PEPPERS

June 2016

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 ipm.ucanr.edu/agriculture/peppers

Publication 3460
University *of* California
Agriculture and Natural Resources
Statewide Integrated Pest Management Program

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UC PEER REVIEWED

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Agricultural Pest Management.

The UC IPM Pest Management Guidelines are available from:

- Online: ipm.ucanr.edu
- UC Cooperative Extension County Offices
- University of California
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This material is partially based on work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Crop Protection and Pest Management Competitive Grants Program.

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 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 read the label and check with local authorities for the most up-to-date information regarding registration and restrictions on pesticide use. Check with your agricultural commissioner for latest restricted entry intervals.

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Peppers Year-Round IPM Program (9/11)

ANNUAL CHECKLIST

Supplement to UC IPM Pest Management Guidelines

Use these guidelines for a monitoring-based IPM program to effectively manage pests, while reducing the risks of pesticides on the environment and human health.

When a pesticide application is considered, review the Pesticide Application Checklist for information on how to minimize the risks of pesticide use to water and air quality. Water quality can be impaired when pesticides drift into waterways or when they move off-site. Air quality can be impaired when pesticide applications release volatile organic compounds (VOCs) into the atmosphere.

This year-round IPM program covers the major pests of peppers production in California. Details on carrying out each practice and information on additional pests can be found in the UC IPM Pest Management Guidelines: Peppers. Color photo identification sheets and examples of monitoring forms can be found at the forms and photo identification pages.

This year-round IPM program covers the major pests of peppers in California.

✓ Done	**Preplant** **Special issues of concern related to environmental quality:** volatile organic compounds (VOCs). Mitigate pesticide effects on air and water quality.
	Select the field, considering: • Soil type • Cropping history • Pest history, especially weed species and plantback restrictions from the previous crop • The need for crop rotation to reduce problems from pathogens, nematodes, weeds, and insects (do not plant consecutive pepper crops, especially for pepper weevil) • Soil fumigation history ◦ Sample soil for nutrient, salinity, and pH to determine fertilizer and soil amendment needs

	Prepare the field (for drip-irrigated peppers).
	• Conduct tillage operations. Preirrigate and cultivate to destroy initial flush of weeds.
	• Choose planting configuration.
	• Prepare planting beds.
	• Apply preplant fertilizer based on soil test results.
	• Install irrigation system.
	• Consider the use of plastic mulch and choose the color depending on management needs (e.g. opaque for weed control or reflective to repel aphids and whiteflies). Before plastic mulch is applied:
	  ◦ Consider treating beds with preemergence herbicides to control problematic weeds such as little mallow and yellow nutsedge.
	  ◦ Consider injecting preplant fumigants to control problematic soilborne pathogens and weeds.
	• Sample for nematodes if cropping history is unknown. Manage, if needed, according to the Peppers Pest Management Guidelines.
	• Control weeds in surrounding crop fields, head rows, fallow fields, and noncrop areas throughout the season.

	Select planting method: direct-seeded or transplant.
	Select an appropriate cultivar to provide desired yield and crop quality goals. Also, consider disease-resistant varieties. Use disease-free transplants, or if direct seeding, indexed pathogen-negative seed or treated seed.
	Throughout the season, clean equipment and tractors before entering a new field to prevent the spread of key soilborne pathogens such as Verticillium and weed propagules.

✓ Done	**Preplant** **Special issues of concern related to environmental quality:** volatile organic compounds (VOCs). Mitigate pesticide effects on air and water quality.
	Check transplants for diseases and insects before planting. Rogue infested or infected plants. **Arthropods** • Beet armyworm • Broad mite (Imperial and Coachella valleys) • Cutworms • Green peach aphid • Flea beetles • Leafminers • Omnivorous leafroller • Pepper weevil • Tomato fruitworm • Tomato (potato) psyllid • Twospotted spider mite • Seedcorn maggot (direct-seeded) • Thrips • Wireworms • Yellowstriped armyworm • Whiteflies **Diseases** • *Alfalfa mosaic virus* • Bacterial spot • Beet curly top • Botrytis gray mold • Cucumovirus mosaic diseases • Gray mold • Impatiens necrotic spot • Pepper potyvirus mosaic diseases • Pepper tobamovirus diseases • Powdery mildew • Root and crown rot and damping-off diseases • White mold

This year-round IPM program covers the major pests of peppers in California.

✓ Done	**Planting (direct seed or transplant)** **Special issues of concern related to environmental quality:** runoff, drift. Mitigate pesticide effects on air and water quality.
	Plant seeds or transplants when soil temperatures are appropriate and the danger of frost has passed.
	Consider all cultural and herbicide practices to manage weeds in direct-seeded or transplanted peppers according to the Peppers Pest Management Guidelines.

This year-round IPM program covers the major pests of peppers in California.

✓ Done	**Seedling or early vegetative growth** **Special issues of concern related to environmental quality:** runoff, drift. Mitigate pesticide effects on air and water quality.
	Irrigate based on crop evapotranspiration (ET) to maximize water use efficiency and reduce the risk of soilborne diseases such as root and crown rot and damping-off diseases.
	Check for pests or their damage. Refer to the Peppers Pest Management Guidelines for management options. **Arthropods** • Beet armyworm • Broad mite (Imperial and Coachella valleys) • Cutworms • Green peach aphid • Flea beetles • Leafminers • Omnivorous leafroller • Pepper weevil • Seedcorn maggot (direct-seeded) • Thrips • Tomato fruitworm • Tomato (potato) psyllid • Twospotted spider mite **Diseases** • *Alfalfa mosaic virus* • Bacterial spot • Beet curly top • Botrytis gray mold • Cucumovirus mosaic diseases • Gray mold • Impatiens necrotic spot • Pepper potyvirus mosaic diseases • Pepper tobamovirus diseases • Powdery mildew • Root and crown rot and damping-off diseases • White mold

✓ Done	**Seedling or early vegetative growth** **Special issues of concern related to environmental quality:** runoff, drift. Mitigate pesticide effects on air and water quality.
	• Wireworms • Whiteflies • Yellowstriped armyworm **Abiotic** • Wind injury (especially in Southern desert valleys)
	Manage weeds • Cultivate close to the seed line to remove weeds and aerate soil. • Cultivate furrow bottoms of mulched fields. • Hand weed approximately 30 days following planting or transplanting.
	Consider applying a fertilizer as a sidedress or drip injection application based on crop needs.

This year-round IPM program covers the major pests of peppers in California.

✓ Done	**Bloom** **Special issues of concern related to environmental quality:** runoff, drift. Mitigate pesticide effects on air and water quality.
	Manage weeds: • Cultivate and hand weed to remove small weeds prior to layby. • Apply layby herbicides before plants begin to fill in the bed. • Hand weed approximately 30 days following planting or transplanting.
	Consider applying a fertilizer sidedress or drip injection application based on crop needs.
	Check for pests or their damage. Refer to the Peppers Pest Management Guidelines for management options. **Arthropods** • Beet armyworm • Broad mite (Imperial and Coachella valleys) • Cutworms • Flea beetles • Green peach aphid • Leafminers • Omnivorous leafroller • Pepper weevil • Seedcorn maggot (damage rare at this stage) • Thrips • Tomato fruitworm • Tomato (potato) psyllid • Twospotted spider mite • Whiteflies • Wireworms (damage rare at this stage) • Yellowstriped armyworm **Diseases or Nematodes** • *Alfalfa mosaic virus* • Bacterial spot • Beet curly top • Botrytis gray mold • Cucumovirus mosaic diseases • Impatiens necrotic spot • Pepper potyvirus mosaic diseases • Pepper tobamovirus diseases • Powdery mildew • Root and crown rot and damping-off diseases • White mold • Verticillium wilt • Root knot nematode **Abiotic** • Wind injury (especially in Southern desert valleys)

This year-round IPM program covers the major pests of peppers in California.

✓ Done	**Fruit development** **Special issues of concern related to environmental quality:** runoff, drift. Mitigate pesticide effects on air and water quality.
	Consider applying fertilizer by sidedress or drip injection application.
	Check for pests or their damage. Refer to the Peppers Pest Management Guidelines for management options. **Arthropods** • Aphids **Diseases** • *Alfalfa mosaic virus*

	• Beet armyworm • Leafminers • Pepper weevil • Spider mites • Thrips • Tomato fruitworm	• Beet curly top • Cucumovirus mosaic diseases • Impatiens necrotic spot • Pepper potyvirus mosaic diseases • Pepper tobamovirus diseases • Powdery mildew • Root and crown rot and damping-off diseases • Tomato spotted wilt virus • Verticillium wilt
	In areas where pepper weevil is a problem, remove from the field any dropped or culled fruit.	
	Survey weeds and keep records to plan for next year. (See example form online.) Handweed to remove late-season weeds.	

This year-round IPM program covers the major pests of peppers in California.

✓ Done	**Harvest and postharvest** Special issues of concern related to environmental quality: runoff, drift. Mitigate pesticide effects on air and water quality.
	In areas with multiple harvests: • Continue to inspect for disease and invertebrate problems. Refer to the Peppers Pest Management Guidelines for management options. • Test plant tissue to determine if potassium fertilizer application is necessary. Test soil to determine soil nitrate status and if supplemental fertigation is necessary. • In areas where pepper weevil is a problem, remove from the field dropped or culled fruit.
	Sample fruit to determine the effectiveness of your pest management program and cultural practices.
	Carry out field sanitation. Destroy and remove all crop debris immediately after harvest and destroy other pathogen, nematode, and insect host plants.

✓ Done	**Pesticide application checklist** When planning for possible pesticide applications in an IPM program, review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	✓ **Choose a pesticide from the UC IPM Pest Management Guidelines for the target pest, considering:**
	• Impact on natural enemies and honey bees. • Potential for water quality problems using the UC IPM WaterTox database. See http://ipm.ucanr.edu/TOX/simplewatertox.html. • Impact on aquatic invertebrates. For more information, see *Pesticide Choice*, UC ANR Publication 8161 (PDF), http://anrcatalog.ucanr.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.ucanr.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.ucanr.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)

✓ Done	**Pesticide application checklist** When planning for possible pesticide applications in an IPM program, review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	• 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).

✓ Done	**Pesticide application checklist** When planning for possible pesticide applications in an IPM program, review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	✓ 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.ucanr.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.ucanr.edu/pdf/8214.pdf • *Protecting Surface Water from Sediment-Associated Pesticides in Furrow-Irrigated Crops*, UC ANR Publication 8403 (PDF), http://anrcatalog.ucanr.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. For more information, see these publications: • *Reducing Runoff from Irrigated Lands: Tailwater Return Systems*, UC ANR Publication 8225 (PDF), http://anrcatalog.ucanr.edu/pdf/8225.pdf • *Reducing Runoff from Irrigated Lands: Storing Runoff from Winter Rains*, UC ANR Publication 8211 (PDF), http://anrcatalog.ucanr.edu/pdf/8211.pdf
	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.ucanr.edu/pdf/8212.pdf
	Consider using cover crops.
	Consider vegetative filter strips or ditches. (For more information, see Vegetative Filter Strips, UC ANR Publication 8195 (PDF), http://anrcatalog.ucanr.edu/pdf/8195.pdf
	Use polyacrylamide (PAM) tablets in furrow irrigation systems to prevent off-site movement of sediments.
	Redesign inlets into tailwater ditches to reduce erosion. (For more information, see Reducing Runoff from Irrigated Lands: Tailwater Return Systems, UC ANR Publication 8225 (PDF), http://anrcatalog.ucanr.edu/pdf/8225.pdf

✓ Done	**Pesticide application checklist** When planning for possible pesticide applications in an IPM program, review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	✓ 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: ipm.ucanr.edu/mitigation/.

General Information

RELATIVE TOXICITIES OF INSECTICIDES AND MITICIDES TO NATURAL ENEMIES AND POLLINATORS (6/16)

Common name (Example trade name and formulation)	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 EC)	6	moderate (mites, leafminers)	M	L	M/H	I	moderate to predatory mites & affected insects
acetamiprid (Assail WP)	4A	moderate (sucking insects, larvae)	—[7]	—[8]	—	II	moderate
azadirachtin (Neemix)	un	broad (insects, mites)	M	L/M	L/M	II	short
Bacillus thuringiensis ssp. *aizawai*	11	narrow (caterpillars)	L	L	L	II	short
Bacillus thuringiensis ssp. *kurstaki*	11	narrow (caterpillars)	L	L	L	III	short
bifenthrin (Brigade)	3A	broad (insects, mites)	H	H	H	I	long
carbaryl (Sevin 4F)	1A	broad (insects, mites)	M/H	H	H	I	long
carbaryl (Sevin XLR Plus)	1A	broad (insects, mites)	L	H	L	I	long
chlorantraniliprole (Coragen)	28	narrow (primarily caterpillars)	—	—	—	III	—
chlorantraniliprole/lambda-cyhalothrin (Voliam Xpress)	28/3A	—	—	—	—	—	—
chlorantraniliprole/thiamethoxam (Voliam Flexi)	28/4A	—	—	—	—	—	—
cryolite (Kryocide)	un	narrow (foliage chewing insects)	L	L	L	III	short
cyantraniliprole (Exirel, Verimark)	28	narrow (primarily caterpillars)	—	—	—	—	—
cyromazine (Trigard WP)	17	narrow (leafminers)	L	L	L	II	short
dinotefuran (Venom)	4A	narrow (sucking insects)	L	—	L	I	short
dimethoate (E)	1B	broad (insects, mites)	H	H	H	I	long
esfenvalerate (Asana XL)	3A	broad (insect, mites)	H	M	H	I	moderate
flonicamid (Beleaf)	9C	narrow (thrips, aphids)	L	L	L	III	short
imidacloprid (Admire)	4A	narrow (sucking insects)	—	L	L	I	long
indoxacarb (Avaunt)	22A	narrow (caterpillars)	—	L	L	I	moderate
insecticidal soap (M-Pede)	—	broad (exposed insects, mites)	M	M	M	III	short
methomyl (Lannate SP, LV)	1A	broad (insects, mites)	H	H	H	I	moderate
methoxyfenozide (Intrepid 2F)	18	narrow (caterpillars)	L	L	L	II	short
permethrin (Pounce WP)	3A	broad (insects, mites)	L	H	H	I	long
petroleum oil	—	broad (exposed insects, mites)	L[9]	L	L	II	short
pymetrozine (Fulfill)	9B	narrow (aphids, whiteflies)	L	L	L	II	short
pyrethrin (PyGanic EC)	3	broad (insects)	—	M	M	I	short
pyriproxyfen (Knack)	7C	narrow (aphids, whiteflies)	L	H[10]	L	II	short
spinetoram (Radiant)	5	narrow (caterpillars, thrips, whiteflies, aphids, leafminers)	M	M[11]	L/M	II	moderate[12]
spinosad (Entrust, Success)	5	narrow (caterpillars, thrips, whiteflies, aphids, leafminers)	M	M[11]	L/M	II	moderate[11]
spiromesifen (Oberon SC)	23	narrow (psyllid, mite, whitefly)	—	—	—	II	—
spirotetramat (Movento)	23	narrow (aphid, psyllid, whitefly)	—	—	—	II	—
thiamethoxam (Actara)	4A	narrow (sucking insects)	—[7]	—	M	I	moderate

H = high M = moderate L = low — = no information un = unknown or uncertain mode of action

Relative Toxicities of Insecticides and Miticides to Natural Enemies and Pollinators

[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 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.

