are available. Limit the use of overhead irrigation. Pick fruit when the vines are dry to prevent spread in the field. Use pathogen-free seed and rotate out of cucurbits. Treat when symptoms first appear if the weather is predicted to be cool and rainy.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.			
A. COPPER HYDROXIDE 37.5% MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M1)	1–1.33 pt	48	0

‡ Restricted entry interval (REI) is the number of hours(unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

ANTHRACNOSE (5/16)

Pathogen: *Colletotrichum lagenarium*

SYMPTOMS AND SIGNS

In California, anthracnose is unusual on cucurbit crops other than seedless watermelon. It can cause leaf, fruit, and/or stem lesions. Foliage lesions are tan to brown except on watermelon foliage where they are dark brown to black. Fruit may develop brown to black, sunken, water-soaked spots. Tiny, black fruiting structures, called acervuli, form within the lesion. In wet weather, pink or orange spores ooze from these fruiting bodies.

COMMENTS ON THE DISEASE

The fungus overwinters on cucurbit plant residue in the soil, on volunteer cucurbits, or on cucurbit seed. Disease development is favored by warm, wet weather. This disease is rarely seen in the field and more often occurs on transplants raised in the greenhouse.

MANAGEMENT

There is resistance in some varieties of watermelon and cucumber, but not in seedless watermelon. Control tactics include crop rotation, use of clean seed, and inspection of transplants. Avoid sprinkler irrigation and keep the tops of the beds dry. Fungicides are rarely needed in California but may be required on seedless watermelons at the first sign of disease.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.			
A. CHLOROTHALONIL			
(Bravo Ultrex, etc.)	1.4–1.8 lb	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M5)			
COMMENTS: Do not apply more than 19.1 lb/acre per season.			
B. MANCOZEB			
(Dithane DF)	2–3 lb	24	5
(Dithane F-45)	1.6–2.4 qt	24	5
(Dithane M-45)	2–3 lb	24	5
(Penncozeb 75DF)	Label rates	24	5
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M3)			
COMMENTS: Labeled for cucumbers, melons, watermelon, and summer squash only.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

BACTERIAL FRUIT BLOTCH (11/05)

Pathogen: *Acidovorax avenae* subsp. *citrulli*

SYMPTOMS AND SIGNS

Although all cucurbits are susceptible, bacterial fruit blotch is only a problem on watermelon. Two- to three-week old fruit are most susceptible to infection. Fruit symptoms begin as small, water-soaked spots. These lesions expand rapidly and may cover the upper surface of the fruit. Later the lesions may turn red brown and develop cracks and a general fruit rot may follow. A white bacterial ooze may form in the lesion during wet weather.

COMMENTS ON THE DISEASE

The occurrence of blotch in California is apparently rare. Although the bacterium is capable of causing a seedling collapse and foliage symptoms, it is the fruit symptoms that are most obvious and distinctive. Disease is favored by high humidity and high temperature. It is spread through the field by mechanical means or by rain or sprinklers. All watermelon varieties are susceptible, but differences in rind color affect disease severity: dark-colored fruit is least susceptible, light green most susceptible, and striped fruit moderately susceptible.

MANAGEMENT

Use clean seed and disease-free transplants. Disease control in transplant greenhouses involves minimizing handling, keeping temperatures and humidity low, and practicing general greenhouse sanitation. Control in the field involves rotation out of cucurbits and control of volunteer watermelon plants. To prevent spread through the field, avoid sprinkler irrigation and do not work in fields with wet foliage.

CHARCOAL ROT (6/12)

Pathogen: *Macrophomina phaseoli*

SYMPTOMS AND SIGNS

Charcoal rot affects all cucurbits. First symptoms are yellowing and death of crown leaves and water-soaked lesions on the stem at the soil line. As the disease progresses, the stem of infected plants ooze amber-colored gum, and the stem eventually becomes dry and tan-to-brown in color. The stem may be girdled by the lesion, resulting in plant death. Numerous microsclerotia, visible as black specks, are embedded in the dead plant tissue.

COMMENTS ON THE DISEASE

Macrophomina phaseolina is a soilborne fungus occurring in most soils in California. The fungus persists in soil as microsclerotia for 3 to 12 years and can infect 500 plant species. The pathogen most commonly infects melon stems at the soil line within 1 to 2 weeks after planting, but the first disease symptoms occur late in the growing season, usually within 1 to 2 weeks of harvest.

The fungus is a stress pathogen and disease incidence increases with increases in water stress, a heavy fruit load, and high temperatures. Although severe charcoal rot is relatively uncommon in furrow- irrigated fields; ironically, its prevalence has increased with the use of buried drip irrigation systems. This may have occurred as a result of increased salt levels (stress) in beds, particularly at the soil surface. Additionally, disease incidence and severity is most common in fields cropped multiple times to melons.

MANAGEMENT

Start looking for charcoal rot during the vegetative growth stage, and note infections to make management decisions for the next crop. Rotation to a nonhost crop for 2 to 3 years can be an effective disease management strategy in some crop production systems. However, avoidance of drought stress throughout the growing season is paramount to disease management. Leaching soil to reduce salinity levels, particularly at soil surface layers, may help reduce the incidence of disease in drip-irrigated fields. Further, destruction of infected plant tissue before the pathogen reproduces at the end of the growing season will prevent a buildup of soil inoculum. The use of grafted transplants (i.e., susceptible scions grafted onto resistant cucurbit rootstock) has been proposed as an effective management strategy for the control of charcoal rot as well as many other soilborne root-infecting pathogens where the use of chemicals is not feasible. No preplant or postplant chemical control measures have been reported. Solarization is not promising for diseases favored by heat like charcoal rot

DOWNY MILDEW (5/16)

Pathogen: *Pseudoperonospora cubensis*

SYMPTOMS AND SIGNS

Downy mildew first appears as small, pale green to yellow, angular spots delimited by leaf veins that give the foliage a mottled appearance. Eventually the spots coalesce and the leaf will turn brown. During moist weather, the lower surface of the leaf may be covered with a white to purple growth. Older leaves become infected first.

COMMENTS ON THE DISEASE

Downy mildew occurs in the Sacramento, upper San Joaquin, Imperial valleys, and in coastal areas. It attacks all cucurbits, although cucumber is the most commonly infected. Spores of the fungus are carried by air currents or by rain-splash or sprinklers. Rain, dew, cool weather, and sprinkler irrigation favor this disease. The disease is more common in the late season.

MANAGEMENT

Use resistant cucumber varieties. There are low levels of resistance in some varieties of melons and watermelons. Avoid overhead irrigation. Start monitoring for downy mildew during the vegetative growth stage and continue through fruit development. Apply a treatment when disease symptoms first occur and repeat if symptoms worsen. Planting early may help to avoid conditions conducive to the disease later in the season.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.			
A. CYAZOFAMID			
(Ranman 400SC)	2.1–2.75 fl oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone inside inhibitor (21)			
COMMENTS: Do not apply more than six applications of Ranman per growing season in cucurbits.			
B. FLUOPICOLIDE			
(Presidio)	3–4 fl oz	12	2
MODE-OF-ACTION GROUP NAME (NUMBER[1]): delocalization of spectrin-like proteins (43)			
COMMENTS: A labeled rate of another product with a different mode of action effective on the target pathogen must be mixed with Presidio fungicide			
C. PROPAMOCARB			
(Previcur Flex)	1.2 pt or 0.6 to 1.2 pt in tank mix	12	2
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Carbonate (28)			
COMMENTS: Do not apply more than 6 pt/season in cucurbits			
D. FAMOXADONE / CYMOXANIL			
(Tanos)	8 oz	12	3
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and Cyanoacetamide (27)			
COMMENTS: Do not make more than one application without alternating with a fungicide that has a mode of action other than Qol (Group 11).			
E. FENAMIDONE			
(Reason 500SC)	5.5 fl oz	12	14
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
COMMENTS: Alternate with a fungicide that has a different mode of action (i.e., group number).			
F. MANCOZEB			
(Dithane DF)	2–3 lb	24	5
(Dithane F-45)	1.6–2.4 qt	24	5
(Dithane M-45)	2–3 lb	24	5
(Penncozeb 75 DF)	Label rates	24	5
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M3)			
COMMENTS: Labeled for cucumbers, melons, watermelons, and summer squash only.			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
G. CHLOROTHALONIL (Bravo Ultrex, etc.)	1.4–1.8 lb	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M5)			
COMMENTS: Do not apply more than 19.1 lb/acre per season.			
H. MEFENOXAM / CHLOROTHALONIL (Ridomil Gold Bravo SC)	2.5 lb	48	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phenylamide (4) and Multi-site contact (M5)			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

FUSARIUM CROWN and FOOT ROT (12/09)

Pathogen: *Fusarium solani* f. sp. *cucurbitae*

SYMPTOMS AND SIGNS

Although all cucurbits are susceptible, Fusarium crown and foot rot is a problem only on squash and pumpkin. The fungus causes water-soaked lesions on the stem at the soil line. Infected plants wilt and die. On the fruit, the lesions usually begin on the area that is resting on the ground. Fruit lesions are firm and dry, with the decayed area exhibiting a concentric ring pattern.

COMMENTS ON THE DISEASE

This fungus survives in the soil and on seed. The disease occurs most often in the Central Coast of California. There are two races of the fungus; race 1 attacks any part of the plant, while race 2 attacks only the fruit. This disease tends to be most severe when melons are planted following barley or other grain crops that are plowed under but not completely decomposed.

MANAGEMENT

Rotate out of cucurbits for 2 to 3 years and use clean seed. Don't plant melons following a barley crop.

FUSARIUM WILT (CANTALOUPE) (6/12)

Pathogen: *Fusarium oxysporum* f. sp. *melonis*

SYMPTOMS AND SIGNS

Seedlings may wilt in fields where inoculum is high. More commonly, symptoms are expressed after fruit set and consist of yellowing of a runner on one side of the plant followed rapidly by wilting of the infected runner. Runner lesions develop externally and extend from the crown to the yellowed tips. Other runners collapse in a similar manner and whole plant collapse occurs rapidly. External lesions may develop on roots accompanied by red gumming at or just below the soil surface. Internally, a dark red-brown vascular discoloration extends from roots to runners.

COMMENTS ON THE DISEASE

The pathogen can cause a serious disease of susceptible varieties. It attacks only varieties of *Cucumis melo* (i.e., melons and muskmelons) and weeds are not considered to be a host. In California, race 2 predominates, but race 1 occurs in very limited areas of Merced, Fresno, and King counties. The pathogen survives in soil as chlamydospores, which are thick-walled asexual spores that can survive in soil for over 20 years. The fungus can also sustain itself on the roots of many plants without causing a disease. The fungus enters plants through roots and disease develops rapidly when soil temperatures are warm.