[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 increase in spider mite numbers.

[8] Acute toxicity low but reproductive capacity is impacted.

[9] Rating depends on rate used.

[10] Kills lady beetles.

[11] Toxic against some natural enemies (predatory thrips, syrphid fly and lacewing larvae, beetles) when sprayed and up to 5 to 7 days after, especially for Dipteran predators such as syrphid flies).

[12] Residual is moderate if solution is between pH of 7 to 8.

Acknowledgments: 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 (6/16)

Scientific name: Western yellowstriped armyworm: *Spodoptera praefica*
Yellowstriped armyworm: *S. ornithogalli*

DESCRIPTION OF THE PEST

Western yellowstriped armyworm

Adult moths of the western yellowstriped armyworm are difficult to distinguish from other nocturnal moths. 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 foliage feeders, 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. Young armyworms skeletonize leaves; older larvae chew holes. Problems caused by the western yellowstriped armyworm may occur if peppers are planted near alfalfa or bean fields. The 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 they are feeding on the crop. Keep crop residue and weeds in field and surrounding areas to a minimum to lessen the attraction of the field.

Armyworms migrating into a field can be deterred by digging a trench or by a strip treatment of an insecticide on the perimeter 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.

Cultural Control

A deep trench can be plowed around the edges of the field with the steep side toward the peppers. This will often prevent movement of armyworm larvae into the crop.

Organically Acceptable Methods

Cultural controls and sprays of *Bacillus thuringiensis* or the Entrust formulation of spinosad are acceptable for use on an organically certified crop.

Monitoring and Treatment Decisions

If larvae are migrating to peppers from nearby fields and a trench can not be dug, treatment may be warranted. Treating only the field border may be effective.

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

UPDATED 6/16

Not all registered pesticides are listed. 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. Always read the label of the product being used.

A.	CHLORANTRANILIPROLE			
	(Coragen)	3.5–5.0 fl oz	4	1
	MODE-OF-ACTION GROUP NUMBER[1]: 28			
B.	CYANTRANILIPROLE			
	(Exirel - foliar)	7–13.5 fl oz	12	1
	(Verimark - soil)	5–10 fl oz	4	1
	MODE-OF-ACTION GROUP NUMBER[1]: 28			
	COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
C.	CHLORANTRANILIPROLE/LAMBDA-CYHALOTHRIN			
	(Voliam Xpress)*	6.0–9.0 fl oz	24	5
	MODE-OF-ACTION GROUP NUMBER[1]: 28/3A			
D.	CHLORANTRANILIPROLE/THIAMETHOXAM			
	(Voliam Flexi)	4.0–7.0 oz	12	1
	MODE-OF-ACTION GROUP NUMBER[1]: 28/4A			
	COMMENTS: Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.			
E.	INDOXACARB			
	(Avaunt)	3.5 oz	12	3
	MODE-OF-ACTION GROUP NUMBER[1]: 22A			
	COMMENTS: Minimum interval between sprays is 5 days. Do not apply more than 14 oz/acre per crop. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
F.	METHOXYFENOZIDE			
	(Intrepid 2F)	Label rates	4	1
	MODE-OF-ACTION GROUP NUMBER[1]: 18			
	COMMENTS: An insect growth regulator. Apply at the beginning of egg hatch. Pheromone traps can be used to detect moth flight. When traps indicate a flight is occurring, monitor plants for eggs and spray when they appear. Do not apply more than 16 fl oz/acre per application or 64 fl oz/acre per season.			
G.	*BACILLUS THURINGIENSIS* ssp. *AIZAWAI*#			
	(various products)	Label rates	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: 11A			
	COMMENTS: *Bacillus thuringiensis* preparations must be consumed by the larva to be effective. Coverage is critical for controlling this pest, especially between and under leaves and where leaves touch the fruit.			
H.	CRYOLITE			
	(Kryocide)	8–12 lb	12	14
	MODE-OF-ACTION GROUP NUMBER[1]: un			

** See label for dilution rates.

‡ 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

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

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.

BEET ARMYWORM (6/16)

Scientific name: *Spodoptera exigua*

DESCRIPTION OF THE PEST

Adult beet armyworms are small, mottled-gray or dusky-winged moths. Females lay eggs in clusters on leaves; the clusters are covered with fluffy, dirty white scales. Eggs hatch in a few days and tiny caterpillars begin feeding while still clustered together on the plant. In 2 to 3 weeks beet armyworm larvae are full grown and about 1 inch long. The body is smooth with few hairs and predominantly green with mottled dark lines along the back. Just above the spiracle, lengthwise along the body, is a dark green to black line edged on each side with white. There is usually a small dark spot above the spiracle on the second pair of true legs.

In addition to peppers, beet armyworm feeds on sugarbeet, alfalfa, beans, tomatoes, and a variety of weeds such as lambsquarters, redroot pigweed, and nettleleaf goosefoot. During winter and spring, the population is concentrated on weeds, but in late spring moths begin laying eggs in the pepper field when the plants are young. Newly hatched larvae feed together near the egg cluster and gradually disperse as they grow; they skeletonize leaves and may spin a loose webbing over the feeding site. Older larvae chew irregular holes in leaves and feed on young fruit.

DAMAGE

Beet armyworm is a serious pest of peppers. It feeds on both leaves and fruit. As the fruit forms, beet armyworm bores into the calyx end. Both defoliation and fruit loss result from the feeding. Unlike many caterpillar pests, the feeding is quite messy, with webbing and excrement present.

MANAGEMENT

Regular monitoring of the leaves and fruit is important in detecting an infestation of beet armyworms. Treatments may be necessary if fruit damage is occurring.

Biological Control

Many natural enemies attack beet armyworms. Among the most common parasites are the wasps *Hyposoter exiguae* and *Chelonus insularis*, and the tachinid fly *Lespesia archippivora*. Viral diseases may also be important; however, none of these organisms provide reliable control of armyworms when they feed on the fruit.

Organically Acceptable Methods

Biological control and sprays of *Bacillus thuringiensis* or the Entrust formulation of spinosad are acceptable for use on an organically certified crop.

Monitoring and Treatment Decisions

Sampling guidelines for beet armyworm in peppers have not been developed. Pheromone traps are useful for determining when major flights occur but not for predicting damage. Look for the cream-colored egg mass or, later, for the feeding on the seedlings and leaves to determine if beet armyworms are present. Also, sample fruit when it first appears. A 5-minute timed search is useful in determining the need for treatment. On average, if one or more larvae or egg masses are found in 5 minutes, treatments may be justified. Ground applications provide maximum effectiveness of the pesticide. Treat if beet armyworms are on the fruit.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
Not all registered pesticides are listed. 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. Always read the label of the product being used.			
A. INDOXACARB (Avaunt) MODE-OF-ACTION GROUP NUMBER[1]: 22A	3.5 oz	12	3

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
COMMENTS: Minimum interval between sprays is 5 days. Do not apply more than 14 oz/acre per crop. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
B. CHLORANTRANILIPROLE			
(Coragen)	3.5–5.0 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 28			
COMMENTS: Can be applied both through the drip line and by foliar spray.			
C. CYANTRANILIPROLE			
(Exirel –foliar)	7–13.5 fl oz	12	1
(Verimark –soil)	5–10 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 28			
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
D. CHLORANTRANILIPROLE/LAMBDA-CYHALOTHRIN			
(Voliam Xpress)*	6.0–9.0 fl oz	24	5
MODE-OF-ACTION GROUP NUMBER[1]: 28/3A			
E. CHLORANTRANILIPROLE/THIAMETHOXAM			
(Voliam Flexi)	4.0–7.0 oz	12	1
MODE-OF-ACTION GROUP NUMBER[1]: 28/4A			
COMMENTS: Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.			
F. METHOXYFENOZIDE			
(Intrepid 2F)	Label rates	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 18			
COMMENTS: Do not apply more than 16 fl oz/acre per application or 64 fl oz/acre per season.			
G. SPINETORAM			
(Radiant SC)	5–10 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Is more efficacious and has longer residual activity than spinosad. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
H. SPINOSAD			
(Entrust)#	1.25–2.5 oz	4	1
(Success)	4–8 oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Use higher rate for larger worms and heavy infestations. Best control is achieved when aimed at newly hatched larvae and coverage is thorough. Can remain toxic to larval stages (especially syrphid fly) for 5 to 7 days after treatment. Do not exceed 29 fl oz of Success or 9 oz of Entrust/acre per crop. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
I. *BACILLUS THURINGIENSIS* ssp. *AIZAWAI*#			
(various products)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 11A			
COMMENTS: Must be consumed by the larva to be effective. Coverage is critical for controlling this pest, especially between and under leaves and where leaves touch the fruit. Control is most effective against newly hatched worms.			
J. METHOMYL*			
(Lannate SP)	0.5–1 lb	48	3
(Lannate LV)	1.5–3 pt	48	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Do not use if psyllids are present. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
K. ESFENVALERATE			
(Asana XL)*	5.8–9.6 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 3A			

	Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
	COMMENTS: Do not exceed 0.35 lb a.i./acre per season. If leafminers are present in the pepper crop, use of this product should be limited to late in the season to minimize negative impacts on biological control. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
L.	CRYOLITE (Kryocide) MODE-OF-ACTION GROUP NUMBER[1]: un	8–12 lb	12	14

** See label for dilution rates.

‡ 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.

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 (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.

FLEA BEETLES (6/16)

Scientific names: Palestriped flea beetle: *Systena blanda*
Potato flea beetle: *Epitrix cucumeris*
Western potato flea beetle: *Epitrix subcrinita*
Striped flea beetle: *Phyllotreta striolata*
Western black flea beetle: *Phyllotreta pusilla*
Western striped flea beetle: *Phyllotreta ramosa*
...and other species

DESCRIPTION OF THE PESTS

Flea beetle adults are small (about 0.125 inch long), shiny, hard beetles with enlarged hind legs that allow them to jump. Different species (e.g. palestriped flea beetle and potato flea beetle) vary in color and markings. Larvae live primarily in the soil, although larvae in a few of the species may mine leaves or plant stems. Larvae are pale yellow to white with short legs and dark, hard heads. Older larvae may resemble small wireworms.

DAMAGE

Adult flea beetles feed on the undersides of leaves leaving small pits or irregularly shaped holes on the leaves. Large populations can kill or stunt seedlings. Older plants rarely suffer economic damage, although their older, lower leaves may be damaged. Adults do most of the damage. Most flea beetle larvae feed on roots, but this activity is not usually of economic concern in peppers.

MANAGEMENT

Flea beetles are common seedling pests, and monitoring newly emerged seedlings is critical for detecting a damaging population. Weed control around the field and using transplants also help to minimize damage by these pests.

Cultural Control

Remove weeds along field margins and deeply disc plant residue in infested fields after harvest. Pay particular attention to cruciferous (Brassicaceae) weeds and crops such as canola, which are common hosts from which beetles can migrate into pepper fields. Transplanting peppers usually avoids the problem unless beetle populations are extremely high.

Organically Acceptable Methods

Cultural controls and sprays of pyrethrin are acceptable for use on organically certified produce.

Monitoring and Treatment Decisions

Check newly emerged seedlings or recently planted transplants for flea beetle damage at least twice weekly until plants are well established. Relatively low populations can cause economic damage when plants are in the cotyledon or first-leaf stages. Once plants have five leaves they can tolerate several beetles per plant without damage. Older plants are even more tolerant. Seedling pepper plants and young transplants do not tolerate flea beetle damage well, and they may be killed if the weather is especially hot, dry, and windy. Damage is generally greater to seedlings than to transplants.

Monitor for flea beetles soon after transplanting or after plants emerge. Treat for flea beetles when small holes show on seedlings or on new transplants. The percentage of plants affected and forecast weather conditions will indicate the need to treat. Once established, plants can overcome moderate flea beetle feeding. If flea beetles are migrating to the pepper field, spot treatment of outside rows or borders may be sufficient. Baits are not effective. One insecticide treatment is usually all that is required.

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

UPDATED 6/16

Not all registered pesticides are listed. 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

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
management, and the pesticide's properties and application timing. Always read the label of the product being used.			
A. ESFENVALERATE (Asana XL)*	5.8–9.6 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Do not exceed 0.35 lb a.i./acre per season. Do not use this product if leafminers are present; it is destructive of their parasites. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
B. DINOTEFURAN (Venom)	1–4 oz (foliar); 5–6 oz (soil)	12	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: Preharvest interval for foliar application is one day; for soil applications it is 21 days. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging. Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.			
C. PERMETHRIN (Pounce 25WP)*	6.4–12.8 oz	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: For use on bell peppers only. Do not apply more than 1.6 lb a.i./acre per season. Do not use this product if leafminers are present; it is destructive of their parasites. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
D. CARBARYL* (Sevin 4F or XLR Plus)	0.5–1 qt	12	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A COMMENTS: Thorough coverage is important. Do not use if psyllids are present. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
E. BIFENTHRIN (Brigade 2EC)	2.1–6.4 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
F. PYRETHRIN# (PyGanic EC 1.4)	16 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Begin applications when insects first appear; do not wait until the plants are heavily infested. Apply in sufficient water for thorough coverage of the plants. Apply at intervals of 7 days or less. Repeat as necessary to maintain control.			

** See label for dilution rates.

‡ 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.

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.

GREEN PEACH APHID (6/16)

Scientific name: *Myzus persicae*

DESCRIPTION OF THE PEST

Green peach aphid is among the most common aphid species found on peppers. It may be present at any time throughout the year but is most common from March through May and September through November. Generally its color is pale green, although at times individuals may be present that are pinkish. During cool weather, individuals are usually more deeply pigmented. Both winged and wingless forms of the green peach aphid have prominent cornicles on the abdomen that are markedly swollen and clublike in appearance. The frontal tubercles at the base of the antennae are very prominent and are convergent. Winged forms of the green peach aphid have a distinct dark patch near the tip of the abdomen; wingless forms lack this dark patch.

DAMAGE

The green peach aphid transmits a number of destructive viruses in pepper including pepper potyviruses and cucumber mosaic cucumovirus. In addition, it can also damage the plant by sucking plant sap. Damaging levels are characterized by large numbers of aphids found on the underside of leaves. Extensive feeding causes plants to turn yellow and the leaves to curl downward and inward from the edges. Honeydew produced by the aphids can be a problem, especially on fresh market peppers. Aphid damage is most prominent on newer, younger leaves in the center of the plant.

MANAGEMENT

Biological and cultural controls can be useful for limiting damage from this aphid. For instance, removing old crop debris from the field will reduce sources of virus and thereby its transmission by aphids, and using reflective mulches early in the season will repel aphids from young plants. Heavy infestations on seedling and young plants may require treatment with insecticides.

Biological Control

The green peach aphid is attacked by a number of common predators, including lacewings, lady beetles, syrphid flies, and parasites, including the parasitic wasps *Lysiphlebus testaceipes*, *Aphidius matricariae, Aphelinus semiflavus*, and *Diaeretiella rapae*, and is susceptible to the fungus disease, *Entomophthora* spp., that commonly attacks aphids. Aphid sampling should always include an evaluation of the presence and activity of natural enemies.

Cultural Control

An important factor in reducing virus spread is good field sanitation, especially the chopping or discing of crop debris immediately after harvest and destruction of alternate host plants. While field sanitation helps control the incidence and spread of viruses transmitted by green peach aphid, it does little to control the aphid itself. The spread of the virus within a geographical area can be reduced by not planting peppers near other pepper fields.

If peppers are planted near large areas of rangeland, it may not be possible to prevent the influx of green peach aphid. Studies have shown, however, that aluminum foil or silver reflective plastic mulches can be effective in repelling aphids from plants.

Organically Acceptable Methods

Biological and cultural controls and sprays of insecticidal soap or pyrethrin are acceptable for use on organically certified crops.

Monitoring and Treatment Decisions

Set out sticky traps before planting and check traps weekly for green peach aphids, along with thrips, tomato psyllid, and whiteflies. Be sure to replace traps as needed. When aphids are observed on traps, start monitoring pepper plants to determine population levels. Treatment thresholds for green peach aphid are not well established. Heavy populations can do extensive damage, particularly on seedlings or young plants. If seedlings or young plants show signs of stress because of aphid feeding, consider an insecticide application. If green peach aphids have been a problem in the past, apply imidacloprid at planting.

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

UPDATED 6/16

Not all registered pesticides are listed. 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. Always read the label of the product being used.

A. PYMETROZINE
(Fulfill) 2.75 oz 12 0
MODE-OF-ACTION GROUP NUMBER[1]: 9B
COMMENTS: Can be applied either by soil or drip applications.

B SPIROTETRAMAT
(Movento) 4.0–5.0 fl oz 24 1
MODE-OF-ACTION GROUP NUMBER[1]: 23

C. IMIDACLOPRID
(Admire Pro –soil) 7–14 fl oz 12 21
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Apply as a soil application according to label directions. Do not apply to vegetables grown for seeds. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

D. IMIDACLOPRID
(Admire Pro –foliar) 1.3–2.2 fl oz 12 0
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Apply as a foliar application according to label directions. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

E. THIAMETHOXAM
(Actara) 2.0–3.0 oz 12 0
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Do not exceed 0.172 lb a.i./acre per season. Thorough coverage is important. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

F. ACETAMIPRID
(Assail 70WP) 0.8–1.7 oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Do not make more than four applications per season or exceed 0.3 lb a.i./acre per season. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

G. DIMETHOATE
(Dimethoate 400) 0.5–0.6 pt 48 0
(Dimethoate E267) 0.75–1 pt 48 0
MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
H. METHOMYL* (Lannate SP)	0.5–1 lb	48	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Apply in sufficient water (5–15 gal/acre by air) to obtain thorough coverage. Apply at 5- to 7-day intervals or as needed. Do not use if psyllids are present. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
I. FLONICAMID (Beleaf 50SG)	2.8–4.28 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 9C			
J. PYRETHRIN# (PyGanic 1.4EC)	16 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: Begin applications when insects first appear; do not wait until the plants are heavily infested. Apply by ground sprayer in sufficient water for thorough coverage of the plants. Apply at intervals of 7 days or less. Repeat as necessary to maintain control.			
K. INSECTICIDAL SOAP# (M-Pede)	2.5 oz/gal water	12	0
MODE OF ACTION: A contact fungicide with smothering and barrier effects.			
COMMENTS: Only gives partial control (about 50%) and may cause phytotoxicity. Apply when aphids first appear or when damage first occurs. Spray to wet all infested plant surfaces. Repeat at weekly to biweekly intervals. Rotate sprays or rinse foliage to avoid more than three consecutive sprays.			

** See label for dilution rates.

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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.

LEAFMINER (6/16)

Scientific name: *Liriomyza trifolii*

DESCRIPTION OF THE PEST

Liriomyzid leafminer adults are small, shiny black flies with a bright yellow triangular spot on the upper thorax. Eggs are white and oval and laid within the leaf. Larvae feed between leaf surfaces, creating meandering tracks or mines. Mature larvae leave the mine and drop to the ground to pupate. The life cycle takes only 2 weeks in warm weather; there can be many generations a year.

DAMAGE

Larvae mine between upper and lower leaf surfaces, creating winding, whitish tunnels that are initially narrow, but then widen as the larvae grow. Leaves injured by leafminers drop prematurely; heavily infested plants may lose most of their leaves.

MANAGEMENT

Leafminers are rarely a problem in the Imperial Valley. In other areas, regular monitoring for leaf mines is important in detecting damaging populations of this pest. Avoid the use of early-season applications of broad-spectrum insecticides (dimethoate, esfenvalerate, methomyl) for control of other pests, in order to conserve natural enemies of the leafminer.

Biological Control

Natural enemies, primarily parasitic wasps in the *Diglyphus* genus, often control leafminers. When parasites are killed by pesticides, leafminer outbreaks are common.

Organically Acceptable Methods

Biological control and sprays of azadirachtin and the Entrust formulation of spinosad are acceptable for use on organically certified produce.

Monitoring and Treatment Decisions

Regularly check leaves for leaf mines, especially between bloom and fruit development. Most mines occur on older bottom leaves and some mines are most obvious from the underside of the leaf. Also look for dead larvae, which is a sign of parasitism. If parasitism levels are at least 50%, the crop will most likely tolerate damage. However, if leafminer populations build up to high levels, a chemical treatment may be necessary. Avoid early-season applications of broad-spectrum insecticides for other insects, because they may cause leafminer outbreaks to occur.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
Not all registered pesticides are listed. 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. 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: Do not apply at less than 7-day interval. Do not exceed 48 fl oz/acre per growing season. Do not apply in less than 20 gal water/acre. Do not make more than two sequential applications. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
B. SPINETORAM (Radiant SC)	6–10 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Is more efficacious and has longer residual activity than spinosad. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
C. SPINOSAD			
(Entrust)#	2–3 oz	4	1
(Success)	6–10 oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Best control is achieved when aimed at newly hatched larvae and coverage is thorough. Can remain toxic to larval stages (especially syrphid fly) for 5 to 7 days after insecticide application. Do not exceed 29 fl oz of Success or 9 oz of Entrust/acre per crop. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
D. CYROMAZINE			
(Trigard WP)	2.66 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 17			
COMMENTS: Do not make more than two sequential applications.			
E. AZADIRACHTIN#			
(Neemix 4.5)	4.0–7.0 fl oz	4	0
MODE-OF-ACTION GROUP NUMBER[1]: un			
COMMENTS: Must be consumed by larvae; kills leafminer after pupation. A regulated product in an organically certified crop.			

** See label for dilution rates.

‡ 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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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 (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.

OMNIVOROUS LEAFROLLER (6/16)

Scientific name: *Platynota stultana*

DESCRIPTION OF THE PEST

Omnivorous leafroller adults are small brown moths, about 0.4 inch (10 mm) long, with a snoutlike projection (palpae) that protrudes forward from the head. The portion of the wings nearest the body is a dark rusty brown color; the outer half is light tan. A small rusty brown spot occurs on the front edge of the wing. When at rest, the wings form a bell-shaped pattern. Females lay the small, elliptical eggs in clusters on the smooth surfaces of leaves and stems, overlapping them like fish scales. At hatching, larvae are about 0.06 inch (1.5 mm) long and white with light tan head capsules and thoracic shields. Middle instars are cream-colored and possess dark heads. Mature larvae are about 0.5 inch (12 mm) long and vary in color from cream to a dark brownish green depending on their diet. They have few setae (bristlelike hairs) scattered over the body and possess whitish oval spots along either side of a dark line running down the middle of the dorsum. The head capsule and thoracic shield of mature larvae is brown. When disturbed, larvae retreat into their nests or wiggle vigorously and drop to the ground on a silk thread.

DAMAGE

This insect feeds on a wide variety of weeds and crops. The larvae build a nest by tying leaves together with silk webbing and remain inside this nest while feeding on the surface of the leaves. When leaves lie over a fruit, or if two fruit are touching, the larva will nest between the surfaces and feed on the fruit, causing substantial scarring. Larvae do not burrow into the fruit.

MANAGEMENT

Regular field monitoring will help to detect potential problems with this pest. Weed control and site location play an important role in preventing infestations of omnivorous leafroller. Treatments may occasionally be necessary.

Cultural Control

Early weed control in the area can help to reduce the population; however, the moths can fly for several miles. Avoid planting peppers near alfalfa or sugarbeet as these are good hosts.

Organically Acceptable Methods

Cultural controls and sprays of *Bacillus thuringiensis* or the Entrust formulation of spinosad are acceptable for used on organically certified produce.

Monitoring and Treatment Decisions

Inspect plants periodically during the growing season in several areas of the field for signs of leaves webbed together. Pay particular attention to weedy areas or locations near other susceptible crops. If nearby alfalfa or sugarbeet fields have been harvested, increase the intensity of the inspection. However, no treatment thresholds have been established.

Good coverage with the spray is critical for control because the larvae are difficult to reach within the folded leaves.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
Not all registered pesticides are listed. 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. Always read the label of the product being used.			
A. METHOXYFENOZIDE (Intrepid 2F) MODE-OF-ACTION GROUP NUMBER[1]: 18	Label rates	4	1

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
COMMENTS: An insect growth regulator. Apply at the beginning of egg hatch. Pheromone traps can be used to detect moth flight. When traps indicate a flight is occurring, monitor plants for eggs and spray when they appear. Do not apply more than 16 fl oz/acre per application or 64 fl oz/acre per season.			
B. SPINETORAM			
(Radiant SC)	5–10 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Is more efficacious and has longer residual activity than spinosad. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
C. SPINOSAD			
(Entrust)#	1.25–2.5 oz	4	1
(Success)	4–8 oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Use higher rate for larger worms and heavy infestations. Best control is achieved when aimed at newly hatched larvae and coverage is thorough. Can remain toxic to larval stages (especially syrphid fly) for 5 to 7 days after insecticide application. Do not exceed 29 fl oz of Success or 9 oz of Entrust/acre per crop. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
D. *BACILLUS THURINGIENSIS* ssp. *AIZAWAI*#			
(various products)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 11A			
COMMENTS: Must be consumed by the larva to be effective. Coverage is critical for controlling this pest, especially between and under leaves and where leaves touch the fruit. Control is most effective against newly hatched worms.			
E. METHOMYL*			
(Lannate SP)	0.25–0.5 lb	48	3
(Lannate LV)	0.75–1.5 pt	48	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Do not use if psyllids are present. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
F. ESFENVALERATE			
(Asana XL)*	5.8–9.6 fl oz.	12	7
MODE-OF-ACTION GROUP NUMBER[1]: 3A			
COMMENTS: If leafminers are present in the pepper crop, use of this product should be limited to late in the season to minimize negative impacts on biological control. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
G. CRYOLITE			
(Kryocide)	8–12 lb	12	14
MODE-OF-ACTION GROUP NUMBER[1]: un			

** See label for dilution rates.

‡ 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.

\# 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 (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.

PEPPER WEEVIL (6/16)

Scientific name *Anthonomus eugenii*

DESCRIPTION OF THE PEST

The pepper weevil is a common pest in southern California where it can migrate in from areas with warm winters or survive year-round in years when winters are mild. The adult pepper weevil is a small beetle, about 1/8 inch (3 mm) long, with a dark body that has a brassy luster to it. Larvae are off-white grubs with a brown head and are about 1/4 inch (6 mm) when mature.