MANAGEMENT

Start looking for Fusarium wilt during the vegetative growth stage. Note any infections for management prior to future plantings. Resistance to race 2 is available and should be used in fields with a history of the disease. Most cultivars currently in use in California do not have resistance to race 1. Steam clean equipment after working in an infested field. Rotation out of melons for 5 years will significantly reduce, but not eliminate soil inoculum

FUSARIUM WILT (WATERMELON) (6/12)

Pathogen: *Fusarium oxysporum* f. sp. *niveum*

SYMPTOMS

If inoculum levels of *Fusarium* are high, seedlings may wilt in the field. More commonly, however, Fusarium wilt symptoms occur after fruit set and consist of yellowing and wilting of one runner or one side of the plant. External lesions on the runner extend from the crown to the runner tip, which is bright yellow. Other runners soon collapse and the plant dies. External lesions may develop on roots accompanied by red gumming at or just below the soil surface. Internally a dark vascular discoloration occurs.

COMMENTS ON THE DISEASE

There are three races of *Fusarium oxysporum* f. sp. *niveum*, but only race 1 occurs in California. There is polygenic resistance to race 1 in many varieties, but high inoculum levels can overcome the resistance. It is common to find a few infected plants in a field even if a resistant variety is grown.

MANAGEMENT

Start looking for Fusarium wilt during the vegetative growth stage. Note infections to make management decisions for the next crop. Use resistant cultivars. To reduce the inoculum load, it is necessary to rotate out of watermelon for 10 years, because the fungus may reproduce on resistant watermelons even if there are no wilt symptoms. Many older seeded watermelon varieties have little *Fusarium* resistance and will perform better in fields fumigated for plant parasitic nematodes and vine decline.

MEASLES (11/05)

SYMPTOMS

Small lesions (2 to 4 mm) occur on fruit, stems, and leaves. Initially the spots appear water soaked but soon the center dies and turns tan. Spots are superficial on fruit but may have a slight overgrowth causing bumpiness.

COMMENTS ON THE DISEASE

This is an abiotic disorder caused by guttation (i.e., water soaking injury). Measles occur more commonly on smooth-skinned cucurbits harvested in fall and on heavy soil types. Wet soils are necessary for measles to occur.

MANAGEMENT

Reducing irrigations in fall has been shown to virtually eliminate measles on honeydew fruit. Either switching to alternate row irrigation after fruit set or eliminating the final irrigation will prevent the problem.

PHYTOPHTHORA FRUIT AND CROWN ROT (6/08)

Pathogen: *Phytophthora capsici* and other species

SYMPTOMS AND SIGNS

Phytophthora fruit and crown rot is most commonly found on squash and pumpkins, but all cucurbits are susceptible. This disease occurs suddenly in a field and plants wilt and die within a few days of infection. Infected fruit rot quickly. The roots and stems are soft, water-soaked, and brown. A downy growth is often apparent on plant lesions during periods of high humidity.

COMMENTS ON THE DISEASE

This disease only occurs where the soil has been moist for an extended period of time. *Phytophthora capsici* also infects tomatoes and peppers and is found throughout the state.

MANAGEMENT

Good water management is usually sufficient to control this disease. Provide good drainage and avoid excessive soil moisture by extending intervals between irrigations and avoiding long irrigation periods.

POWDERY MILDEW (5/16)

Pathogens: *Sphaerotheca fuliginea* (=*Podosphaera xanthii*)
Erysiphe cichoracearum (=*Golovinomyces cichoracearum*)

SYMPTOMS AND SIGNS

All cucurbits are susceptible to powdery mildew, but the disease is less common on watermelon than on other cucurbits. Powdery mildew first appears as pale yellow spots on stems, petioles, and leaves. These spots enlarge as the white, fluffy mycelium grows over plant surfaces and produces spores, which give the lesions a powdery appearance. Affected leaves become dull, chlorotic, and may show some degree of wilting in the afternoon heat; eventually they become brown and papery.

COMMENTS ON THE DISEASE

Powdery mildew of cucurbits may occur at any time in coastal and desert production areas but is more common in fall in the San Joaquin Valley and Sacramento Valley. The disease may be caused by one of two species of mildew fungi, although *E. cichoracearum* is rare. Several races of each fungus also exist. The pathogens generally overwinter on weeds and their spores can be carried long distances by air currents. Infection is favored by high humidity (50 to 90%), and disease development is favored by vigorous plant growth and moderate temperatures.

MANAGEMENT

Plant resistant varieties, follow good sanitation practices, and control weeds. Start monitoring for powdery mildew during the vegetative growth stage and continue through fruit development. Carefully monitor even those fields with powdery mildew resistant varieties, because there is evidence that plant resistance-breaking races are present in California. Strains resistant to strobilurins (group 11) have already been found throughout the state. If multiple fungicide applications are needed to control powdery mildew, alternate materials with different modes of action especially if using fungicides with medium to high resistance potential (azoxystrobin [Quadris], myclobutanil [Rally], pyraclostrobin [Cabrio], pyraclostrobin/boscalid [Pristine], trifloxystrobin [Flint,] and trifumizole [Procure]). Apply a treatment when disease symptoms first occur and repeat if symptoms reappear.

Common name (Example trade name)	Amount per acre	R.E.I‡ (hours)	PHI‡ (days)
UPDATED 5/16			
When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.			
A. CYFLUFENAMID (Torino)	3.4 oz	4	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phenyl-acetamide (U6)			
B. QUINOXYFEN (Quintec)	4–6 fl oz	12	3
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinoline (13)			
COMMENTS: Registered for use on melons, including cantaloupe and watermelon. Not effective if disease is established. Do not apply more than 24 fl oz/acre per season.			
C. TRIFLUMIZOLE (Procure 480SC)	4–8 fl oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)			
COMMENTS: Do not apply more than 40 fl oz of Procure 480SC/acre per season.			
D. MYCLOBUTANIL (Rally 40WSP)	2.5–5 oz	24	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)			
COMMENTS: Do not apply more than 1.5 lb/acre per season.			
E. FLUOPYRAM / TRIFLOXYSTROBIN (Luna Sensation)	4.0–7.6 fl oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Succinate dehydrogenase inhibitor (7) and quinone outside inhibitor (11)			
COMMENTS: For use in watermelons only.			

Common name (Example trade name)	Amount per acre	R.E.I‡ (hours)	PHI‡ (days)
UPDATED 5/16			
F. PYRACLOSTROBIN / BOSCALID			
(Pristine)	12.5–18.5 oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11) and succinate dehydrogenase inhibitor (7)			
COMMENTS: Do not make more than one application before alternating to a fungicide with a different mode of action other than Group 11.			
G. PENTHIOPYRAD			
(Fontelis)	12–16 fl oz	12	1
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Succinate dehydrogenase inhibitor (7)			
H. MICRONIZED SULFUR#			
(Microthiol)	Label rates	24	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M2)			
COMMENTS: Sulfur can injure plants, especially when temperatures reach 95°F. Do not use on sulfur-sensitive varieties.			
I. POTASSIUM BICARBONATE#			
(Kaligreen)	2.5–5 lb	4	1
MODE-OF-ACTION (NUMBER[1]) An inorganic salt. (NC)			
COMMENTS: Use the higher rate when disease pressure is severe. Direct contact with the fungus is required for control. Conditionally allowed in an organically certified crop; check with your certifier.			
J. CINNAMALDEHYDE			
(Cinnacure)	0.25–1 gal	4	0
MODE OF ACTION: A botanical fungicide.			
COMMENTS: Make no more than two consecutive applications before rotating to a fungicide with a different mode of action. May not provide good control under all conditions.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

Acceptable for use on organically grown produce.

ROOT ROTS (DAMPING-OFF) (5/16)

Pathogens: *Pythium* spp., *Phytophthora* spp., *Rhizoctonia solani*, *Acremonium* spp., *Fusarium equiseti*, *Fusarium solani*, and *Thielaviopsis basicola*

SYMPTOMS AND SIGNS

Root rots can affect all of the cucurbits at any growth stage. However, *Rhizoctonia* and *Thielaviopsis* are generally limited to infecting cucurbit seedlings. In plants infected with *Pythium*, *Phytophthora*, or *Rhizoctonia*, the hypocotyl collapses and turns tan to brown, roots die, and cotyledons and/or leaves wilt. Infection by *Acremonium* or *Fusarium* occurs where the seed coat attaches to the hypocotyl. The hypocotyl and roots turn red-brown and the portion above swells slightly. Plants may not die, but become stunted with cotyledons and leaves turning dark green. *Thielaviopsis basicola* turns roots and lower hypocotyl black; cotyledons and leaves become dark green. Infections can lead to stunting, vine collapse, and death.

COMMENTS ON THE DISEASE

Pythium, *Phytophthora*, and *Rhizoctonia* require free moisture and cool soil temperatures for disease development. Planting early before soil temperatures are adequately warm or planting into poorly drained beds will likely increase disease. Melons following alfalfa generally have greater risk of infection by *Pythium* spp.

Acremonium spp. occurs in old melon fields in Stanislaus, Merced, Fresno, and San Joaquin counties. Disease incidence is severe when melons of any cultivar are planted without rotation. Rotation with wheat reduces incidence and severity. Planting depth also influences disease incidence. Deeply planted melons are more severely affected.

Fusarium equiseti root rot occurs in the central and south San Joaquin Valley and is more severe when melons are planted following cotton.

Fusarium solani is rarely seen but occurs occasionally on squash, pumpkin, and melons. The pathogen is most prevalent in the Colusa, Sutter, and Yuba county areas, but also has been observed on honeydew melons in Stanislaus County.

Thielaviopsis basicola does not usually infect cucurbits. Because the pathogen also attacks cotton, it is more likely to occur in the southern San Joaquin Valley. Chilling stress is necessary for disease to occur.

MANAGEMENT

Prevent root rot damage to seedlings by planting appropriately. Fungicides also provide control.

- Planting beds should be high and well drained.
- Waiting to plant until soil temperatures are 65° to 70°F will generally prevent seedling infections by *Pythium*, *Phytophthora*, or *Rhizoctonia*.
- For *Acremonium* seedling root rot, shallow planting (0.5 inch) and irrigating up is the preferred method of managing this disease.
- For *Thielaviopsis* root rot, plant when soil is warm.
- Use treated seed in no-till, conservation-till, and when planting through cover crops to reduce the potential for seedling diseases.
- If *Pythium*, *Phytophthora*, or *Acremonium* spp., or *Fusarium equiseti* are present, an application of fungicides, depending on the species present, provides good control.
- Plants infected with *Fusarium* may recover if the weather is warm and the field is irrigated enough to wet the soil surface; this allows the roots to regenerate and the plants to produce a normal, but delayed, crop.