Adult females lay eggs in holes they create in pepper buds or in the base of young pepper pods. Larvae develop and feed inside on the seed core or tissue of the pod wall. The pepper weevil has three larval instars and larval development requires 2 to 3 weeks. Pupation occurs within the pepper pod and requires 3-6 days. There are multiple generations a year. Peppers are the primary host, but feeding also occurs on nightshades, especially silverleaf nightshade, *Solanum elaeagnifolium*.

DAMAGE

Adult weevils feed on fruit and leaf buds. Larvae feed inside the pods and cause young fruit to drop prematurely, reducing yields. Larger fruit often do not drop when infested, resulting in crop contamination.

MANAGEMENT

Pepper weevils can be managed with field sanitation and crop rotation, which is critical in managing this pest. Monitor with pheromone-baited sticky traps to determine the need to treat.

Biological Control

Parasitic wasps have been observed on the weevil larvae, but their impact in controlling this pest appears to be minimal.

Cultural Control

- Inspect pepper transplants to make sure they aren't infested, and remove nightshade plants from the pepper field and its margins.
- During fruit development and at harvest, remove culled or dropped fruit from the field.
- Immediately following harvest, remove and destroy fruit from the field and the surrounding areas. Shred and disc pepper plant residue.
- If pepper weevil is a problem, rotate to another crop next season. Pepper weevils only develop on solanaceous plants, so avoid rotating to crops like tomato and eggplant, and control solanaceaous weeds.

Organically Acceptable Methods

Cultural controls and sprays of pyrethrin are acceptable for use on organically certified produce.

Monitoring and Treatment Decisions

As recommended by University of Florida research, estimate adult pepper weevil numbers with pheromone-baited yellow sticky traps and by visual examination. Pheromone-baited yellow sticky traps may also be useful in early detection.

Prior to bloom, place traps in the field to detect first adult emergence, and on the perimeter of the field to detect migration into the field. Mount traps on poles that can be adjusted during crop growth to ensure that the bottom of the traps are just at or slightly below the tops of the plants. Check traps twice a week in the morning or more frequently if adults are known to be present. Apply treatments when the first adult is captured.

Alternatively, the terminal buds can also be used to determine the treatment threshold. Check two terminal vegetative buds per plant for adults and treat when one or more adults are found per 400 buds.

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

UPDATED 6/16

Not all registered pesticides are listed. 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. Always read the label of the product being used.

A. ESFENVALERATE
(Asana XL)* — 5.8–9.6 fl oz — 12 — 7
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Do not exceed 0.35 lb a.i./acre per season. Can cause leafminer outbreaks to occur by reducing natural enemies such as parasitic wasps. If leafminers are present in the pepper crop, use of this product should be limited to late in the season to minimize negative impacts on biological control. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

B. CARBARYL*
(Sevin 4F or XLR Plus) — 0.5–1 qt — 12 — 3
MODE-OF-ACTION GROUP NUMBER[1]: 1A
COMMENTS: Thorough coverage is important. Do not use when psyllids are present. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

C. BIFENTHRIN
(Brigade 2EC) — 2.1–6.4 fl oz — 12 — 7
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

D. PERMETHRIN
(Pounce 25WP)* — 6.4–12.8 oz — 12 — 3
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: For use on bell peppers only. Do not apply more than 0.8 lb a.i./acre per season. Only use this product late in season if leafminers are present; it is destructive of their parasites.

E. PYRETHRIN#
(PyGanic EC 1.4) — 16 oz — 12 — 0
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Begin applications when insects first appear; do not wait until the plants are heavily infested. Apply in sufficient water for thorough coverage of the plants. Apply at intervals of 7 days or less. Repeat as necessary to maintain control. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

** See label for dilution rates.

‡ 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.

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.

THRIPS (6/16)

Scientific names: Western flower thrips: *Frankliniella occidentalis*
Onion thrips: *Thrips tabaci*
...and other species

DESCRIPTION OF THE PESTS

Thrips are very small, slender insects that are best seen with a hand lens. Mature western flower thrips are 0.06 inch (1.5 mm) long, while onion thrips are slightly smaller at 0.05 inch (1.3 mm) long. The most distinctive characteristic of thrips is two pairs of wings that are fringed with long hairs. Adults are pale yellow to light brown in color. Immature stages have the same body shape as adults but are lighter in color and are wingless. Western flower thrips adults have red-colored pigment in their simple eyes (ocelli) while onion thrips' simple eyes are gray.

Thrips have a very extensive host range, including cereals, onions, garlic, and broadleaved crops, but it is only the species of plants that are infected by *Tomato spotted wilt virus* and on which the thrips can complete their entire life cycle that play an important role in the disease cycle. In California, the key crop hosts include tomato, pepper, lettuce, radicchio and fava bean. Important weed hosts include little mallow (*Malva parviflora*), sowthistle (*Sonchus oleraceus)*, and prickly lettuce (*Lactuca serriola*).

The adults are the only life stage that can fly, but they are not strong fliers. Adult thrips can be carried on wind currents, on clothing, and in association with plants. The length of the thrips life cycle (from egg to adult) varies depending on environmental conditions, but is generally 30-45 days, though it can be as little as 14 days.

DAMAGE

The primary damage caused by thrips to peppers is the vectoring of *Tomato spotted wilt virus*. The virus can only be acquired by the immature stage of thrips, whereas plant-to-plant transmission primarily occurs by adults. The adult thrips can transmit the virus for the remainder of their lives, which can last 30 to 45 days. However, the adults do not pass the virus to their progeny through the egg.

High populations of thrips can cause damage with their feeding, which distorts plant growth, deforms flowers, and causes white-to-silvery patches on emerging leaves that often have tiny black fecal specks in them.

MANAGEMENT

If possible, avoid planting peppers next to onions, garlic, or cereals, because thrips often build up to large numbers on these crops. Also, avoid fields near greenhouses where ornamentals (cut flowers) are grown, as these plants serve as hosts for thrips and the virus they transmit.

Use reflective mulches early in the season to repel thrips. Put up yellow sticky traps, which are also useful for monitoring aphids, whiteflies, and tomato psyllid, and monitor the movement of thrips.

Insecticide treatments for thrips are usually not warranted in the Imperial Valley but may be needed for suppression of *Tomato spotted wilt virus* in the San Joaquin Valley and coastal growing areas. If thrips are present, treat seedlings and transplants with imidacloprid (treat transplants before placement in the field and at planting). Treating plants with foliar insecticide sprays throughout the season on a need basis may limit in-field spread of *Tomato spotted wilt virus* to some extent. Rotate classes of insecticides to minimize insecticide resistance in thrips.

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
Not all registered pesticides are listed. 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. Always read the label of the product being used.			
A. IMIDACLOPRID			

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
(Admire Pro –foliar)	1.3–2.2 fl oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Spray transplants 3 to 7 days before placing in field. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.			
B. IMIDACLOPRID			
(Admire Pro –soil)	7–14 fl oz	12	21
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Apply through drip at planting or as a band on the surface of the bed. Effective for up to 6 weeks and does not substantially affect natural enemies. Combine with an insectcide application before transplanting, because it takes about a week for the plant to take up the insecticide. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.			
C. SPINETORAM			
(Radiant SC)	6–10 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
D. SPINOSAD			
(Entrust)#	1.25–2.5 oz	4	1
(Success)	4–8 oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 5			
COMMENTS: Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
E. METHOMYL*			
(Lannate SP)	0.25–0.5 lb	48	3
(Lannate LV)	0.75–1.5 pt	48	3
MODE-OF-ACTION GROUP NUMBER[1]: 1A			
COMMENTS: Do not use if psyllids are present. Efficacy increases when combined with a pyrethroid such as zeta-cypermethrin (Mustang). Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
F. SPIROTETRAMAT			
(Movento)	4.0–5.0 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER[1]: 23			
G. DIMETHOATE			
(Dimethoate 400)	0.5–0.6 pt	48	0
(Dimethoate E267)	0.75–1 pt	48	0
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Do not use if psyllids are present. Efficacy increases when combined with a pyrethroid such as zeta-cypermethrin (Mustang). Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
H. FLONICAMID			
(Beleaf 50SG)	2.8–4.28 oz	12	0
MODE-OF-ACTION GROUP NUMBER[1]: 9C			

** See label for dilution rates.

‡ 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.

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

UPDATED 6/16

\# 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.

TOMATO FRUITWORM (6/16)

Scientific name *Helicoverpa (=Heliothis) zea*

DESCRIPTION OF THE PEST

Tomato fruitworm adults are medium-sized moths with a wing span of about 1 to 1.3 inch (25-35 mm). They are pale tan to medium brown, or sometimes have a slight greenish tinge. The front wings are variously marked and usually have an obscure dark spot in the center and a lighter band inside a dark band around the tip. The hind wings are drab white and have a dark gray band around their tip. A diffuse light spot is in the center of the dark band.

At hatching, tomato fruitworm larvae are creamy white caterpillars with a black head and conspicuous black tubercles and hairs. Larger larvae vary in color from yellowish green to nearly black and develop fine white lines along the body but retain the black spots at the base of bristlelike hairs. Older larvae also have patches of stubby spines on their body segments that are much shorter than the bristles and can be seen best with the use of a hand lens.

Eggs are tiny, hemispherical, and slightly flattened on top with coarse striations or ribs running from base to tip. They are easy to confuse with looper eggs, but looper eggs have fine striations. Fruitworm eggs are laid singly on both upper and lower surfaces of the leaves usually in the upper part of the plant. When first laid they are creamy white, but develop a reddish brown ring after 24 hours.

DAMAGE

Soon after hatching, the larvae burrow into the fruit, usually near the calyx, and remain inside, feeding on the flesh. Infested fruit decay, turn red, and fall off the plant early, reducing yield. Larvae consume very little foliage.

MANAGEMENT

Regular monitoring of pepper fields is important in detecting and managing this pest. Weed control, site location, and biological control are important in reducing the potential for damage. Insecticide treatment may be necessary when monitoring indicates a need.

Cultural Control

These insects have a wide host range. Weed control in the area can help to reduce the population; however, the moths can fly great distances. Avoid planting peppers near field corn or garbanzo beans.

Biological Control

Tomato fruitworm eggs can be heavily parasitized by *Trichogramma pretiosum*. Experimental releases of *Trichogramma* have resulted in control of fruitworm on pole tomatoes. Parasitized eggs are completely black. When any eggs are found they should be held in vials for several days to determine the level of parasitism. The parasitic wasp, *Hyposoter exiguae*, attacks fruitworm larvae and can reduce fruitworm populations considerably; however, often the worm will die inside the fruit and the parasite cocoon remains in the fruit as a contaminant.

Organically Acceptable Methods

Cultural and biological control and sprays of *Bacillus thuringiensis* or the Entrust formulation of spinosad are acceptable for use in an organically certified crop.

Monitoring and Treatment Decisions

Start monitoring for tomato fruitworm at the seedling stage and continue through harvest. Inspect the upper part of the plants for fruitworm eggs. Examine the eggs closely with a hand lens to determine the stage of development of the larvae and check for parasitism. If necessary, treat within 2 to 3 days after the head capsule has formed. There are no treatment thresholds.

Timing of sprays is critical because the worms enter the fruit shortly after hatching and are thus susceptible to the pesticide for only a brief period. In peppers grown for fresh market consumption and where fruit aesthetics are paramount, treatments may be needed when egg laying is documented.

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

UPDATED 6/16

Not all registered pesticides are listed. 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. Always read the label of the product being used.

A. SPINETORAM
(Radiant SC) 5–10 fl oz 4 1
MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

B. SPINOSAD
(Entrust)# 1–2 oz 4 1
(Success) 3–6 oz 4 1
MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: Use higher rate for larger worms and heavy infestations. Best control is achieved when aimed at newly hatched larvae and coverage is thorough. More broad-spectrum than *Bacillus thuringiensis* but has very low toxicity to humans, vertebrates, and the adults of many natural enemies. Can remain toxic to larval stages (especially syrphid fly) for 5 to 7 days after insecticide application. Do not exceed 29 fl oz of Success or 9 oz of Entrust/acre per crop. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

C. METHOXYFENOZIDE
(Intrepid 2F) 10–16 fl oz 4 1
MODE-OF-ACTION GROUP NUMBER[1]: 18
COMMENTS: An insect growth regulator. Apply at the beginning of egg hatch. Pheromone traps can be used to detect moth flight. When traps indicate a flight is occurring, monitor plants for eggs and spray when they appear. Do not apply more than 16 fl oz/acre per application or 64 fl oz/acre per season.

D. CYANTRANILIPROLE
(Exirel –foliar) 7–13.5 fl oz 12 1
(Verimark –soil) 5–10 fl oz 4 1
MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

E. CHLORANTRANILIPROLE/LAMBDA-CYHALOTHRIN
(Voliam Xpress)* 6.0–9.0 fl oz 24 5
MODE-OF-ACTION GROUP NUMBER[1]: 28/3A

F. CHLORANTRANILIPROLE/THIAMETHOXAM
(Voliam Flexi) 4.0–7.0 oz 12 1
MODE-OF-ACTION GROUP NUMBER[1]: 28/4A
COMMENTS:
Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

G. CHLORANTRANILIPROLE
(Coragen) 3.5–5.0 fl oz 4 1
MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: May be applied as either a foliar spray or via drip irrigation.

H. *BACILLUS THURINGIENSIS* ssp. *KURSTAKI*#
(various products) Label rates 4 0
MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: Must be consumed by the larva to be effective. Coverage is critical for controlling this pest, especially between and under leaves and where leaves touch the fruit.

I. INDOXACARB
(Avaunt) 3.5 oz 12 3

	Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16				
	MODE-OF-ACTION GROUP NUMBER[1]: 22A COMMENTS: Minimum interval between sprays is 5 days. Do not apply more than 14 oz/acre per crop. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
J.	ESFENVALERATE			
	(Asana XL)*	5.8–9.6 fl oz	12	7
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Do not apply more than 0.35 lbs a.i./acre per season. If leafminers are present in the pepper crop, limit use of this product to late in the season to minimize negative impacts on biological control. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
K	METHOMYL*			
	(Lannate SP)	0.25–0.5 lb	48	3
	(Lannate LV)	0.75–1.5 pt	48	3
	MODE-OF-ACTION GROUP NUMBER[1]: 1A COMMNENTS: Do not use if psyllids are present. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			

** See label for dilution rates.

‡ 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.

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.

TOMATO (POTATO) PSYLLID (6/16)

Scientific Names: *Bactericera cockerelli*

DESCRIPTION OF THE PEST

The adult psyllid is a small insect (about 1/8 inch or 3 mm) that resembles a cicada. The adults have white or yellowish markings on the thorax, clear wings, and lines on the abdomen between segments. The tiny eggs are laid on stalks, most commonly on the underside of leaves and along leaf margins, and are best seen with the use of a hand lens. Initially white, they turn a pink color a few hours after they are laid.

Nymphs hatch from eggs in 4 to 15 days and have scalelike, flattened, oval, yellowish green to orangish bodies with red eyes and three pairs of short legs. Older nymphs are greenish and fringed with hairs and have wing buds, which make them easy to distinguish from whitefly nymphs. They develop through five stages (instars) in 2 to 3 weeks before becoming winged adults. Nymphs feed most often on the underside of leaves.

Tomato psyllids have an extensive range of acceptable hosts, but solanaceous plants (tomatoes, potatoes, nightshades) are preferred.

DAMAGE

Psyllids have the potential to rapidly build up large populations on peppers. The nymphs, and possibly the adults, inject a toxin while feeding on the foliage, which can cause transplants to die. In larger, pre-flowering plants it can cause stunting, chlorosis, and curling of the leaves. This can lead to either no fruit production or overproduction of very small, non-commercial grade fruit. Collectively, these symptoms are known as psyllid yellows.

In coastal and San Joaquin Valley growing areas they are also known to transmit *Candidatus* Liberibacter *solanacearum,* a pathogen of solanaceous crops, which amplifies psyllid feeding damage.

In addition to direct feeding damage, psyllids produce large amounts of honeydew, which often causes sooty mold to colonize. This can result in significant crop losses if the fruit becomes unmarketable. Unlike aphid honeydew, which is a liquid, psyllid honeydew is white and powdery. The powdery deposits must be removed to make the fruit marketable.

MANAGEMENT

Management strategies are aimed at preventing the development of large populations in the field when fruit is present. An application of imidacloprid at planting is an important component of tomato psyllid management. Monitoring fields by inspecting plants as well as the use of sticky traps is essential to detecting a population before it can become established and will help determine the need for in-season foliar treatments.

Biological Control

While predators and parasites may attack psyllids, most parasites attack too late in the psyllid life cycle to stop crop loss and biological control does not appear to be a promising control strategy in the field.

Organically Acceptable Methods

Sprays of the Entrust formulation of spinosad are acceptable for use on organically certified produce.

Monitoring and Treatment Decisions

Monitor fields to determine the need for in-season treatments. Where psyllids occur, place yellow sticky cards near the tops of plants growing at the field margins to monitor psyllid movement. Place the traps on adjustable poles so the height of the traps can be modified with plant growth. If tomato psyllids are caught in traps, examine the foliage of pepper plants located at the field margins for eggs and nymphs. If more than five psyllids per plant are found, treat. Be sure to alternate treatment materials to help prevent the development of insecticide resistance.

Consider treating with imidacloprid at planting if psyllids are present. It is very important not to use carbamates (Sevin, Lannate, Vydate) for the control of other pests as these materials actually promote the development of psyllid populations.

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

UPDATED 6/16

Not all registered pesticides are listed. 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. Always read the label of the product being used.

AT PLANTING

A. IMIDACLOPRID
(Admire Pro –soil) 7–10.5 fl oz 12 21
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: For a direct-seeded crop apply at planting as a side dress, through drip irrigation, or over the top as seedlings emerge. For transplanted peppers, apply at planting either through drip irrigation or as a soil application. Does not harm most natural enemies. To reduce the potential for the development of resistance, avoid the use of neonicotinoids both as a soil and a foliar application on the same crop. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

GROWING SEASON

A. ABAMECTIN
(Agri-Mek SC)* 1.75–3.5 fl oz 12 7
MODE-OF-ACTION GROUP NUMBER[1]: 6
COMMENTS: Do not apply at less than 7-day interval. Do not exceed 48 fl oz/acre per growing season. Do not apply in less than 20 gal water/acre. Do not make more than two sequential applications. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

B. PYRIPROXYFEN
(Knack) 8–10 fl oz 12 1
MODE-OF-ACTION GROUP NUMBER[1]: 7C
COMMENTS: An insect growth regulator that is not harmful to most natural enemies.

C. SPIROTETRAMAT
(Movento) 4.0–5.0 fl oz 24 1
MODE-OF-ACTION GROUP NUMBER[1]: 23
COMMENTS: Minimum interval between applications is 7 days and maximum allowed per season is 10 fl oz.

D. SPIROMESIFEN
(Oberon 2SC) 7.0–8.5 fl oz 12 1
MODE-OF-ACTION GROUP NUMBER[1]: 23
COMMENTS: Do not exceed three applications per crop or make applications at less than 7-day intervals.

E. SPINOSAD
(Entrust)# 1.25–2.5 oz 4 1
(Success) 4–8 fl oz 4 1
MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: Do not exceed 29 fl oz of Success or 9 oz of Entrust/acre per crop. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

** See label for dilution rates.

Acceptable for use on organically certified produce.

‡ 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.

TWOSPOTTED SPIDER MITE (8/07)

Scientific name *Tetranychus urticae*

DESCRIPTION OF THE PEST

Eggs of the twospotted spider mite are round, clear, and colorless when laid but become pearly white when ready to hatch. Nymphs and adults are egg-shaped and generally yellow or greenish in color. On each side of their bodies are one or more dark spots; the top of the abdomen is free of spots. Twospotted mites are generally found in small colonies on the underside of mature pepper leaves in late summer.

DAMAGE

Twospotted mites are not damaging to peppers in California production areas. They seem to prefer other solanaceous crops, such as eggplant, more than peppers.

MANAGEMENT

Mites are not a major problem on peppers and treatments are generally not required.

WHITEFLIES (6/16)

Scientific Names: Silverleaf whitefly: *Bemisia argentifolii*
Greenhouse whitefly: *Trialeurodes vaporariorum*

DESCRIPTION OF THE PESTS

Several species of whiteflies may infest peppers. Silverleaf whitefly is also known as sweetpotato whitefly B biotype. Proper identification of silverleaf whiteflies and greenhouse whiteflies is important because other whitefly species do not cause economic damage in pepper. Use a hand lens to examine both immatures and adults. Whitefly adults are tiny (0.06 inch, 1.5 mm long), yellowish insects with white wings. Silverleaf whiteflies hold their wings somewhat vertically tilted, or rooflike, over the body; the wings do not meet over the back but have a small space separating them. Greenhouse whitefly adults are very similar in appearance to the silverleaf whitefly but hold their wings flatter over the back and there is no space between the wings where they meet in the center of the back.

Whiteflies are found mostly on the undersides of leaves. They fly readily when plants are disturbed. The tiny, elongated eggs hatch into a first larval stage that has legs and antennae and is mobile. Both 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-eye 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 filament around the edge and the edge is somewhat vertical where it contacts the leaf surface.

DAMAGE

Whiteflies damage peppers by sucking enormous quantities of sap and covering plants with sticky honeydew. Black sooty mold grows over the honeydew, lowering the photosynthetic capacity of the plant and making the fruit unattractive. Feeding by high populations may result in stunting, poor growth, defoliation, and reduced yields.

MANAGEMENT

Whitefly populations are not consistent from year to year, so monitoring is important in detecting and preventing the development of populations in any given year. In addition, an integrated pest management program for whiteflies includes following good cultural practices, such as host-free periods, conserving natural enemies, and using pesticides only when necessary.

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 beetle larvae. 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 parasitic wasp, *Encarsia formosa,* has been used successfully to control greenhouse whitefly in greenhouses or protected crop situations elsewhere in the world where peppers are more commonly grown in this manner.

Cultural Control

The best control for silverleaf whiteflies is to maximize the distance and time interval between host crops. When possible, plant peppers at least one-half mile upwind from key silverleaf whitefly hosts such as melons, cole crops, and cotton. Maintain good sanitation in areas of winter and spring host crops and weeds by destroying and removing all crop residues as soon as possible. Control weeds in noncrop areas including head rows and fallow fields and harvest alfalfa on as short a schedule as possible. In addition, allow the maximum time between silverleaf whitefly host crops and produce vegetables and melons in the shortest season possible.

Adult silverleaf whiteflies are repelled by silver- or aluminum-colored mulches. Place reflective polyethylene mulches on planting beds before seeding or transplanting to significantly reduce rate of colonization by whiteflies and delay the buildup of damaging numbers of whiteflies by 4 to 6 weeks. The mulches lose their effectiveness when more than 60% of the surface is covered by foliage. Therefore, they are effective only for the first few weeks after seedling emergence or transplanting.

Greenhouse whiteflies are often induced by applications of broad-spectrum pesticides. Avoid such materials early in the season.

Organically Acceptable Methods

Cultural and biological control as well as sprays of insecticidal soaps and certain oil sprays are acceptable for use on organically certified produce.

Monitoring and Treatment Decisions

Routinely check field margins for whiteflies; these areas are usually infested first. Be especially alert for rapid population buildup when nearby host crops are in decline. During these critical periods, check pepper fields twice weekly. Sticky traps placed for aphids, thrips, or tomato psyllid, may be useful in detecting initial whitefly migrations into fields.

Allow natural enemies an opportunity to control light silverleaf whitefly infestations. If higher populations are present at the field margins than the field centers, then treat only the field margins. This approach will reduce treatment costs and help preserve natural enemies in the field. The treatment threshold for silverleaf whitefly is about 4 adults per leaf in a random 30-leaf sample of healthy leaves. Thresholds have not yet been established for greenhouse whitefly.

If whiteflies are present, consider treating with imidacloprid when transplanting or at the seedling stage for direct-seeded plants. Insecticidal soaps and oils are not as effective as the other materials and require frequent application and good coverage. Be sure the spray application covers the undersides of leaves to contact whiteflies.

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

UPDATED 6/16

Not all registered pesticides are listed. 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. Always read the label of the product being used.

A. IMIDACLOPRID
(Admire Pro) — 7–14 fl oz — 12 — 21
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Apply as a soil application according to label directions. See label for information on preventing the development of resistance in whitefly populations to this insecticide. To reduce the potential for the development of resistance, avoid the use of neonicotinoids both as a soil and a foliar application on the same crop. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

Review and follow the Treatment table updated: 11/23 effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

B. PYRIPROXYFEN
(Knack) — 8–10 fl oz — 12 — 1
MODE-OF-ACTION GROUP NUMBER[1]: 7C
COMMENTS: An insect growth regulator that is not harmful to most natural enemies. However, it does not kill adults, so if adults are present, add either bifenthrin (Brigade) at 2.1 to 6.4 oz/acre to the spray. For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum a.i. on any label when tank mixing products that contain the same a.i.

C. ACETAMIPRID
(Assail 70WP) — 1.1–1.7 oz — 12 — 7
MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: Apply in a minimum finished spray volume of 5 gal/acre by aircraft or 20 gal/acre by ground. Do not make more than four applications per season or exceed 0.3 lb a.i./acre per season. To reduce the potential for the development of resistance, avoid the use of neonicotinoids both as a soil and a foliar application on the same crop. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

D. CYANTRANILIPROLE

Common name (Example trade name)	Amount per acre**	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
(Exirel –foliar)	13.5–20.5 fl oz	12	1
(Verimark –soil)	6.7–10 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER[1]: 28			
COMMENTS: Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
E. INSECTICIDAL SOAP#			
(M-Pede)	1% solution or less	12	0
MODE OF ACTION: A contact insecticide with smothering and barrier effects.			
COMMENTS: This insecticide has no residual and requires frequent applications and thorough coverage.			
F. DINOTEFURAN			
(Venom)	1–4 oz (foliar); 5–6 oz (soil)	12	See comments
MODE-OF-ACTION GROUP NUMBER[1]: 4A			
COMMENTS: Preharvest interval for foliar application is one day; for soil applications it is 21 days. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
Review and follow the Treatment table updated: 11/23 effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.			
G. SPIROMESIFEN			
(Oberon 2SC)	7.0–8.5 fl oz	12	1
MODE-OF-ACTION GROUP NUMBER[1]: 23			
H. SPIROTETRAMAT			
(Movento)	4.0–5.0 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER[1]: 23			
I. NARROW RANGE OILS# (TriTek, Ultra-Fine Oil, Organic JMS Stylet Oil)	1% solution or less	4	0
MODE OF ACTION: Contact including smothering and barrier effects.			
COMMENTS: This insecticide requires frequent applications and thorough coverage. Check with certifier to determine which products are organically acceptable.			

** See label for dilution rates.

‡ 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.

Diseases

(Section reviewed 12/09)

ALFALFA MOSAIC VIRUS (12/09)

Pathogen: *Alfalfa mosaic virus* (AMV)

SYMPTOMS AND SIGNS

Typical symptoms of pepper plants infected with *Alfalfa mosaic virus* are a distinct yellow or whitish mosaic on leaves. Relative to uninfected plants, fruit may be stunted and misshapen.

COMMENTS ON THE DISEASE

Alfalfa mosaic virus infections of peppers more commonly occur when peppers are grown near alfalfa fields. *Alfalfa mosaic virus* is seedborne in alfalfa and essentially all alfalfa fields can be considered infected. *Alfalfa mosaic virus* is transmitted by several species of aphids and spread from alfalfa to surrounding crops via aphids is common. Aphids transmit the virus only while probing the leaf tissues. Once an aphid acquires *Alfalfa mosaic virus*, it retains the ability to transmit the virus for only a short period of time (minutes to hours) and spread is local and can be very rapid within fields. In general, field spread is related to overall aphid activity, not to the presence of colonizing aphids. Except in fields near alfalfa, the disease is usually not economically important.