If root rots are observed during the vegetative growth stage, note infections to make management decisions for the next crop.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A.	MEFENOXAM (Ridomil Gold SL)	Label rates	48	5
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)			
	COMMENTS: Can be used as a soil drench or at planting treatment for Pythium and Phytophthora diseases.			
B.	FLUOPICOLIDE (Presidio)	3–4 fl oz	12	2
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Benzamide (43)			
C.	THIOPHANATE-METHYL (Topsin-M WSB)	0.5 lb	24	1
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Methyl benzimidazole (1)			
	COMMENTS: Effectively controls seedling root rots caused by *Acremonium* spp.; most useful in areas (Stanislaus, Merced, Fresno, and San Joaquin counties) where *Acremonium* is prevalent.			
D.	AZOXYSTROBIN (Quadris)	11.0–15.5 fl oz	4	1
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
	COMMENT: For *Rhizoctonia solani*.			
E.	METALAXYL (Acquire)	Label rate	24	NA
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)			
	COMMENTS: Acquire is not labeled for use in California, but seed treated in and obtained from another state can be legally used in California even for a chemical not registered on cucurbits in California.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

NA Not applicable.

SUDDEN WILT (6/12)

Pathogens: Various fungi (*Acremonium cucurbitacearum*, *Pythium* spp., and *Rhizopycnis vagum*)

SYMPTOMS AND SIGNS

Symptoms of sudden wilt begin when the crown leaves yellow, followed by a rapid collapse of the entire plant. Plant death quickly proceeds across a field. *Pythium* spp. cause a watersoaked, brown root rot. *Acremonium* causes corky bands on primary and secondary roots. Infected roots are straw colored or slightly darker than healthy roots. *Rhizopycnis* causes a reddish tinge to the upper tap root. Infected tissue may be corky.

COMMENTS ON THE DISEASE

All pathogens are soilborne. The disease usually occurs just before harvest, and the foliage and roots in affected fields may appear healthy for the majority of the season. *Pythium* infection generally follows a period of cool weather, rain, or heavy irrigation. However, in low desert production areas, *P. aphanidermatum* and *P. myriotylum* often cause sudden wilt, and both of these pathogens are favored by warm, wet soil conditions.

MANAGEMENT

Start looking for sudden wilt during the vegetative growth stage. Note infections to make management decisions before the next crop. The disease is unpredictable. The development of the disease occurs so quickly and without warning that control measures are impossible to implement. Practice long-term rotation (at least 2–3 years out of cucurbits) to help prevent the build-up of these pathogens. For *Pythium* control, provide good drainage and avoid excessive soil moisture by extending intervals between irrigations and avoiding long irrigation periods. Fungicides have not proven effective in controlling sudden wilt.

VERTICILLIUM WILT (6/12)

Pathogen: *Verticillium dahliae*

SYMPTOMS AND SIGNS

Verticillium wilt can affect all cucurbits. The first symptoms are wilting and yellowing of crown leaves, which eventually dry up. Wilting gradually progresses out toward the runner tips; in severe cases, the plant dies. Death may take weeks. A light brown vascular discoloration in roots is sometimes seen in cross section. Aboveground vascular tissue is also discolored and can be seen by cutting through a node near the base of the plant. Tolerant or resistant varieties may show symptoms but seldom die.

COMMENTS ON THE DISEASE

Verticillium dahliae survives for years in soil as tiny, dormant sclerotia. The pathogen has a wide host range including many vegetable crops, weeds, and trees. When roots of susceptible crops grow in close proximity, sclerotia germinate and infect the roots. Verticillium wilt is most severe during relatively cool periods and subsides during the hottest part of the summer, but wilting is usually seen during warm dry periods when the plant is under stress, such as after fruit set. The pathogen grows in the water-conducting tissue (xylem), causing plugging and interference with water transport.

MANAGEMENT

Start looking for Verticillium wilt during the vegetative growth stage. Note infections to make management decisions before the next crop. Use tolerant or resistant varieties. Most shipping varieties of cantaloupes grown in California have a moderate degree of resistance, and honeydew melons have greater resistance than cantaloupes. The Persian cultivar is highly susceptible. Do not plant highly susceptible melon varieties in fields with high populations of *V. dahliae*. For example, avoid fields where cotton was growing if it was severely infected by this disease. Soil solarization has been used experimentally to control this disease in cotton and tomato, but has not been tested in cucurbits because of its expense. Incorporating broccoli residue into the soil can reduce populations of *V. dahliae*. Also, preplant fumigation with chloropicrin effectively controls this disease but generally is not cost effective.

VINE DECLINE (CROWN BLIGHT) (5/16)

Pathogen: *Monosporascus cannonballus*

SYMPTOMS AND SIGNS

Vine decline of melons, caused by the root-infecting ascomycete *Monosporascus cannonballus*, is characterized by the sudden and generally uniform canopy collapse of entire fields 1 to 2 weeks before harvest. The most susceptible hosts are cantaloupe and watermelon and, to a lesser extent, honeydew melons. The disease is particularly severe in the hot and semi-arid production regions of the world.

In California, the disease is most prevalent in the Imperial Valley, Coachella Valley and the Palo Verde Valley. However, it occurs sporadically in the mid- and lower San Joaquin Valley. The rapidity and severity of collapse are generally associated with high ambient temperatures, heavy whitefly/leafminer infestations, heavy fruit loads, and water stress.

First symptoms include chlorosis and necrosis of older crown leaves and occasionally wedge-shaped necrotic areas on crown leaves extending to petiole. Within several days of the first foliar symptoms, the canopy collapses. At the time of canopy collapse, root symptoms in most commercial fields are generally lacking. However, within days following plant death, roots lesions will become evident on primary and secondary roots, followed by the production of numerous perithecia (small, black, round structures that measure 0.5 mm in diameter and protrude from the dead tissue) within the next 7 to 14 days.

COMMENTS ON THE DISEASE

Monosporascus cannonballus is indigenous to the southwestern U.S. The host range of this fungus in the field is restricted to cucurbits. The fungus persists in soil as ascospores that serve as the survival and primary source of inoculum for root infection. Although ascospores can germinate and colonize roots at temperature as low as 68°F, the optimum is between 75° to 85°F. In a spring-planted crop, root infection occurs about 57 days after planting, whereas in a late-spring or fall-planted crop, root infection can occur within 9 days after planting.

Disease incidence and severity is most pronounced in crops maturing during late May to mid-September. Pathogen reproduction in infected roots occurs primarily within 7 to 14 days following plant death. The root system of a single infected plant can support the production of 400,000 ascospores. The latter population, if incorporated into a cubic foot of soil via cultivation, would result in a population of 10 ascospores per gram of soil. Commercial melon fields with a known history of this disease contain as few as 2 ascospores per gram of soil.

MANAGEMENT

For fields with a known history of vine decline, preplant soil fumigation significantly reduces the resident population of the pathogen in soil as well as the percentage of roots infected by the fungus. However, because fumigation does not eliminate the pathogen, the residual population will infect, reproduce on infected roots, and buildup the population following consecutive cropping to melons. Thus, destruction of infected roots immediately after the final harvest is critical to maintenance of low soil populations of the pathogen (not only in fumigated soils but also in fields that have little or no history of the disease). An immediate postharvest application of metam sodium (applied via the drip irrigation system) or cultivation (which lifts the roots onto the soil surface for rapid desiccation) will inhibit pathogen multiplication in infected roots and prevent a build up of inoculum (ascospores) in soil.

Start looking for symptoms of vine decline during the vegetative growth stage. Solarization is not a promising technique for diseases favored by heat like vine decline. Postplant soil treatment with fludioxonil (Cannonball), a fungicide, may suppress disease development. Additional management strategies may include, when appropriate or cost effective, the use of grafted melons on resistant squash rootstock. Rotation out of melons will significantly reduce but not eliminate soil inoculum. Some cantaloupe varieties are tolerant to this pathogen, and some varieties, such as Caravelle and Desert Mark, are more susceptible than others.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			

When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A.	METAM SODIUM* (Vapam, Sectagon)	Label rates	See label	NA
	COMMENTS: Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.			
B.	CHLOROPICRIN* (Tri-Con 50/50)	Label rates	See label	NA
	COMMENTS: Tarp seal is mandatory for application of this product in cucurbits. Fumigation may temporarily raise the level of ammonia nitrogen and soluble salts in the soil. This is most likely to occur when heavy rates of fertilizer and fumigant are applied to soils that are cold, wet, acid, or have high inorganic matter. To avoid injury to plant roots, fertilize as indicated by soil tests made after fumigation. To avoid ammonia injury and nitrate starvation to crops, avoid using fertilizers containing ammonia salts and use only fertilizers containing nitrates until after the crop is well established and the soil temperature is about 65° F. Liming highly acid soils before fumigation stimulates nitrification and reduces the possibility of ammonia toxicity.			
C.	FLUDIOXONIL (Cannonball)	Label rates	12	14
	MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phenylpyrrole (12)			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

NA Not applicable.

YELLOWS (MOLYBDENUM DEFICIENCY) (11/05)

SYMPTOMS

Crown leaves become bright yellow and margins become necrotic. Leaves are stunted and misshapen. Symptoms move out the runners until the entire plant is affected. Fruit set is eliminated and plants may be killed.

COMMENTS ON THE DISEASE

Yellows is the result of a molybdenum deficiency in cucurbit plants. Molybdenum is generally available in high enough quantity for all plant growth. However, under acid soil conditions molybdenum is difficult for melons of some cultivars to absorb. Yellows occurs commonly in the Stanislaus County production areas and has been associated with cut and fill areas along the California aqueduct and the Delta-Mendota Canal.

MANAGEMENT

A single application of sodium molybdate at 200 ppm will result in a complete recovery of affected plants in 2 to 3 days.

Viruses

(Section reviewed 12/09)

CUCUMBER MOSAIC (12/09)

Pathogen: *Cucumber mosaic virus* (CMV)

SYMPTOMS

The first symptom of cucumber mosaic is a clearing of veins, followed by development of mosaic patterns or mottling consisting of irregularly shaped, dark green areas alternating with light green or yellow areas. Leaves on some species and cultivars are drastically reduced in size and growth is often retarded. Malformations of the fruit can also occur.

COMMENTS ON THE DISEASE

Cucumber mosaic virus has a very wide host range including cucurbits (except watermelon), tomato, spinach, celery, safflower, beans, blackeyes, peppers, beets, potatoes, many ornamentals and weeds. The virus is transmitted by many species of aphids and could be seedborne.

MANAGEMENT

The occurrence of this virus is erratic and unpredictable; consequently, control of this disease is not attempted. In studies, silver reflective plastic mulches applied at planting have been shown to be effective in repelling aphids from plants, thereby reducing or delaying virus infection. Mulches help plants off to a healthy start and are effective until expanding foliage covers the reflective surface. Mulches may need to be removed in the desert areas when summer temperatures are excessive for optimal growth of plants. However, in the Central Valley and cooler areas, mulches have not caused plant damage in the summer; in fact, they improve soil moisture and nutrient retention, which may further aid plant productivity.