Alfalfa mosaic virus is the only virus in the alfamovirus group and has a wide host range among weed and crop plants.

MANAGEMENT

In general, *Alfalfa mosaic virus* is not a major problem in California peppers, although local *Alfalfa mosaic virus* infections occur each year. The best way to control *Alfalfa mosaic virus* is to avoid planting peppers near alfalfa fields. No resistance is currently available in commercial pepper cultivars. Insecticides aimed at controlling the aphid vectors are largely ineffective. They will not kill aphids before aphids transmit the virus to plants.

BACTERIAL SPOT (12/09)

Pathogen: *Xanthomonas campestris* pv. *vesicatoria*

SYMPTOMS AND SIGNS

Bacterial spot appears as spots that form on leaves, stems, and fruit. Leaf spots first appear as small, angular spots on the undersurface of the leaf. The spots, which are about 0.25 inch in diameter, are initially water-soaked and later turn brown. Elongated raised cankers form on the stems. Fruit spots are circular, brown, and raised with a cracked, roughened, and wartlike surface.

COMMENTS ON THE DISEASE

The bacterium is seedborne and can occur within the seed or on the seed surface. The pathogen is disseminated with seed or on transplants. Bacterial spot is a relatively minor disease that is favored by high relative humidity and free moisture on the surface of the plant. Symptoms develop 5 to 15 days after inoculation and develop most rapidly at temperatures of 68°F or above. The bacteria do not survive in soil after the infected plant residue decomposes. Some strains of the bacteria favor pepper, others favor tomato, and others are equally pathogenic on both tomato and pepper.

MANAGEMENT

Use indexed pathogen-negative seed, treated seed, or disease-free transplants. Rotate out of peppers for at least 1 year. Use furrow or drip irrigation instead of overhead irrigation. Treatment with copper spray is justified only under high pressure as might occur with sprinkler irrigations. Resistance to copper is known to occur in California populations of this pathogen.

BEET CURLY TOP (12/09)

Pathogen: *Beet curly top geminivirus* (BCTV)

SYMPTOMS AND SIGNS

The internodes of infected plants shorten, resulting in extremely stunted plants. The upper portion of infected plants resembles a rosette or small flower bouquet. Leaves turn yellow or light green and may roll upward. Fruit are small and remain upright instead of drooping. Plants infected at an early age may die.

COMMENTS ON THE DISEASE

The virus has a very large host range that includes many vegetables, field crops, and weeds. It is transmitted by the sugarbeet leafhopper, *Circulifer tennelus*, from susceptible host plants such as Russian thistle, which thrives in the coastal ranges or in desert areas. Curly top usually appears on scattered plants in pepper fields.

MANAGEMENT

Resistant varieties are available for beans and sugarbeet, but not for pepper or tomato. A statewide program to control the leafhopper vector with insecticide sprays on its breeding grounds limits the number of leafhoppers that move to agricultural areas. Control measures are not recommended for individual fields.

CUCUMBER MOSAIC (11/12)

Pathogen: *Cucumber mosaic cucumovirus* (CMV)

SYMPTOMS AND SIGNS

Symptoms on plants with cucumovirus mosaic diseases can vary, but in general, plants show an overall lighter color along with mosaic patterns (alternating light and dark green areas) on at least some leaves, especially on the younger leaves. Often, the main leaf vein is distorted and somewhat zigzag in appearance. Plants generally show stunting, leaf curling, and mosaic, and mature leaves can develop necrotic areas shaped like oak leaves. Fruit may be malformed and have conspicuous concentric rings or spots. It can be difficult to accurately differentiate plants affected by *Cucumber mosaic cucumovirus* from those affected by the potyviruses. In general, *Cucumber mosaic cucumovirus* infections are more severe than infections by the potyviruses. However, mixed infections are very common, and this virus and one or more of the potyviruses can simultaneously infect plants.

COMMENTS ON THE DISEASE

Cucumber mosaic cucumovirus is spread from plant to plant by aphid vectors; many aphid species are competent vectors. Aphids transmit *Cucumber mosaic cucumovirus* while probing the leaf tissues. Once an aphid acquires *Cucumber mosaic cucumovirus*, it retains the ability to transmit the virus for only a short time (minutes to hours); the spread of the virus is thus local and very rapid within fields. In general, field spread is related to overall aphid activity, not to the presence of colonizing aphids.

Several strains or pathogenic variants of this virus exist. This virus has a tremendously wide host range among broadleaf crop and weed species, and thus, eliminating alternate sources of inoculum is not a feasible management strategy.

MANAGEMENT

No good sources of *Cucumber mosaic cucumovirus* resistance in peppers are currently available. Efforts are under way to develop resistant cultivars, both through traditional plant breeding and with biotechnology. Eliminating weeds and using reflective mulches to repel the insect vector may reduce the incidence of this disease.

Chemical pesticide strategies are not effective. Insecticides directed at controlling the aphid vectors are not effective in preventing this virus because they cannot kill the aphids before transmission occurs; however, growers should still attempt to manage vector populations when possible (for more information, see GREEN PEACH APHID).

IMPATIENS NECROTIC SPOT (12/09)

Pathogens: *Impatiens necrotic spot virus* (INSV) in the tospovirus group

SYMPTOMS AND SIGNS

Symptoms on plants infected with *Impatiens necrotic spot virus* include overall yellowing (chlorosis), dead (necrotic) spots on leaves or terminal shoots, and general stunting. Fruits show chlorotic spots, red or green areas surrounded by yellow halos, and concentric rings that may become necrotic. Symptoms are similar to those caused by another tospovirus, *Tomato spotted wilt virus* (TSWV) (for more information on this virus, see TOMATO SPOTTED WILT).

COMMENTS ON THE DISEASE

In California, INSV is vectored primarily by western flower thrips. When nymphs acquire tospoviruses by feeding on infected plants, they will retain the ability to transmit the virus for the remainder of their lives. INSV has a host range that consists mostly of ornamentals and is not as broad as that of TSWV.

MANAGEMENT

While spraying for the thrips vector will not prevent these virus diseases from occurring, growers should still attempt to manage thrips populations when possible.

POTYVIRUS MOSAIC DISEASES (12/09)

Pathogens: *Pepper mottle potyvirus* (PepMoV), *Tobacco etch potyvirus* (TEV), and *Potato Y potyvirus* (PVY)

SYMPTOMS AND SIGNS

Symptoms on plants with potyvirus mosaic diseases can vary, but in general, plants show an overall lighter color along with mosaic patterns (alternating light and dark green areas) on at least some leaves, especially on the younger leaves. Plants will often show stunting, leaf curling, and fruit distortion along with the mosaic pattern on leaves. Symptoms may be similar to those caused by cucumber mosaic virus.

COMMENTS ON THE DISEASE

All of the potyviruses affecting pepper are transmitted from plant to plant by several species of aphids. Aphids are able to transmit these viruses for very short periods of time (minutes to a few hours). The type of aphid activity that promotes virus spread occurs when aphids are actively moving through the pepper crop and are probing the plant tissues before they begin feeding. Once aphids colonize plants, settling down to feed, transmission is greatly reduced. Thus, spread is often very rapid. In general, field spread of potyviruses occurs when aphid activity in fields is high.

All of the potyviruses that affect peppers have wide host ranges that include other crops and many weed species, particularly those within the Solanaceae (tomato, potato, eggplant, and nightshade family). Various strains of the potyviruses exist, some of which differ in their specific pathogenicities. It is very common to find plants simultaneously infected by more than one of the pepper potyviruses and also by cucumber mosaic virus. While spraying for the aphid vector will not prevent virus infections from occurring, growers should still attempt to manage vector populations when possible.

MANAGEMENT

Some resistance, derived from various plant species closely related to peppers, is currently available and efforts are under way to develop more resistant varieties. In general, sources of genetic resistance in bell types is greater for *Potato Y potyvirus*, followed by *Tobacco etch potyvirus*, followed by *Pepper mottle potyvirus*.

No effective chemical control practices have been developed for potyvirus mosaic diseases in California. The incidence of these viruses is unpredictable between years and locations. Insecticides are not effective in controlling the spread of these viruses because they do not kill aphids before the aphids can acquire and transmit the viruses to plants.

Silver reflective plastic mulches applied at planting have been shown to be effective in repelling aphids from plants, thereby reducing or delaying virus infection.

POWDERY MILDEW (6/16)

Pathogen: *Leveillula taurica* (imperfect stage = *Oidiopsis taurica*)

SYMPTOMS AND SIGNS

Powdery mildew primarily affects leaves on pepper plants. Although the disease commonly occurs on older leaves just before or at fruit set, it can develop at any stage of crop development. Symptoms include patchy, white, powdery growth that enlarges and coalesces to cover the entire lower leaf surface. At times the powdery growth is present on the upper leaf surface as well. Leaves with mildew growing on the undersurface may show a patchy yellowish or brownish discoloration on the upper surface. The edges of infected leaves may roll upwards exposing the white, powdery fungal growth. Diseased leaves drop from the plants and leave the fruit exposed to the sun, which may result in sunburning.

COMMENTS ON THE DISEASE

Powdery mildew can be severe during the warmest part of summer and can cause heavy yield losses. The pathogen has a very wide host range and inoculum from one host plant species can cross-infect other host plants. In California, powdery mildew inoculum can come from crops such as onion, cotton, tomato, all varieties of peppers, and weeds such as annual sowthistle and groundcherry.

This powdery mildew pathogen differs from powdery mildew pathogens in other genera in that it primarily occurs inside the leaf rather than on the leaf surface. Cleistothecia (sexual spores) of the *Leveillula* perfect stage rarely occur in California, but asexual spores (conidia) are produced and disseminated by wind. In general, high humidity favors germination of conidia. Infection of plants can occur over a wide temperature range (64° to 91°F or 18° to 33°C) under both high and low humidity. Under favorable conditions, secondary infections occur every 7 to 10 days, and disease can spread rapidly. Temperatures over 95°F that commonly occur in the interior valleys of the state can temporarily suppress development.

MANAGEMENT

Regular monitoring to detect powdery mildew, especially during warm weather, is important to time fungicide applications early enough to prevent damage. Powdery mildew is managed primarily with fungicides.

Cultural Control

The fungi that cause powdery mildew can survive between crop seasons on other crops and on weed species. The degree of survival depends on environmental conditions. Because of the wide host range of the fungus, it is difficult to control the amount of inoculum that overwinters in California. Thus, simple sanitation methods in and around pepper fields may not provide a sufficient reduction in the primary inoculum to provide disease control.

Most pepper cultivars used in California do not possess acceptable levels of resistance to powdery mildew. Currently, there are no breeding programs aimed at developing resistant cultivars to pepper powdery mildew.

Organically Acceptable Methods

Sprays of sulfur and potassium bicarbonate are acceptable for use on organically grown peppers.

Treatment Decisions

Fungicides can provide satisfactory control and prevent economic loss if applied during the early stages of the infection. Effective control requires spraying with high pressure and high volume of water for optimum penetration of the crop canopy by the fungicide. Good coverage is necessary for satisfactory control; ground applications give better coverage than air.

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

UPDATED 6/16

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

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
A. SULFUR (Sulfur DF)#	5 lb	24	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M2)			
COMMENTS: Provides only partial control even when applied early. To prevent injury to the crop, do not apply within 2 weeks of an oil application.			
B. AZOXYSTROBIN (Quadris)	6–15.5 fl oz	4	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
C. PYRACLOSTROBIN (Cabrio EG)	8–12 oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
COMMENTS: Do not apply more than 6 applications 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 four applications per year. Do not apply more than 1.25 lb/acre. Use allowed under a Supplemental Label.			
E. QUINOXYFEN (Quintec)	4–6 fl oz	12	3
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinoline (13)			
COMMENTS: Alternate after each use with a fungicide that has a different mode of action.			
F. TRIFLOXYSTROBIN (Flint)	1.5–2 oz	12	3
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)			
G. POTASSIUM BICARBONATE# (Kaligreen)	2.5–3 lb	4	1
MODE OF ACTION: An inorganic salt.			
COMMENTS: While this product has been tested for other crops, research is lacking for its use in peppers and observations indicate it provides only partial control. Thorough coverage and frequent applications are necessary.			
H. PENTHIOPYRAD (Fontelis)	16–24 fl oz	12	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Succinate dehydrogenase inhibitor (7)			

‡ 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 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. For fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17, make no more than one application 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.

ROOT AND CROWN ROTS AND DAMPING-OFF DISEASES (6/16)

Pathogens: *Phytophthora capsici, Pythium aphanidermatum*, and other *Pythium* spp.

SYMPTOMS AND SIGNS

Damping-off is primarily caused by *Pythium* spp. Seedlings affected by damping-off fail to emerge or fall over and die soon after emergence. Stems usually have a dark, shriveled portion at the soil line. Damping-off is generally limited to areas where drainage is poor or where soil is compacted, but whole fields can be affected, especially in early plantings exposed to rain.

Root and crown rot is primarily caused by *Phytophthora capsici*. Symptoms on affected pepper plants include rapid wilting and death of pepper plants. Close examination of the roots and stems is necessary to confirm the cause of disease. The disease can develop at any stage of pepper plant growth. Taproots and smaller lateral roots show water-soaked, very dark brown discoloration of surface, cortical, and vascular tissues. Very few lateral roots remain on diseased plants and the tap roots may also be shorter compared to those of healthy plants. The most striking difference between healthy and diseased plants is the total amount of root tissue. Stems are usually infected at the soil line. Stem lesions first become dark green and water-soaked, followed by drying and turning brown. A lesion can girdle a stem, resulting in wilting of plants above the lesion and subsequent death. Under some conditions, *P. capsici* can also cause a brown foliar blight on pepper.

Another important soilborne disease of pepper in California, Verticillium wilt, causes foliar symptoms similar to those seen in root and crown rot diseases; however, Verticillium wilt does not cause any browning or rotting of the root surface and cortex. In contrast, the xylem tissues of main stems and roots of *Verticillium dahliae*-infected pepper show brown to black streaking and discoloration.

COMMENTS ON THE DISEASE

Disease caused by *P. capcisi* can develop at any stage of growth, but once pepper seedlings reach the 2- or 3-leaf stage, they generally are no longer susceptible to infection by *Pythium* spp. However, *Pythium* spp. can cause root rot when peppers are grown on plastic mulch.

"Damping-off" is a general term for the death of seedlings in damp conditions, either before or after emergence. It is mainly an early-season problem, causing greatest losses in cool, wet soils. Because almost all California pepper production uses transplants, this disease is of more concern in the greenhouse if potting soil is contaminated or overwatered.

Although infection is most common under cool conditions, *P. capcisi* can infect seedlings in warmer soils. Damping-off due to *Pythium* spp. may increase where green manures such as volunteer grain are worked into the soil just before planting. Damping-off does not necessarily carry over from one season to another in the same places, but appears only when and where conditions favor infection.

Neither *P. capcisi* nor *Pythium* spp. is seedborne. However, both can survive in soil for long periods as thick-walled oospores. Contaminated transplants or soilborne inoculum are sources of primary infections. Irrigation water often disseminates fungal propagules from infested areas to other parts of the field. Thus, irrigation can significantly increase the incidence and severity of root and crown rot in pepper. Increased frequency and duration of irrigation favor disease development.

Water, temperature, and soil texture are the major factors affecting the development of damping-off and root and crown rot. The presence of water is mandatory; soil saturation for as little as 5 to 6 hours can result in infection, and susceptible varieties can become severely diseased in as little as 5 days. Optimum temperature for plant infection is 75° to 92°F (24° to 33°C). Symptoms usually appear following a warm, wet period. The disease is severe in fine-textured (clay) soils that drain slowly and in highly compacted soils. Severely infected fields may have nearly complete loss of plants.

Infections that occur late in the season may reduce vigor and yield of plants without killing them. In addition, if the foliage wilts during the hottest time of the day and exposes fruit to the open air, such fruit can become sunburned and therefore unharvestable.

MANAGEMENT

Factors that influence the development of damping-off and root and crown rot diseases in peppers in a given season include varietal susceptibility, amount and frequency of irrigation, and soil compaction and drainage. Crop rotation, proper irrigation, and clean transplants are critical in managing this disease. Fields that have a history of root and crown rots may need fungicide treatments at planting.

Cultural Control

The disease can be effectively prevented by:

- Using clean transplants
- Proper field and seedbed preparation
- Good water management
- Employing a 2-year crop rotation that exclude susceptible plants

Soil and bed preparation

Practices that reduce or alleviate soil compaction may improve control; for example, growing plants on raised beds. If possible, avoid planting when the soil is cool. Seeds germinate faster and seedlings are more vigorous when the soil is warm: thus they are less likely to be damaged.

Irrigation

Use sprinklers during germination to better control irrigation and lessen the chance of infection. In heavy soils that are poorly drained, root and crown rot may be reduced by irrigating every other row on each irrigation or by carefully managing drip irrigation.

Resistance

Commercial cultivars with acceptable levels of resistance to the disease are available. However, in general peppers are very susceptible to these diseases.

Treatment Decisions

Fungicides are sometimes used preventively in fields with histories of root rot or problems with drainage. Use a fungicide seed treatment to prevent damping-off.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.			
A. MEFENOXAM			
(Ridomil Gold SL)	1 pt (soil-applied)	48	7
	0.5 pt (foliar)	48	7
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)			
COMMENTS: Apply at planting and make two subsequent post-directed applications at 30-day intervals. Do not exceed 1.5 pt/acre per crop season (soil applied) or 0.5 pt/acre per crop season (foliar application). Mechanically incorporate or sprinkler-irrigate to move the pesticide into the root zone. Do not use for peppers grown in greenhouses.			
B. FLUOPICOLIDE			
(Presidio)	3–4 fl oz	12	2
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Benzamide (43)			
COMMENTS: A tank mix with a labeled rate of another labeled fungicide product with a different mode of action must be used for resistance management.			
C. PHOSPHOROUS ACID			
(various products)	Label rates	See label	See label
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phosphonate (33)			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
COMMENTS: Research on the use of this pesticide has not been conducted in California, but field experience suggests that it may provide control in a preventive program. Multiple applications are necessary to achieve control.			

‡ 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. For fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17, make no more than one application 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.

TOBAMOVIRUS DISEASES (11/12)

Pathogens: *Tobacco mosaic virus* and others
(Reviewed 12/09; Updated 10/12)

SYMPTOMS AND SIGNS

Symptoms on plants infected with *Tobacco mosaic tobamoviruses* vary among cultivars, vary with specific viruses or strains, and depend on the temperature, light intensity, day length, and age of the plant. Symptoms can include necrosis on any plant part, defoliation, leaf distortion, and mosaic symptoms on leaves, stems, and fruit.

COMMENTS ON THE DISEASE

An important source of primary inoculum is contaminated seed. The virus is carried on the seed coat, and thus can be removed from contaminated seeds by washing seed with dilute solutions of tri-sodium phosphate. The tobamoviruses on pepper are readily spread mechanically within the field by handling and mechanical damage to plants, but not by insect, nematode or fungal vectors.

The tobamoviruses are very stable viruses. They can survive in plant debris for many years.

MANAGEMENT

The best control is to use seed that has been treated to eliminate the seedborne inoculum. Minimizing plant handling and damage also is important for reducing field spread of tobacco mosaic virus. Good sources of plant resistance genes (L1-L4 genes) to various tobamoviruses also exist and are present in commercially available cultivars. No chemical strategies are effective.

TOMATO SPOTTED WILT (12/09)

Pathogen: *Tomato spotted wilt virus* (TSWV) in the tospovirus group

SYMPTOMS AND SIGNS

The symptoms of tomato spotted wilt in pepper vary depending on the stage of growth that the plant is infected, the cultivar, co-infections with other viruses, and other factors such as environmental conditions. Certain symptoms of TSWV infection—the spotting, bronzing, and necrosis of leaves and the ringspots on fruit—are fairly typical.

Seedling Infection

Plants infected at the early stages of growth (e.g., as transplants) are stunted. Leaves will be stunted with necrotic spots or rings. Severely infected plants may die.

Early Infections in the Field

One of the earliest initial symptoms is a bronze appearance on infected leaves, along with a drooping or wilting of the infected plant. This is associated with development of necrotic spots on leaves, which may include vein necrosis, as well as necrosis of the stems and petioles. Eventually the entire plant becomes stunted and may show a drooped or wilted appearance; necrosis becomes more pronounced on infected leaves, petioles, and stems. Developing green fruit will be bumpy and show diagnostic spots and concentric rings that are initially pale or yellow but may become necrotic. Ripe fruit are distorted and often show extensive necrotic rings or etching.

Late Infections in the Field

When plants are infected later in development, only a part of the plant may develop symptoms, whereas the rest of the plant will remain healthy (this is because of the inability of the virus to move into mature parts of the plant). The initial symptoms in leaves include curling, pale green to yellow discoloration, and purpling of the leaves. Fruits on such infected shoots may become bumpy, deformed, and often develop spots, ringspots, and necrosis.

COMMENTS ON THE DISEASE

Tomato spotted wilt virus is transmitted by various species of thrips, including the western flower thrips, *Frankliniella occidentalis*, the onion thrips, *Thrips tabaci*, and the chili thrips, *Scirtothrips dorsalis*. *Tomato spotted wilt virus* also infects the thrips vector. This virus is not seedborne and it is not spread by contact; it is only spread from plant to plant by thrips.

Nymphs that acquire the virus by feeding on infected plants will retain the ability to transmit it for the remainder of their lives. *Tomato spotted wilt virus* cannot be passed from infected females through the eggs.

TSWV has a wide host range, and can infect hundreds of species of plants, including monocots and dicots. These plants include crops, ornamentals, and weeds. However, it is important to emphasize that all plant hosts are not equally important in contributing to the development of tomato spotted wilt disease in crop plants. It is only the species of plants that are infected by TSWV and on which the thrips can complete their entire life cycle that play an important role in the disease cycle. In California, the key field crop hosts include tomato, pepper, radicchio, and lettuce. Important weed hosts include little mallow (*Malva parviflora*), sowthistle (*Sonchus oleraceus)*, and prickly lettuce (*Lactuca serriola*), among others.

MANAGEMENT

Effective management of tomato spotted wilt in areas where it is known to occur in California requires an integrated pest management (IPM) approach that targets the thrips vector and the virus.
This IPM strategy can be divided into three parts:

Before the Growing Season

- Use virus- and thrips-free transplants (ideally from transplant houses that monitor for thrips and inspect for disease).
- Manage thrips populations on transplants if necessary (for more information, see THRIPS).
- Practice good weed management in and around fields to be planted with pepper.

Note that TSWV-resistant pepper cultivars suitable for use in California are not yet available.

During the Growing Season

- Avoid planting new fields near older fields (especially those fields confirmed to have TSWV infection).
- Monitor fields for the presence of thrips and manage populations (see THRIPS for more information).
- Monitor for TSWV using a number of tests including the enzyme-linked immunosorbent assay (ELISA) and immunostrip tests that are based on antibodies that recognize TSWV proteins and the polymerase chain reaction test (PCR) that detects the virus genetic material. The immunostrip is a rapid result test for plant viruses that involves the use of 'dip-sticks' that are put in bags with sap prepared from plant samples; the results are obtained in 5-10 minutes. TSWV immunostrips and buffer bags are commercially available from companies such as AgDia (http://agdia.com) and EnviroLogix (http://envirologix.com).
- Consider roguing plants infected at the seedling stage.
- Practice good weed management in and around fields.

After the Growing Season

- Sanitation is very important; it is important to promptly remove and destroy old crops and volunteers after harvest (e.g., plowing and physical removal). Ideally this practice is followed on a regional basis.
- Control weeds and any volunteers on fallow fields or unused land nearby where tomato crops will be planted.

VERTICILLIUM WILT (11/12)

Pathogen: *Verticillium dahliae*

SYMPTOMS AND SIGNS

Verticillium dahliae can infect pepper plants at any growth stage. Symptoms include yellowing and drooping of leaves on a few branches or on the entire plant. The edges of the leaves roll inward on infected plants, and foliar wilting ensues. The foliage of severely infected plants turns brown and dry. Growth of pepper plants inoculated with aggressive strains of *V. dahliae* in greenhouse or of pepper plants infected early in the season under field conditions is severely stunted with small leaves that turn yellow-green. Subsequently, the dried leaves and shriveled fruits remain attached to plants that die. Brown discoloration of the vascular tissue is visible when the roots and lower stem of a wilted plant are cut longitudinally. Another important soilborne disease of pepper in California, Phytophthora root rot, causes similar foliar symptoms; however, Phytophthora root rot causes extensive browning and rotting of the root cortex, while the roots of *V. dahliae*-infected pepper plants show no external discoloration or decay.

COMMENTS ON THE DISEASE

Verticillium wilt, caused by *Verticillium dahliae,* is a soilborne fungus that colonizes the vascular tissues of plants. *Verticillium dahliae* has a broad host range, causing vascular discoloration and wilt of many economically important crops. Microsclerotia produced by *V. dahliae* may survive under field conditions for up to 14 years in the absence of a host. The microsclerotia germinate in the vicinity of host roots and cause infection. Verticillium wilt is favored by cool air and soil temperatures. Peppers are resistant to isolates of *V. dahliae* from many hosts, and only certain strains of *V. dahliae*, such as those from eggplant and pepper, are pathogenic on peppers. In recent years, an increase in the incidence of Verticillium wilt on many types of pepper has been observed in the central coast of California, resulting in significant reduction in yields.

MANAGEMENT

There are no effective control methods once the disease has occurred in the field; therefore management strategies should concentrate on avoiding the problem.

- Resistance to Verticillium wilt in commercial cultivars of peppers is not common and is difficult to identify in pepper germplasm.
- Because of the longevity of microsclerotia and the broad host range of *V. dahliae*, crop rotation is usually not a feasible option for control of Verticillium wilt in many crops. However, rotations with broccoli, corn, wheat, barley, sorghum or safflower for a period of at least 2 years (the longer the rotation, the better) can reduce inoculum and subsequent plant infection. These crops are not hosts for the *Verticillium* pathogen, and populations of the pathogen will decline in fields where host plants are not present. In severe cases, do not replant peppers in the field for a minimum of 3 years.
- Clean equipment and tractors before entering a new field to prevent the spread of soilborne pathogens such as *V. dahliae*.

Check for symptoms of Verticillium wilt through fruit development and keep records of infections in order to make decisions for future plantings.

Preplant soil fumigation with metam sodium is usually not economically viable for controlling Verticillium wilt in peppers. However, when metam is applied to the soil for weed control, concurrent reductions of *Verticillium* propagules often occur.

Nematodes

(Section reviewed 6/16)

Scientific names: Root-knot nematodes: *Meloidogyne incognita* and *M. javanica*
Stubby root nematode: *Paratrichodorus minor*

DESCRIPTION OF THE PESTS

Plant-parasitic nematodes are microscopic roundworms that feed on plant roots. They survive in soil and plant tissues, and several species may occur in a field. The host range varies according to the species, with some being able to infest a wide variety of crops and others being limited to a narrow crop range. Symptoms of nematode infestation also vary according to the nematode species and crop type and are often non-specific (yellowing, stunting). Root knot nematode species, however, cause typical galling on roots of infested plants. The geographical distribution of the different species is highly dependent on temperature, soil type, and cropping history.

DAMAGE

Root knot and stubby root nematodes are the most serious nematode parasites on bell peppers in California. Heavy infestations of root knot nematodes can cause significant reduction in crop stand, and growth and yield of plants. Damage caused by root knot nematode infestations is more severe in light-textured soils that have 50% or more sand, such as loamy sands and sandy loams, where plants with damaged roots quickly become stressed for water. Stubby root nematode can reduce growth and yield of plants and prefer lighter soil types.