CUCURBIT APHID-BORNE YELLOWS (6/08)

Pathogen: *Cucurbit aphid-borne yellows luteovirus* (CABYV)

SYMPTOMS

Cucurbit aphid-borne yellows luteovirus causes a general yellowing of the older leaves, which become thick and leathery. The major veins of these leaves remain green. Growth and yield of infected plants may be reduced.

COMMENTS ON THE DISEASE

This virus is persistent: it is acquired and transmitted in hours and the aphid vector may retain the virus for its entire life. Vector specificity is high; the cotton (melon) aphid, *Aphis gossypii*, transmits the virus very efficiently while the green peach aphid, *Myzus persicae*, is a poor vector. The source of the virus is unknown, possibly wild cucurbits.

MANAGEMENT

The occurrence of this virus is erratic and unpredictable; consequently, control of this disease is not attempted. Although not tested specifically on this virus disease, silver reflective plastic mulches applied at planting have been shown to be effective in repelling aphids from plants, thereby reducing or delaying virus infection. These mulches help plants off to a healthy start and are effective until expanding foliage covers the reflective surface. Reflective mulches may need to be removed in the desert areas when summer temperatures are excessive for optimal growth of plants. However, in the Central Valley and cooler areas, these mulches have not caused plant damage in the summer; in fact, they improve soil moisture and nutrient retention, which may further aid plant productivity.

CUCURBIT YELLOW STUNTING DISORDER (6/08)

Pathogen: *Cucurbit yellow stunting disorder virus* (CYSDV)

SYMPTOMS

Infected cucurbit plants initially show a chlorotic (yellow) spotting, which eventually develops into a striking interveinal chlorosis (yellowing) in which the veins remain more or less green but the rest of the leaf turns bright yellow. Leaves will often roll upward and become brittle. Fruit on infected plants may appear normal but often have reduced levels of sugars; this results in poor marketability and economic loss. Symptoms of *Cucurbit yellow stunting disorder virus* infection can be confused with abiotic factors, such as nutrient deficiency.

COMMENTS ON THE DISEASE

Cucurbit yellow stunting disorder is a primarily a disease of cucurbits (e.g., melons, watermelon and squash) and is caused by a plant virus named *Cucurbit yellow stunting disorder virus* CYSDV; genus *Crinivirus*, family *Closteroviridae*). This virus was first detected in southern California and Arizona in fall of 2006, infecting cantaloupe and honeydew melon, watermelon, and various types of squash. Other crops it infects include alfalfa (*Medicago sativa*), lettuce (*Lactuca sativa*), and snap bean (*Phaseolus vulgaris*), as well as several weed species.

Cucurbit yellow stunting disorder virus is spread from plant-to-plant exclusively by the whitefly vector, *Bemisia tabaci.* All biotypes of *B. tabaci* known to exist in North America can transmit the virus efficiently, including biotypes A, B and Q. *Cucurbit yellow stunting disorder virus* is not transmitted by the greenhouse whitefly (*Trialeurodes vaporariorum*). Whitefly transmission is entirely responsible for virus spread over short distances (e.g., within and between fields). The virus is not transmitted mechanically (by touch) nor is it seed-transmitted. Consequently, the disorder is almost always associated with whiteflies; it does not take many insects to spread the virus. For more information, see WHITEFLIES.

Cucurbit yellow stunting disorder virus is spread over long distances through the movement of infected plants, especially cucurbit transplants. As it can take 3 to 4 weeks for disease symptoms to develop following infection, infected symptomless plants can be unknowingly transported. The virus also can be moved long distance by virus-carrying whiteflies that may accompany transported plant material such as cucurbits and other susceptible infected plants with or without symptoms. Finally, the virus can be maintained in infectious form within whiteflies for up to 9 days. Because *Bemisia tabaci* whiteflies can move long distances, especially with high winds, the virus may be transported over long distances in this manner as well.

Cucurbit yellow stunting disorder virus has the potential to cause serious damage to cucurbit production, particularly in areas where *B. tabaci* populations become well established during the growing season. In addition to California, the virus is presently an economic problem in many countries that have Mediterranean climates (e.g., countries in the Middle East and southern Europe).

Although *Cucurbit yellow stunting disorder virus* has a relatively narrow host range, it was able to overwinter in California and Arizona in 2006-07. Although the incidence of CYSDV was relatively low in spring-planted melons in 2007, it was high in fall-planted melons in the Imperial and Yuma Valleys in both years. Thus, it appears that the virus is now established in southern California. It remains to be seen if it will primarily be a problem in fall-planted cucurbits or if it will increase in incidence in spring-planted melons as well.

MANAGEMENT

Monitoring for the incidence of the virus in California to document the establishment of the virus and the pattern of infection of cucurbits in the desert growing regions of the southwestern United States is ongoing.

Rapid and precise tests for the virus are available at UC Davis and the USDA-ARS in Salinas. These tests can be carried out in less than 24 hours. Anyone finding cucurbits with CYSDV-like symptoms can contact their county farm advisor, Robert Gilbertson at UC Davis (telephone: 530-752-3163; e-mail: rlgilbertson@ucdavis.edu) or William Wintermantel at USDA-ARS (telephone: 831-755-2824; e-mail: bill.wintermantel@ars.usda.gov). Another virus, *Cucurbit aphid borne yellow virus* (CABYV), which is found in California and also causes yellowing in cucurbits, can be confused with *Cucurbit yellow stunting disorder virus* (for more information, see CABYV). Molecular tests are needed to differentiate the two viruses.

Currently, a number of management strategies are recommended to minimize the chance of this virus becoming established throughout California and/or causing significant losses to cucurbit production in southern California.

Before the Growing Season

- Although the virus is not seed-transmitted, it is important to use pathogen-free, high quality seed.
- Use virus- and whitefly-free transplants.
- DO NOT import cucurbit (or any potential whitefly host) transplants from areas known to have the virus (Texas, Florida, or Mexico).
- Manage whiteflies on transplants; for more information, see WHITEFLIES.

During the Growing Season

- Plant immediately after any cucurbit-free period (either an arranged regional host-free period or true winter season).
- Avoid planting new fields near older fields (especially those with plants confirmed to be infected by the virus).
- Apply a soil application of a neonicotinoid insecticide (imidacloprid, dinotefuran, or thiamethoxam) at transplanting. Recent research results indicate that dinotefuran may slow the spread and development of the disease, whereas imidacloprid and thiamethoxam may be less effective (see WHITEFLIES for more information).
- Monitor whitefly populations throughout the growing season and implement insecticide application as needed. Rotate insecticides with different modes-of-action group numbers to minimize development of insecticide resistance.
- If feasible, cover seedbeds with floating row covers of fine mesh (Agryl or Agribon) in mid-bed trenches of 12-inch depth for fall planting season (row covers need to be removed for pollination, but they prevent early infections).
- Practice good weed management in and around fields to the extent feasible.

After the Growing Season

- Sanitation is very important; remove and destroy old crops and volunteers on a regional basis (e.g., plowing and physical removal).
- In areas lacking a true winter season (i.e., temperatures low enough to prevent crop cultivation and whitefly survival), implement a voluntary or enforced regional cucurbit -free period to eliminate the virus from the cropping system.

CURLY TOP (12/09)

Pathogen: *Beet curly top virus* (BCTV)

SYMPTOMS

Symptoms of curly top include stunting, stiffness, short internodes, and leaves that are darker green than normal. Runner tips tend to turn up. Plants infected in seedling stage die. Leaves may roll upward and have a crinkled appearance. Older plants may turn yellow and die.

COMMENTS ON THE DISEASE

Curly top is rare in cucurbits. The virus is transmitted by the beet leafhopper, *Circulifer tenellus*; the leafhopper retains the virus and is capable of transmitting it for its entire life. *Curly top virus* has a wide host range including many weeds.

MANAGEMENT

No control is practiced.

POTYVIRUSES (6/12)

Pathogens: *Watermelon mosaic virus* (WMV), formerly Watermelon mosaic virus II
Papaya ringspot virus (PRSV-W), formerly Watermelon mosaic virus I
Zucchini yellow mosaic virus (ZYMV)

SYMPTOMS

Each virus produces similar symptoms and mixed infections are common. The first symptom is a clearing of veins, followed by development of mosaic patterns or mottling consisting of irregularly shaped, dark green areas alternating with light green or yellow areas. Leaves on some species and cultivars are drastically reduced in size and growth is often retarded. *Watermelon mosaic virus* tends to cause raised, blisterlike areas on leaves and to reduce leaf size severely. *Zucchini yellow mosaic virus* typically causes the leave lobes to become long and narrow. Malformations of the fruit can occur with all three of the viruses.

COMMENTS ON THE DISEASE

All three viruses are found in wild and volunteer cucurbits. *Watermelon mosaic virus* also occurs in weeds such as goosefoot, lambsquarters, Russian thistle, various legumes, cheeseweed and other related plants. All three viruses are transmitted by many species of aphids. After feeding on an infected plant, aphids only retain the ability to transmit these viruses for very short periods of time (minutes to a few hours). In general, spread of potyviruses in the field occurs when aphid activity is high and is often very rapid and localized.

MANAGEMENT

Start looking for potyviruses during the vegetative growth stage. Note infections to make management decisions before the next crop because during the season, mosaic viruses are difficult to control. Spraying with insecticides is rarely effective for control because the insect transmits the virus before being killed by the insecticide. Because their occurrence is erratic and unpredictable, control of these viruses is not attempted. In studies, silver reflective plastic mulches applied at planting have been shown to be effective in repelling aphids from plants, thereby reducing or delaying virus infection. These mulches help plants off to a healthy start and are effective until expanding foliage covers the reflective surface. Reflective mulches may need to be removed in the desert areas when summer temperatures are excessive for optimal growth of plants. However, in the Central Valley and cooler areas, these mulches have not caused plant damage in the summer; in fact, they improve soil moisture and nutrient retention, which may further aid plant productivity.

SQUASH MOSAIC (6/08)

Pathogen: *Squash mosaic virus*

SYMPTOMS

Symptoms of squash mosaic include mosaic patterns and mottling of the leaf along with deformed fruit.

COMMENTS ON THE DISEASE

The virus is vectored by the spotted cucumber beetle (*Diabrotica* spp.) and other related beetles. The beetles can retain the virus up to 20 days after feeding on an infected plant. The virus is also seed-borne.

MANAGEMENT

Use virus-free seed to eliminate primary inoculum.

Nematodes

(Section reviewed 5/16)

Scientific Names: Root knot nematode: *Meloidogyne arenaria*, *M. incognita*, and *M. javanica*
Lesion nematode: *Pratylenchus* spp.
Stubby root nematode: *Trichodorus* sp. and *Paratrichodorus* sp.
Needle nematode: *Longidorus africanus*

DESCRIPTION OF THE PESTS

Nematodes are typically microscopic elongated roundworms that occur in nearly every aquatic and terrestrial environment. The vast majority of soil-dwelling nematodes cannot harm plants but play an important role in the soil food web and in nutrient cycling. Plant parasitic nematodes obtain their food only from living plant tissues. They feed by puncturing cells and withdrawing the contents with a needle-like mouthpart called a stylet. Most plant parasitic nematode species are similar in appearance. However, correct identification is important when developing an IPM strategy because they differ in damage potential, environmental requirements, and host range.

SYMPTOMS AND DAMAGE

The following symptoms may be indications of a nematode problem but could also result from other biotic or abiotic causes such as fungal diseases, insect injury, irrigation problems, or nutrient deficiencies. Aboveground symptoms for plant parasitic nematodes may include patches of variable crop growth with stunted, chlorotic, and/or excessively wilted plants. Often the size of leaves and number of flowers are reduced. Nematode-infested plants may grow less vigorously, be smaller in size, and produce lower yield and diminished fruit quality compared to cucurbits in nematode-free soil. Young seedlings are particularly sensitive to nematode attack.

Root knot nematodes (*Meloidogyne* spp.) are by far the most important plant parasitic nematodes in cucurbits. All cultivated cucurbits are very susceptible to the southern (*M. incognita*) and Javanese (*M. javanica*) root knot nematodes while they are poor hosts to the northern root knot nematode (*M. hapla*). In the presence of sufficient soil moisture, second stage juveniles (J2) hatch from eggs and invade host roots at soil temperatures above 64°F. Once inside the root, the juveniles soon become immobile while establishing a feeding site that sustains them through three additional molts to the adult stage. This life style is classified as sedentary endoparasitic. Plant cells that contribute to the nematode's nutrition enlarge and the root deforms, showing characteristic galls or knots. These may grow to one inch or more in diameter and harbor one or more of the developing nematodes. Galls severely reduce water and nutrient transport in the plant. The development rate of nematodes is temperature related. At soil temperatures of 77° to 82°F, the optimal range for the development of root knot nematode species, they complete their life cycle within 3 to 4 weeks. Each female produces an egg mass that contains several hundred eggs embedded in a protective gel. The eggs are immediately ready to hatch. Crop damage is greatest in warm regions with coarser-textured soils such as sand or sandy loam.

Lesion nematodes are migratory endoparasites that invade roots and move and feed within the root cortex. In contrast to root knot nematodes, they are able to leave the host if conditions become unfavorable. Infestation may cause reddish brown to dark brown lesions on roots. Lesion nematode species are not known to cause economic damage on cucurbits in California. However, the root lesions may predispose plant tissues to invasion of fungi and bacteria that can accelerate root decay.

All other potentially crop-damaging nematodes are ectoparasites; they feed on the outside of the root. Stubby root nematodes prefer to feed on root tips. Symptoms include short feeder roots, stunting, and yellowing of plants. The needle nematode has been found only in the Imperial Valley where it can cause damage to cucurbits. Its relatively long mouth stylet can damage the growing point of roots, which may cause terminal root swelling, cessation of root elongation, and root necrosis. Pin nematodes, *Paratylenchus* species, occur in production fields but are not known to cause significant damage to cucurbits in California.

FIELD EVALUATION

The severity of crop damage is related to the nematode species, their population density at planting, and soil temperature. It is critical to know these factors to make rational management decisions. If a previous field or crop had problems caused by nematodes that are listed as pests of cucurbits, population levels may be high enough to cause damage to seedlings. If nematode species have not previously been identified, take soil samples and send them to a diagnostic laboratory for identification.

Take soil samples from within the main root zone (2 to 16 inches deep). Divide the field into sampling blocks of not more than 5 acres each that are representative of cropping history, crop injury, or soil texture. Take several subsamples randomly from a block, mix them thoroughly, and make a composite sample of about 1 pint (or about 500 cm^3) for each block. Place the samples in separate plastic bags, seal them, and place a label on the outside with your name, address, location, the current/previous crop, and the crop you intend to grow. If plants with symptoms are available, place the roots in the same bag with the soil. Ideally the samples should be kept at 54 to 59°F in a cooler and transported as soon as possible to a diagnostic laboratory. Contact your UC farm advisor for more details about sampling, to help you find a laboratory for extracting and identifying nematodes, and for help in interpreting sample results.

MANAGEMENT

Cultural Practices

- Rotation with nonhost crops can reduce nematode population levels. Before selecting a rotational crop, make sure it is truly a nonhost crop for the species/race of root knot nematode present in your field.
- Deep plowing, fallowing, and solarization can further reduce nematode population levels, especially root knot nematodes. Soil solarization may be useful, especially in the desert production areas of Southern California, but it is neither as effective nor as reliable as chemical fumigation.
- Special attention must be paid to weed control, both in nonhost rotations and fallowing. Many common weeds are hosts to root knot nematodes. These include:
  - black and hairy nightshade
  - yellow and purple nutsedge
  - pigweed
- Striving for optimum growing conditions by addressing other abiotic and biotic plant stress factors such as soil moisture, nutrition, insect pests, and other diseases may minimize nematode damage.

Resistant Cultivars

None available

Monitoring and Treatment Decisions

Start looking for symptoms caused by nematodes during the vegetative growth stage. If symptoms are found, investigate if they are caused by root knot nematodes. Use this information to plan for future plantings.

Studies in California have shown that the damage threshold for root knot nematodes (*M. incognita*) in cantaloupe at planting is near the detection level (1.6 J2/100 cm^3). A preplant density of 40 J2/100 cm^3 is likely to cause at least 30% yield loss. Although this kind of research has not been done on squash, pumpkin, or cucumber, threshold levels for *M. incognita*, *M. javanica*, and *M. arenaria* in these crops is probably similar to those in cantaloupe. There are no current treatment guidelines for lesion, stubby root, or needle nematodes.

To mitigate nematode damage, apply nematicides preplant or at planting. Consider postplant applications only for supplemental suppression of plant parasitic nematodes.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			

When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management andenvironmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

PREPLANT

A. 1,3-DICHLOROPROPENE* / CHLOROPICRIN*

(InLine)	Label rates	See label	NA

COMMENTS: Multipurpose liquid fumigant for the preplant treatment of soil to control plant-parasitic nematodes, symphylans, and certain soil-borne pathogens using drip irrigation systems only. Use of a tarp seal is mandatory for all applications of this product. Fumigants such as 1,3-dichloropropene are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
B. 1,3-DICHLOROPROPENE* (Telone EC)	Label rates	See label	NA
COMMENTS: Liquid fumigant for the preplant treatment of soil against plant-parasitic nematodes and certain other soil pests in cropland using drip irrigation systems only. Fumigants such as 1,3-dichloropropene are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.			
C. CHLOROPICRIN*	Label rates	See label	NA
COMMENTS: If treated area is covered with a plastic tarpaulin immediately after application, dosage may be reduced.			
D. METAM SODIUM* (Vapam, Sectagon)	Label rates	See label	NA
COMMENTS: Contact your farm advisor for advice on the most effective application method for a particular situation. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.			
E. ETHOPROP* (Mocap 15% Granular)	2.1 lb/1000 row feet (12–15 inches wide)	72 (3 days)	NA
COMMENTS: Registered for use on cucumbers only. Apply just before planting. Mix into the top 2-4 inches of soil right after application. Do not allow the granules or spray to contact the seed. Make only one application per crop.			
F. 1,3-DICHLOROPROPENE* (Telone II)	Label rates	See label	NA
COMMENTS: Do not disturb the soil for at least 7 days after application. Fumigants such as 1,3-dichloropropene are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.			
PREPLANT AND PLANTING			
A. OXAMYL* (Vydate L)	1–2 gal	48	1
COMMENTS: To control lesion and root knot nematodes, except *Meloidogyne javanica*. Rate is for broadcast application. For band treatment, use proportionately less. After application and before planting, incorporate 4 inches. Registered on cucumber, cantaloupe, honeydew melon, watermelon, squash, and pumpkin.			
POSTPLANT			
A. OXAMYL* (Vydate L)	2–4 pt	48	1
COMMENTS: Apply foliar or via drip chemigation for supplemental control of root knot nematodes, except *Meloidogyne javanica* and lesion nematodes.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

NA Not applicable.

Weeds

(Section reviewed 12/09)

INTEGRATED WEED MANAGEMENT (7/13)

Crops in the cucurbit family include melons, watermelon, squash, pumpkin, luffa, gourd, and cucumber. Each crop has its own growth characteristics, which in turn influence weed management options. Cucurbits are most commonly grown in the warmest areas of the state, such as the San Joaquin Valley, the Sacramento Valley and the low desert valleys. Weeds can cause yield reductions, especially when crops are not grown during their preferred season. In addition, weeds interfere with harvest by making fruit difficult to find. The vigorous growth of many cucurbits makes integrated weed management feasible and reduces the need for herbicides. In any case, an integrated approach is necessary because of the limited availability of registered, effective, selective herbicides.

Vigorous, rapid growth of some cucurbits (melons, watermelon, and squash) during warm seasons makes them very competitive with the weeds and a single cultivation may be all that is needed for weed control. Other cucurbits such as cucumbers grow less vigorously and require additional weed control measures. Most cucurbit crops in California are grown in the open, but to produce fruit out of season the crop is grown in modified climates or under techniques such as hothouses, tunnels, plastic mulches, mid-bed trenches, and row covers. When cucurbits are grown out of season, they grow more slowly and are less competitive against weeds, requiring a more diligent weed control program for optimum yield and quality. In these situations, cultivation is not possible and hand hoeing or a preplant fumigant is necessary. Crop rotation is also a useful weed management tool because it allows different control measures to be used in the various cropping systems, thus avoiding the increase of specific weed populations.

Herbicides, combined with good cultural practices, control many weed pests of cucurbits. Generally, when a cucurbit crop is grown using climate modification techniques, soil fumigants are used before planting. Otherwise herbicides are applied before planting and mechanically mixed in the soil (preplant incorporated) or after planting and incorporated with irrigation (preemergence). Other herbicides are applied after planting to emerged weeds and are referred to as postemergence herbicides. Preemergence herbicides can also be applied during the layby period to keep the crop weed-free until harvest.

The choice of herbicide depends upon the weed species expected to occur and plantback restrictions. Plantback restrictions must be carefully considered because herbicide soil residues can limit the growth of sensitive rotational crops. Read labels closely for information regarding registration, use, and plantback restrictions.

MONITORING

Monitor the fields and keep records of the weed species that occur in each field during the period of the year when the crop will be grown, especially at planting time, but before hand weeding or cultivation, to determine what weeds escaped preplant treatment. Not only are these records valuable in planning weed management strategies, but they also help track the occurrence of hard-to-control weeds. Just before harvest, survey weeds again and record their location for future management. Keep records of specific locations in the field where weeds are producing seed. Weed patches are relatively stable within a field and spot treatments to these weed clusters may improve weed control in future crops. Avoid fields that have high populations of certain weeds such as common purslane, field bindweed, or nutsedge, as these weeds are not adequately controlled by currently available weed management methods.

WEED MANAGEMENT BEFORE PLANTING

To prevent the buildup of weed seed in the soil, cultivate weeds before they set seed in rotation crops. After harvest of the rotation crop, clean cultivate the field, plant a green manure crop, or use an herbicide to prevent weed infestations. Fallow bed herbicide treatments are sometimes used on pre-formed beds to prevent winter weed growth and allow early spring melon planting. An application of glyphosate (Roundup) can help suppress field bindweed. A banded application of metam sodium, centered on the seed line, will help suppress yellow nutsedge.

Just before planting cucurbits, preirrigate the field to germinate weed seeds and cultivate or use a nonselective herbicide such as paraquat or glyphosate (Roundup) to destroy them. (Glyphosate can be particularly helpful in controlling perennial weeds before the crop is planted.) Carrying out this operation as close to planting time as possible ensures that soil temperature and climatic conditions are similar to those that will occur during the crop

germination period, thus maximizing the number of weeds controlled. Cultivate as shallowly as possible in order not to bring up dormant weed seed from deeper soil layers. Install mulch to reduce pressure for most weeds, except for nutsedges.

If planting into a cover crop or utilizing a conservation-tillage or no-till system, apply a burn-down herbicide prior to planting when the cover crop is less than 1 ft tall so it is easier to manage.

Preplant Fumigants

Soil fumigants are necessary to prevent severe yield loss from weeds that are favored by the warm conditions created when climate modifications such as a clear soil mulch, tunnel, or mid-bed trench are used. Metam sodium may be used as a soil fumigant before planting a cucurbit crop. It is used primarily to control soilborne diseases and nematodes, but it also controls weeds. Weed control results have sometimes been inconsistent with metam sodium; be sure to apply it to well-prepared, moist seedbeds that are free of clods.

Herbicides

Bensulide (Prefar) is a narrow range, persistent herbicide that controls some small-seeded annual grasses, such as annual bluegrass, barnyardgrass, crabgrass, and some broadleaf weeds, such as pigweed and purslane. It can be mechanically incorporated shallowly (1 to 2 inches) before planting, or applied after planting under sprinkler irrigation. Consider the weed history of a field to determine the potential value of a bensulide application. Corn, sudangrass, and sorghum are sensitive to soil residues of bensulide following a cucurbit crop; see label for specific restrictions.

WEED MANAGEMENT AT PLANTING

Plant or transplant cucurbits into uniform beds utilizing a precision planting system that will promote a uniform crop and allow cultivation close to the seed line. This reduces the need for hand hoeing and lowers weed control costs.

Planting into a preirrigated field with dry surface soil is feasible for all cucurbits but is most effective for large-seeded ones such as melons, watermelon, and squash. This technique involves planting the seed into moist soil below a dry soil layer. To use mulch planting, first preirrigate the field, and then shallowly cultivate 2 to 4 inches deep when the surface dries. Cultivation kills any emerged weeds and creates a dry barrier (mulch) over moist soil into which the crop is sown. The field is not irrigated again until the crop reaches the third to fourth leaf stage. Mulch planting can fail and herbicide treatments may be required if it rains after sowing, if field conditions (e.g., soil type, fertility) are irregular, or if the dry mulch layer is too deep and irrigation is required to germinate the crop.

WEED MANAGEMENT AFTER PLANTING

After planting but before the crop or weeds emerge, bensulide can be applied and incorporated with sprinkler irrigation or through chemigation to control small-seeded annual grasses and some broadleaf weeds. Paraquat can be used to control emerged weeds after planting but before crop emergence. Take care, as emerged cucurbit plants will be killed if contacted by this herbicide.

After the crop emerges, sethoxydim (Poast) and clethodim (Select Max) can be used to control seedlings of some annual and perennial grasses. The effectiveness of these materials, however, is reduced when grasses are under moisture stress. Later growth stages of annual grasses are more difficult to control. Follow label instructions regarding the use of adjuvants with these herbicides. Sethoxydim will not control annual bluegrass and it varies in its ability to control particular grass species. For effective control of perennial grasses (bermudagrass and johnsongrass), two applications will be required. Carfentrazone (Shark) can be applied as a hooded spray to control small broadleaf weeds between crop rows. Avoid contacting cucurbits, because carfentrazone may cause injury.

During the growing season cultivation practices vary depending on the crop grown, the season it is grown in, and the use of climate modification techniques. Close cultivation is only possible before runners (vines) are produced. Hand hoeing is often used to supplement machine cultivation and thin the crop to the required density. Late-season hand hoeing can help reduce weed seed but almost always results in some yield loss.

Layby

During cooler seasons or for crops that have a long growing season, a layby herbicide can be beneficial. Trifluralin, DCPA (Dacthal), and ethalfuralin (Curbit) can be used after thinning or during the layby period to control late emerging grasses and annual broadleaf weeds. They are applied as a directed spray to the soil surface when the crop has four to five leaves, taking care not to contact the crop foliage. Trifluralin requires mechanical

incorporation and ethalfuralin is most effective when it is incorporated with a sectioned rolling cultivator within 1 to 2 hours after application. DCPA does not require mechanical incorporation. None of these herbicides will control emerged weeds; they are only effective on germinating seed. Their main benefit is to keep the weed populations low to facilitate harvest. Some carryover can occur under certain conditions, creating a plantback problem. Consult the herbicide label before application.

ORGANIC WEED CONTROL IN CUCURBITS (6/12)

Controlling weeds in organic cucurbits requires the use of many techniques and strategies in order to achieve economically acceptable weed control and yields. Weeds can always be pulled or cut out, but the question is simply how much can a grower spend in terms of time and money to reduce weed pressure. The more a grower is able to reduce weed pressure (seed and perennial propagules), the more economical it is to produce crops.

MONITORING

Monitor the fields and keep records of the weed species that occur in each field during the period of the year when the crop will be grown, especially at planting time but before hand weeding or cultivation to determine what weeds have escaped treatment. Not only are these records valuable in planning weed management strategies, but they also help track the occurrence of hard-to-control weeds. At harvest, keep records of specific locations in the field where weeds are producing seed. Weed patches are relatively stable within a field and management to these weed clusters may improve weed control in future crops. Avoid fields that have high populations of certain weeds such as common purslane, field bindweed, or nutsedge, as these weeds are not adequately controlled by currently available weed management methods.

MANAGEMENT

Water Management

Water management is a key tool for controlling weeds in cucurbits. There are a number of ways that careful use of irrigation management can assist growers in reducing weed pressure. A process called "pregermination" involves irrigating (or rainfall) before planting to germinate weed seeds, which can then be killed by light cultivation or flaming. Pregermination should be done as close as possible to the date of planting to assure that the weed spectrum does not change with the changes in the season or weather.

Dust mulches are also used in cucurbits. This technique is compatible with the process of pregermination. After weeds are killed by cultivation, the top 2 to 3 inches of soil are allowed to dry and form a dust mulch. At planting the dust mulch is pushed away and large seeded cucurbits can be planted into the zone of soil moisture. The cucurbit seed can germinate and grow with no supplemental irrigations that would otherwise germinate another flush of weeds.

Drip tape buried below the surface of the bed can provide moisture to the crop and minimize the amount of moisture that is available to weeds on the surface. If properly managed, this technique can provide significant weed control during the non-rainy periods of the year.

Cultivation

Cultivation is probably the most widely used method of weed control in organic vegetable systems. Mechanical cultivation uproots or buries weeds. Weed burial works best on small weeds, while larger weeds are better controlled by destroying the root-shoot connection or by slicing, cutting, or turning the soil to separate the root system from contact with the soil. Cultivation is effective against almost all weeds. Effective cultivation requires good land preparation for precision and accuracy. Shallow cultivation usually is best, because it brings fewer weed seeds to the surface. Level beds allow greater precision in depth of tillage. Cultivation requires relatively dry soil conditions; delay subsequent irrigations long enough to prevent re-rooting of weeds.

The goal of cultivation is to remove the weeds as close to the seed row as possible without disturbing the crop. In most cases precision cultivation can take care of weeds on over 90 percent of the bed. The remaining weeds must be removed from the seed row by hand or other mechanical means. Cultivation implements are often mounted on sleds for accurate, close cultivation in row crops. Guide wheels, cone wheels, and other devices are also used, but are generally less precise than sleds. Various implements are attached to these guidance setups to remove weeds.

Even the best cultivators will not eliminate all weeds, thus hand weeding is often needed. It is easier to remove weeds while they are small. The proper timing between cultivations depends on the speed of weed growth: in spring a 2- to 3-week period is about right, in the fall or winter, longer periods between cultivations may suffice.

Early occurrence of persistent weeds may be more damaging to crop yield than are weeds that establish late. Late-season weeding often disturbs crop root system or knocks off flowers or fruit and consistently results in reduced yields. Obviously, late-season cultivations to reduce weed seed production must be weighed against the potential for yield loss.

Flamers
Flamers can be used for weed control with propane-fueled models being most common. Fire causes the cell sap of plants to expand, rupturing the cell walls. Flaming can be used before the crop emerges. Weeds must have less than two true leaves for greatest efficiency of the burner. Grasses are harder to kill by flaming because the growing point is below the ground. After flaming, weeds that have been killed change from a glossy to a matte finish. This occurs very rapidly in most cases. Typically, flaming can be done at 3 to 5 mph through fields, although this depends on the heat output of the unit being used. Best results are obtained under windless conditions, as winds can prevent the heat from reaching the target. Early morning or evening is the best times to observe the flame for adjustment.

Mulches
Mulches blocks light, preventing weed germination or growth. Many materials can be used as mulches including plastics or organic materials such as municipal yard waste, wood chips, straw, hay, sawdust, and newspaper. To be effective, a mulch needs to block all light to the weeds therefore different mulch materials vary in the depth necessary to accomplish this.

Plastic mulches vary in thickness from 1.5 mil to about 4 mil. The most common plastic color for weed control is black, as it completely blocks light. Plastic mulches are generally placed on the beds and their edges covered with dirt to prevent their blowing away. Drip irrigation is needed under the plastic mulches to provide the crop with moisture. Certain weeds such as nutsedge are not completely controlled by plastic mulches, because they are able to penetrate the plastic. Other weeds are also able to grow in the openings provided for crops. Further problems with plastic mulches include maintaining them in place under windy conditions, disposal after crop harvest, and the cost (including the need for drip irrigation).

Organic mulches such as municipal yard waste, straw, hay, wood chips, etc., must be maintained in a layer 4 or more inches thick. Coarse green waste works better as a mulch. Organic mulches can also be grown in place. Plants used in this way include subterranean clovers, ryegrass, fava beans, oats, barley, rye, etc. These mulches (or living mulches as they are sometimes referred) must die or be killed before planting the crop to avoid excessive competition with the crop.

Organic Herbicides
Herbicides are chemicals that kill or suppress plants by affecting plant physiological processes. The number of herbicides that are organically acceptable are limited and include contact materials such as citric acid, clove oil, cinnamon oil, lemongrass oil, and various soaps. Herbicides can be used to selectively control weeds by application ahead of crop emergence or by use of shielded or directed applications. These herbicides kill plants that have emerged, but have no residual activity on those subsequently emerging.

SPECIAL WEED PROBLEMS (6/12)

COMMON PURSLANE, JUNGLERICE, AND BARNYARDGRASS

The weeds Common purslane, Junglerice, and Barnyardgrass are particular problems when a climate modification technique is used in early spring to promote early harvest. Halosulfuron (Sandea), applied preemergence, can provide good control of junglerice and some suppression of purslane. Bensulide is effective against these weeds, but inadequate soil incorporation has frequently resulted in poor levels of control. Avoid growing cucurbit crops for early harvest in fields heavily infested with these weeds.

NUTSEDGE

Nutsedge is a serious weed in spring- and summer-planted crops. Yellow and purple nutsedge are perennial weeds that reproduce from underground tubers and can survive for several years in soil. Each tuber contains several buds that are capable of producing plants. One or more buds on the tuber germinate at a time to form new plants; however, if a bud or plant is destroyed by cultivation or an herbicide, then a new bud is activated. Halosulfuron (Sandea), applied postemergence, provides good to excellent control of nutsedge and is labeled for all cucurbit crops. In some cucurbit crops (watermelon and summer squash), however, only directed applications are permitted and nutsedge can remain a problem in the seed line. A banded application of metam sodium, centered on the seed line, will help suppress yellow nutsedge. Other options include rotating to crops where effective herbicide and cultural control methods can be used or continuous cultivation during a summer fallow period. Deep plowing (9 to 10 inches) with a moldboard plow before listing the beds can bury nutsedge tubers to a sufficient depth so that their emergence is slowed down during the crop establishment period.

FIELD BINDWEED

Field bindweed is a widely distributed perennial weed that can reduce cucurbit yields. Glyphosate (Roundup), paraquat (Gramoxone Inteon), and trifluralin (Treflan) all provide partial control of this weed. This weed can be controlled with a postharvest application of glyphosate or during the fallow season using glyphosate and cultivation; or, deep plow using chisel plows on reclamation blades at depths of 16 inches in dry soil during the summer before planting.

COMMON and SCIENTIFIC NAMES OF WEEDS (12/09)

Common Name	Scientific Name
Barley	*Hordeum sp.*
Barnyardgrass	*Echinochloa crus-galli*
Bermudagrass	*Cynodon dactylon*
Bindweed, Field	*Convolvulus arvensis*
Bluegrass, Annual	*Poa annua*
Brome, Ripgut	*Bromus diandrus*
Burclover, California	*Medicago polymorpha*
Canarygrass, Littleseed	*Phalaris minor*
Crabgrasses	*Digitaria spp.*
Cudweeds	*Gnaphalium spp.*
Docks	*Rumex spp.*
Fiddlenecks	*Amsinckia spp.*
Filarees	*Erodium spp.*
Fleabane, Hairy	*Conyza bonariensis*
Foxtails	*Setaria spp.*
Goosefoot, Nettlefoot	*Chenopodium murale*
Groundcherries	*Physalis spp.*
Groundsel, Common	*Senecio vulgaris*
Henbit	*Lamium amplexicaule*
Horseweed	*Conyza canadensis*
Johnsongrass	*Sorghum halepense*
Knotweed, Prostrate	*Polygonum arenastrum*
Lambsquarters, Common	*Chenopodium album*
Lettuce, Prickly	*Lactuca serriola*
Lovegrass	*Eragrostis spp.*
Mallow, Little Cheeseweed)	*Malva parviflora*
Medic, Black	*Medicago lupulina*
Morningglories	*Ipomoea spp.*
Mustards	*Brassica spp.*
Nettles	*Urtica spp.*
Nightshade, Black	*Solanum nigrum*
Nightshade, Hairy	*Solanum sarrachoides*
Nutsedge, Purple	*Cyperus rotundus*
Nutsedge, Yellow	*Cyperus esculentus*
Oat, Wild	*Avena fatua*
Panicum, Fall	*Panicum dichotomiflorum*
Pigweeds	*Amaranthus spp.*
Puncturevine	*Tribulus terrestris*
Purslane, Common	*Portulaca oleracea*
Radish, Wild	*Raphanus raphanistrum*
Rescuegrass	*Bromus catharticus*
Rocket, London	*Sisymbrium irio*
Ryegrasses	*Lolium spp.*
Shepherd's-Purse	*Capsella bursa-pastoris*
Sowthistles	*Sonchus spp.*
Sunflower, Common	*Helianthus annuus*
Sweetclover, Yellow	*Melilotus officinalis*
Thistle, Russian	*Salsola tragus*

SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL

(7/13)

	BEN	CAR	CLE	DCP	ETH	GLY	HAL	MET*	OXY	PAR*	SET	TRI
ANNUAL WEEDS												
Barley, Wild	P	N	C	—	C	C	—	C	P	P	C	C
Barnyardgrass	C	N	C	—	C	C	—	C	P	P	C	C
Bluegrass, Annual	C	N	P	—	C	C	P	C	P	P	N	C
Brome, Ripgut	P	N	C	—	C	C	N	C	P	C	C	C
Burclover, California	N	N	N	N	N	P	—	N	P	P	N	N
Canarygrass	C	N	C	—	N	C	—	C	P	P	C	C
Cereals	N	N	C	—	P	C	—	C	N	P	C	P
Chickweed, Common	P	P	N	C	C	C	C	C	P	C	N	C
Crabgrass	C	N	C	—	C	C	—	C	N	C	C	C
Cudweeds	N	—	N	N	N	C	—	C	N	N	N	N
Docks	N	—	N	—	P	C	—	C	P	P	N	P
Fiddlenecks	N	C	N	C	C	C	—	C	C	P	N	C
Filarees	N	P	N	P	N	P	—	C	C	P	N	N
Fleabane, Hairy	N	N	N	N	N	C	—	C	P	C	N	N
Foxtails	C	N	C	—	C	C	—	C	N	C	C	C
Goosefoot, Nettlefoot	P	—	N	C	C	C	—	C	C	C	N	C
Groundcherries	N	C	N	C	C	C	—	C	C	C	N	N
Groundsel, Common	N	—	N	N	N	C	C	C	C	C	N	N
Henbit	N	—	N	P	C	C	—	C	C	C	N	C
Horseweed	N	N	N	N	N	C	—	C	P	P	N	N
Knotweed, Prostrate	C	—	N	P	C	C	—	C	P	P	N	C
Lambsquarters, Common	C	C	N	C	C	C	N	C	C	P	N	C
Lettuce, Prickly	N	—	N	N	P	C	C	C	C	P	N	N
Lovegrasses	C	N	C	—	N	C	—	C	P	P	—	C
Mallow, Little (Cheeseweed)	N	C	N	P	N	P	—	N	C	N	N	N
Medic, Black	N	—	N	—	N	P	—	N	—	P	N	N
Morningglories	N	C	N	N	P	C	P	P	C	P	N	N
Mustards	N	P	N	P	N	C	C	C	C	C	N	N
Nettles	P	C	N	P	C	N	C	C	C	P	N	P
Nightshade, Black	N	C	N	P	C	C	N	C	C	C	N	N
Nightshade, Hairy	N	C	N	P	C	C	N	C	C	C	N	N
Oat, Wild	N	N	C	—	C	C	—	C	P	P	C	P
Panicum, Fall	C	N	C	—	C	C	—	C	N	P	C	C
Pigweed	C	C	N	C	C	C	P	P	C	C	N	C
Puncturevine	N	—	N	P	N	C	—	C	P	C	N	P
Purslane, Common	C	P	N	C	C	C	P	C	C	C	N	C
Radish, Wild	N	P	N	N	N	C	C	C	C	C	N	N
Rescuegrass	—	N	C	—	C	C	—	C	—	—	—	C
Rocket, London	N	C	N	P	N	C	C	C	C	C	N	N
Ryegrasses	P	N	C	—	C	C	N	C	N	P	C	C
Shepherd's-Purse	N	P	N	N	N	C	C	C	P	P	N	N
Sowthistles	N	N	N	P	P	C	C	C	C	P	N	N
Sunflower, Common	N	—	N	P	N	C	C	C	C	P	N	N
Sweetclover, Yellow	N	—	N	—	N	P	—	N	P	P	N	N
Thistle, Russian	N	C	N	C	C	C	—	C	P	C	N	P

	BEN	CAR	CLE	DCP	ETH	GLY	HAL	MET*	OXY	PAR*	SET	TRI
Velvet Leaf	N	C	N	N	—	P	C	—	—	C	N	N
PERENNIAL WEEDS												
Bermudagrass, Seedling	C	N	C	—	C	C	N	C	P	P	C	C
Bermudagrass, Established	N	N	P	—	N	C	N	P	N	N	P	N
Bindweed, Field, Seedling	N	C	N	N	—	C	—	P	N	P	N	P
Bindweed, Field, Established	N	P	N	N	—	P	—	P	N	N	N	P
Johnsongrass, Seedling	C	N	C	—	C	C	N	C	N	C	C	C
Johnsongrass , Established	N	N	C	—	N	C	N	P	N	N	C	N
Nutsedge, Purple	N	N	P	N	N	P	C	P	N	N	N	N
Nutsedge, Yellow	N	N	N	N	N	P	C	P	N	N	N	N

C = control P = partial control N = no control — = no information

BEN = bensulide (Prefar)
CAR = carfentrazone (Shark)
CLE = clethodim (Select Max)
DCP = DCPA (Dacthal)
ETH = ethalfluralin (Curbit EC)
GLY = glyphosate (Roundup)
HAL = halosulfuron (Sandea)
MET = metam sodium* (Vapam, etc.)
OXY = oxyfluorfen (Goal 2XL)
PAR = paraquat* (Gramoxone Inteon)
SET = sethoxydim (Poast 1.5EC)
TRI = trifluralin (Treflan)

* Permit required from agricultural commissioner for purchase or use.

HERBICIDE TREATMENT TABLE (5/16)

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

The following are listed alphabetically. When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide's properties, and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

PREPLANT FUMIGATION

A. METAM SODIUM* (Vapam, Sectagon)	50–75 gal	See label	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 27

COMMENTS: Metam is a water soluble, soil-applied biocide. For best results, it should be applied to well tilled soil free of large clods that was moistened by rainfall or preirrigated 2 weeks previously in order to enhance germination of weed seeds. Typical application is with a subsurface spray blade into premade beds. Set spray blades to cut 2 to 3 inches below the soil surface with disc hillers following behind to form a 3- to 5-inch soil cap over treated area. After 7 to 14 days, the caps are removed and allowed to air before planting. Typically only a 6- to 12-inch band is treated in order to reduce costs. It can be injected into the sprinkler irrigation system and applied through drip irrigation tubes placed under a plastic mulch. There have been numerous failures with metam, mostly because of improper soil preparations. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.

BEFORE PLANTING

A. BENSULIDE	5–9 lb a.i.		
(Prefar 4E)	5–9 qt	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 8

COMMENTS: A narrow-spectrum herbicide applied before weed seeds germinate; good for annual grasses and common purslane. Can be mechanically incorporated shallowly (1–2 inches) before planting, or applied after planting and incorporated with sprinkler irrigation. Can also be applied by chemigation, through sprinkler, surface drip, or subsurface drip irrigation. Very safe on all cucurbits. Also very persistent; check label for plantback (rotational crop) restrictions. Use allowed under a Special Local Needs label.

B. CARFENTRAZONE	0.0074–0.0237 lb a.i.		
(Shark EW)	0.5–1.6 oz	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14

COMMENTS: Rate depends on weed species. For best activity, apply when weeds are less than 4 inches tall or rosettes less than 3 inches wide. Provides control of emerged annual broadleaves, but has no preemergence activity. A nonionic surfactant or crop oil concentrate or methylated seed oil is required. Good spray coverage is essential for good control. Apply in a minimum of 10 gallons of water per acre.

C. GLYPHOSATE (Roundup Powermax)	See label	See comments	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9

COMMENTS: A nonselective, foliar herbicide applied before planting to premade beds to kill emerged weeds. Restricted entry interval (REI) is 4 hours for Roundup. Allow 3 days after treatment before planting. Use the lower rate for annual grasses and weeds, the higher rate on perennial weeds. Add ammonium sulfate at 8 to 15 lbs per 100 gal to improve glyphosate activity if using hard water. Always add the ammonium sulfate to the water before adding glyphosate or other adjuvants. Add a nonionic surfactant for difficult-to-control weeds. Consult the label for specific recommendations on particular weed species. Do not apply to weeds stressed for moisture. For perennial weeds, allow 7 days after application before cultivating.

D. OXYFLUORFEN	0.25–0.5 lb a.i.		
(Goal 2XL)	1–2 pt	24	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

UPDATED 5/16

COMMENTS: Rate depends on weed size, but the rate used also determines the minimum period between treatment and planting: Cantaloupe = 60 days for the low rate and 90 days for the high rate; watermelon = 60 days for either rate; other cucurbits = 90 days for the low rate and 120 days for the high rate. Provides control of annual broadleaves both before and after they emerge. Incorporate with 2 inches of irrigation water and don't disturb soil until planting time. Work beds with a rolling cultivator or similar tool to a depth of 2.5 inches before planting to avoid crop injury or stand loss. Once beds have been worked before planting, the herbicide is no longer effective. However, crop injury can result if beds are not thoroughly worked before planting. This herbicide lasts 4 to 8 weeks in the soil and has a 10-month plantback restriction for nonlabeled crops. Apply in a minimum of 20 gallons of water per acre.

E.	PARAQUAT*	0.5–1 lb a.i.		
	(Gramoxone SL 2.0)	2–4 pt	12	0

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22

COMMENTS: A nonselective foliar herbicide that kills emerged weeds. Can be used before planting or after planting but before the crop emerges. Any crop plants exposed to the spray will be killed, even germinating seed in the crook stage. No soil residual activity. Use the lower rate on small broadleaf weeds, the higher rate on larger weeds and grasses. A nonionic surfactant must be added at the rate of 8 to 32 oz/100 gal, with the higher surfactant rate needed for larger weeds and grasses. Wear protective clothing as paraquat is highly toxic if ingested, inhaled, or contacts the skin. Most active on warm, sunny days, particularly late afternoon.

AT PLANTING

Before crop and weeds emerge

A.	BENSULIDE	5–6 lb a.i.		
	(Prefar 4E)	5–6 qt	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 8

COMMENTS: A narrow spectrum herbicide, good for annual grasses and common purslane. Can be mechanically incorporated shallowly (1–2 inches) before planting, or applied after planting and incorporated with sprinkler irrigation. Very safe on all cucurbits. Also very persistent; check label for plantback (rotational crop) restrictions.

B.	ETHALFLURALIN			
	(Curbit EC)	Label rates	24	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3

COMMENTS: Apply to the soil surface within 2 days after planting and before crop and weeds emerge. In sprinkler-irrigated fields, activate with a minimum of 0.5 inches of water; a rainfall after application will also serve to activate it. Excessive irrigation or rainfall may move the herbicide deep in the soil, and injury can occur. In furrow- or drip-irrigated fields, a shallow cultivation will activate. Injury potential is greater if seeding depth is too shallow.

C.	HALOSULFURON-METHYL	0.023–0.047 lb a.i.		
	(Sandea)	0.5– 1 oz	12	See label

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 2

COMMENTS: Do not use in watermelons. Controls many broadleaf weeds and suppresses nutsedge.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			

AFTER PLANTING

After crop and weeds emerge

A. CARFENTRAZONE — 0.0074–0.0237 lb a.i.
(Shark EW) — 0.5–2 oz — 12 — 0
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14
COMMENTS: Must be applied with a hooded or shield applicator, as contact with the cucurbit vines will cause injury. Rate depends on weed species. For best activity, apply when weeds are less than 4 inches tall or rosettes less than 3 inches wide. Provides control of emerged annual broadleaves, but has no preemergence activity. A nonionic surfactant or crop oil concentrate or methylated seed oil is required. Good spray coverage is essential for good control. Apply in a minimum of 10 gallons of water per acre.

B. CLETHODIM — 0.091–0.121 lb a.i.
(Select Max) — 12–16 fl oz — 24 — 14
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1
COMMENTS: Controls actively growing small grasses except for bromes and fescues. Apply to annual bluegrass at 4-leaf stage. Repeat treatments are necessary for perennial grasses, but a minimum of 14 days is required between applications. Do not apply a postemergence broadleaf herbicide within one day of clethodim or reduced grass control will occur. Symptoms appear in 7 to 14 days, depending on species and environmental conditions. Apply in 10 to 40 gal water/acre. Always add a crop oil concentrate at 1% v/v in the finished spray solution.

C. HALOSULFURON-METHYL — 0.023–0.047 lb a.i. — See label
(Sandea) — 0.5–1 oz — 12 — 57: melons
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 2
COMMENTS: For use on seed and transplant cucurbits for the control of nutsedge. Apply over the top of direct-seeded cucumber, cantaloupe, honeydew, Crenshaw melons, pumpkins, and winter squash from the 4-true leaf stage through first bloom. Maximum use rates are lower for over-the-top applications (see label). Following bloom, or in other cucurbits including watermelon and summer squash, applications must be made either as a directed spray or with shields to minimize contact with the crop. Make applications to transplanted cucurbits at least 14 days after transporting but before 1st bloom. Following bloom, applications to transplanted cucurbits must be made either as a directed spray or with shields to minimize contact with the crop. Injury may result if the spray contacts the foliage. Use of 0.25 to 0.5% v/v of nonionic surfactant is recommended. Use of crop oil concentrate or silicone surfactants is not recommended because of increased risk of injury. Do not apply if a soil application of an organophosphate insecticide has been made. Do not apply a foliar organophosphate insecticide within 21 days before or 7 days after any halosulfuron treatment.

D. SETHOXYDIM — 0.09375–0.28125 lb a.i.
(Poast) — 0.5–1.5 pt — 12 — See label
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1
COMMENTS: A selective, foliar herbicide for control of grasses. Addition of a surfactant (crop oil concentrate or nonionic surfactant) is essential. Usually safe to the crop, except on very warm, sunny days; this may be due to the surfactant. Injury observed has been small necrotic spots on treated leaves. Not effective on drought stressed grasses or on certain species (e.g., annual bluegrass, sprangletop).

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/16			
LAYBY (POST THINNING)			
A. DCPA	4.5–10.5 lb a.i.		
(Dacthal Flowable)	6–14 pt	12	0
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3			
COMMENTS: Apply when cucurbits have 4 to 5 true leaves, as a banded spray to clean cultivated soil, to control annual grasses and some annual broadleaf weeds. In sandy loam soils, maximum preemergence rate of 10 lb/acre is recommended.			
B. ETHALFLURALIN			
(Curbit EC)	Label rates	24	0
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3			
COMMENTS: Apply as a directed spray to avoid contact with the growing tips. Use when field is free of emerged weeds and incorporate with a sectioned rolling cultivator within 1 to 2 hours after application. Similar to trifluralin but also controls nightshades.			
C. TRIFLURALIN			60: watermelon
(Treflan 4D or HFP)	Label rates	12	30: all others
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3			
COMMENTS: Rate is dependent on soil type. Apply as a directed spray to clean cultivated soil when the crop has 3 to 4 leaves. Immediate mechanical incorporation into the top 2 to 3 inches of soil is required. Leaves and runners contacted by trifluralin may be stunted temporarily; lobes on leaves may be thickened and veins constricted. Controls annual grasses and broadleaf weeds.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

1 Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://wssa.net/.

NA Not applicable.

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Precautions for Using Pesticides

Pesticides are poisonous and must be used with caution. READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER. Follow all label precautions and directions, including requirements for protective equipment. Apply pesticides only on the crops or in the situations listed on the label. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently. This publication reflects legal restrictions current on the date next to each pest's name.

Legal Responsibility

The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation

Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage

Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. DO NOT store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container Disposal

Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Consult your county agricultural commissioner for correct procedures for handling and disposal of large quantities of empty containers.

Protection of Nonpest Animals and Plants

Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Crops and other plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

Posting Treated Fields

For some materials, *restricted entry intervals* are established to protect field workers. Keep workers out of the field for the required time after application and, when required by regulations, post the treated areas with signs indicating the safe re-entry date. Check with your county agricultural commissioner for latest restricted entry interval.

Preharvest Intervals

Some materials or rates cannot be used in certain crops within a specified time before harvest. Follow pesticide label instructions and allow the required time between application and harvest.

Permit Requirements

Many pesticides require a permit from the county agricultural commissioner before possession or use. When such materials are recommended, they are marked with an asterisk (*) in the treatment tables or chemical sections of this publication.

Maximum residue levels

Before applying pesticides to crops destined for export, check maximum residue levels (MRLs) of importing country at http://mrldatabase.com.

Processed Crops

Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before applying a pesticide.

Crop Injury

Certain chemicals may cause injury to crops (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal Safety

Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. NEVER eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care IN ADVANCE as required by regulation.