SYMPTOMS

The symptoms described below are indicative of a nematode problem, but are not diagnostic as they could result from other causes as well. Infestations may occur without causing any aboveground symptoms.

Nematode infestations damage the plant roots, and therefore symptoms reflect poorly functioning root systems. Aboveground symptoms of severe root knot and stubby root nematode infestations include patches of chlorotic, stunted, necrotic, or wilted plants. Nematode-infested plants are more susceptible to moisture or temperature stress and exhibit stress symptoms earlier than other plants. Furthermore, root systems that have been damaged by nematodes are often more susceptible to infection by soil-inhabiting fungi such as Fusarium and Verticillium species.

Feeding by root knot nematodes results in characteristic galls on roots. Severely galled roots may appear malformed and the root system shortened and thickened. Roots of plants infested with stubby root nematode are likely to have numerous, short and stubby lateral roots.

FIELD EVALUATION

To make management decisions, it is important to know which nematode species are present. If a previous crop had problems caused by nematodes that are also listed as pests of bell pepper or other solanaceous vegetables, population levels may be high enough to cause damage to subsequent crops. If nematode species have not previously been identified, take soil samples and send them to a diagnostic laboratory for identification.

Take soil samples soon after harvest or preferably just before harvest, within the root zone of the previous crop. Divide the field into sampling blocks of not more than five acres each that represent 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 quart (1 liter) for each block.

Place root systems of suspect plants into plastic bags with soil. Place soil samples in separate plastic bags, seal them, and place a label on the outside with your name, address, location, the current or previous crop, and the crop you intend to grow. Keep samples cool (do not freeze), and transport as soon as possible to a diagnostic laboratory. Contact your Farm Advisor to help you find a laboratory for extracting and identifying nematodes, and for help in interpreting sample results.

MANAGEMENT

In fields infested with root knot nematodes, crop rotation may not be feasible because of their extensive host range; care is needed in the selection of rotation crops because some may be good alternate hosts. New resistant

varieties of peppers may prove useful. Soil solarization may help to lower the nematodes in the top layers of the soil and avoid an early infestation of the plants. Roots are likely to become infested as the season progresses by nematodes that survived in the deeper soil layers.

Resistant varieties

Recently, root knot nematode-resistant bell pepper varieties have become available. These varieties are resistant against the root knot nematode species *Meloidogyne incognita*, *M. javanica*, and *M. arenaria*. Two of these resistant varieties are "Charleston Belle" and "Carolina Wonder." "Carolina Cayenne" is a nematode-resistant hot pepper variety. Under high soil temperature conditions (between 82° to 90°F) the level of resistance may decrease. Although results from field studies done in South Carolina are very promising, the usefulness of these varieties under California conditions and with California nematode populations has yet to be evaluated.

Varieties that are resistant to stubby root nematodes are not available.

Sanitation

Clean soil from equipment with water before moving from infested to noninfested fields, and keep fields free of weeds, because some weed species, such as nightshade, are excellent hosts for root knot nematodes.

Fallow

Weed-free fallow reduces most nematode populations. Fallowing is more effective if soil is plowed and exposed to sun. Irrigation during the dry period stimulates egg hatch and so further reduces nematode populations if proper weed control is maintained.

Solarization

Solarization can be used in areas with sufficient solar radiation. Typically, the soil is irrigated and then covered with clear plastic for 4 to 6 weeks during the hot summer period. The effectiveness depends mainly on the heat that can be generated under the plastic during a certain period. Although nematodes in upper soil layers can effectively be reduced, re-infestation of roots by nematodes that survived deeper in the soil will occur. Solarization can, however, provide plants a nematode-free environment early on in the growing season when plants are most susceptible to damage. For further information, contact your local farm advisor or see *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds*.

Treatment decisions

Damage thresholds for root knot and stubby root nematodes on peppers have not been developed. If present, damage may occur and preplant treatment is warranted.

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

UPDATED 6/16

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

PREPLANT

A. 1, 3-DICHLOROPROPENE/CHLOROPICRIN*
(InLine) Label rates See label NA
COMMENTS: Multi-purpose liquid fumigant for the preplant treatment of soil against plant-parasitic nematodes, symphylans, and certain soilborne 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.

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 fields 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.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
C. METAM SODIUM* (Vapam, Sectagon 42, Metam Sodium)	Label rates	See label	NA
. . . or . . .			
METAM POTASSIUM* (K-pam)	Label rates	See label	NA
COMMENTS: Contact your Farm Advisor for advice on the most effective application method (flood, sprinkler, shank, or drip) for a particular situation. Good herbicidal properties. Fumigants such as metam sodium and metam potassium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone..			

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

‡ 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.

Weeds

(Section reviewed 12/09)

INTEGRATED WEED MANAGEMENT (11/12)

Peppers are a warm-season crop that need a long growing season. They are produced in a number of regions in the state. The earliest production district is in the Coachella Valley. There is also significant production in the Central Valley and the inland areas of the coastal production districts. Peppers are planted in a number of bed sizes that range from 40 to 60 inches wide. On narrower beds they are planted in one to two seed lines per bed and on wider beds they are planted in two seed lines.

Peppers in California are nearly all transplanted, which gives the crop some advantage over the weeds. Unfortunately pepper transplants are slow to establish and initially compete poorly with weeds, which can reduce pepper yields by competing for light, water, and nutrients as well as delaying maturity. Weeds germinating during the first 6 to 8 weeks after transplanting can have serious consequences. After 8 to 10 weeks, yield is less affected by late-emerging weeds; however, weeds can interfere with harvest and produce weed seeds that can be troublesome in rotational crops. In some growing areas such as Southern California, fresh market peppers are grown on beds covered with black plastic mulch, which prevents germination of most weed species.

Effective weed management in peppers begins with proper field selection and identification of potential weed problems. It involves preirrigation and cultivation, proper land and planting bed preparation, sanitation, and proper selection of herbicides.

When combined with good cultural practices, available herbicides can control many of the weed species that are found in pepper fields. The choice of herbicide depends upon the weed species that are present and the cultural practices followed by the grower.

Preemergence herbicides are soil applied and mechanically mixed with the soil or are irrigated into the soil before weeds emerge. They are effective against germinating seeds before they emerge from the soil; these materials usually give residual control. **Postemergence herbicides** are sprayed onto the foliage of the weeds after they have emerged. They are absorbed by the leaves and stems of the weeds and translocated to the site of action; thus they work best when sprayed on unstressed plants. Some herbicides have both preemergence and postemergence activity.

Herbicides work best if they are applied when soil moisture is adequate for plant growth. Preemergence herbicides are effective against germinating seeds, not dry seeds. Do not apply these materials to wet soils, however, as compaction can occur. Postemergence herbicides work best on unstressed plants, which absorb and translocate the material more readily than stressed plants.

In pepper production, many growers establish their beds in fall, but in Southern California beds are created in April. To keep beds weed-free during winter, use either a rolling cultivator on rough beds or apply oxyfluorfen before weeds germinate. After weed seedlings emerge, glyphosate or paraquat can be used. In spring the beds can be worked and then fumigated with metam sodium. Alternately, shaped beds may be flamed or treated with preemergence herbicides; both methods require subsequent hand weeding.

Herbicides may also be applied after planting but before crop emergence. Generally after peppers emerge, growers rely on hand hoeing to remove weeds from the seed line and cultivation to keep the rest of the bed tops and furrows weed-free. Herbicides may be needed for grass weed problems after pepper transplanting or after the crop emerges.

In coastal production areas peppers are sometimes rotated with strawberry. Strawberry fields receive pre-plant fumigation and remaining weeds are managed with opaque mulch and herbicides; the weed population in the following crop is reduced.

MONITORING

To plan a weed management program, it is essential to know which weed species are present and the relative abundance of each. Conduct weed surveys of each field at least twice a year: the first before planting and the second just before harvest. Identify which weeds are present to determine appropiate management tactics.

Records from previous crops will indicate which weeds escaped control and will likely infest the pepper crop. Also examine fence rows and ditch banks, as these are other sources for weed invasion. Pay special attention to where perennial weeds such as field bindweed and yellow nutsedge occur so that follow-up control measures can be taken.

WEED MANAGEMENT BEFORE PLANTING

Field selection and preparation

Many major weed problems can be reduced by avoiding fields that are severely infested with weeds such as nightshade, little mallow or cheeseweed, field bindweed, nutsedge, and parasitic dodder, which compete effectively with peppers. Irrigation water can also be a source of weeds; keep canal banks free of weeds or install a weed screen on the inlets from canals. Avoid moving weed seed into fields on equipment. When equipment has been used in a weedy field, clean it before entering other fields.

Deep plowing (9–10 inches) with a moldboard plow before listing the beds can bury nutsedge tubers to sufficient depth to prevent their emergence. Preirrigation coupled with light cultivation or flaming can also greatly reduce weed problems by helping to reduce the initial flush of weeds such as nightshades. Herbicides, such as Roundup or Gramoxone, can also be used in this manner.

For direct-seeded crops, a soil cap (2- to 4-inch mound of soil) over the seed line at planting can reduce the first flush of weeds competing with the crop seedling. The dirt mound also reduces soil moisture loss and precludes soil crusting after periods of rainfall. Disks or other implements form the soil cap just after planting. The cap is removed just after pepper seedlings germinate and before rapid elongation of the hypocotyl. Rains could delay cap removal, causing potential pepper stand loss. High temperatures during cap removal can lead to scalding of the emerging pepper seedlings, leading to stand loss. However, under good conditions, weed seeds that germinate in the soil cap are destroyed when the cap is removed and fast-growing weeds that germinate in the original bed are scraped off by the cap removal operation.

Proper land and planting bed preparation allow for more rapid and uniform germination of pepper seeds or for more rapid growth of transplants.

Crop rotations

Crop rotations help to reduce weed problems, as well as disease such as Phytophthora root rot. Corn is a good rotational crop for peppers because herbicides available for use in corn control nightshade and field bindweed. Also, corn is not a host for dodder. Alfalfa is a good choice for a rotational crop because the frequent cutting cycle reduces many weeds and available herbicides eliminate most other weeds. Other crops considered to be useful rotational crops with peppers include beans, cereals, cotton, garlic, rice, onions, carrots, lettuce, cole crops and safflower. Avoid crops such as tomatoes, potatoes and eggplant; they are in the same family as peppers (Solanaceae) and similar herbicides are used in their production, resulting in similar uncontrolled weeds.

Herbicides

Oxyfluorfen (GoalTender), paraquat (Gramoxone SL 2.0), and glyphosate (Roundup Powermax) can be used to control weeds on winter beds. They help keep the beds weed-free during winter.

Preplant herbicides

In spring apply preemergence herbicides just before planting. They are incorporated into the soil either mechanically or by sprinkler irrigation. The entire bed top may be treated or band treatments applied over the seedling row. Band treatments proportionally reduce the herbicide cost and may reduce the risk of herbicide carryover into the next crop. If weeds have already emerged, a postemergence treatment may also be necessary. When band treatments are used, the area between crop rows requires cultivation or some other method of weed control.

In southern California, treat bare beds, before applying a plastic mulch for yellow nutsedge control. For direct-seeded peppers, soil-applied preemergence herbicides such as napropamide (Devrinol) and bensulide (Prefar) can be applied before planting to control grasses and many broadleaf weed species (except nightshades). For transplanted peppers, trifluralin (Treflan) may be incorporated into the bed before transplanting. Pendimethalin (Prowl H2O) is also registered for use before transplanting.

In some areas, especially desert valleys, growers may choose to fumigate the soil with metam sodium, which greatly reduces weeds as well as disease and nematodes. Contact your Farm Advisor for advice on the most effective application method (flood, sprinkler, shank, or drip) for a particular situation.

WEED MANAGEMENT AFTER PLANTING

Transplanting peppers is the dominant method of planting peppers statewide; a much smaller portion of pepper acreage is direct seeded. Weed control following planting between the two planting systems varies to some degree. Initially, using transplants provides the crop a growth advantage over the weeds. However, the slow initial emergence of direct-seeded peppers provides an opportunity to burn off the first flush of germinating weeds with herbicides or flaming before the pepper plants germinate.

Cultivation and Hand Weeding

After transplanting, mechanical cultivation close to the seed line removes weeds on the bed top and furrow, except for those in the seed line. To avoid excessive competition with the peppers and to make removal easier, cultivate when weeds are small. Removing weeds when they are in the seedling stage permits a shallow cultivator setting, which helps to avoid bringing more weed seeds near the surface where they might germinate.

Close cultivation effectively controls many weeds in a pepper field with the exception of dodder and weeds growing in the seed line. Dodder does not require connection with the soil once it has attached to the pepper plant; therefore cultivation will not destroy it after attachment has occurred. Control weeds that can act as alternate hosts for dodder, allowing it to spread onto pepper plants. At thinning, eliminate pepper plants that have dodder attached to reduce dodder problems. When pepper seedlings are tall enough, cultivation tools can be adjusted to throw soil to the base of the plants to create a dust mulch and smother young weed seedlings.

Hand weeding controls weeds in the seed line that are not removed by cultivation. The expense of hand hoeing can be reduced by close cultivation before thinning, which allows the hand crew to move more quickly through the field. The nightshades closely resemble peppers and can at times be difficult to detect by weeding crews. Transplanted peppers are not thinned, but for direct-seeded peppers, escaped weeds in the seed line can be removed at thinning. Generally, one to three hand weedings are needed to maintain peppers free of weeds through harvest.

Cultural Practices

Preventing weeds from setting seed helps reduce the population of weeds in the following crop; this also applies to areas adjacent to cropped fields. A program of roguing out nightshade plants late in the season can dramatically reduce the amount of seed that is deposited in the field at the end of the cropping cycle.

Buried drip irrigation can help reduce weed problems by keeping the tops of the beds dry. If peppers are direct seeded, a second irrigation system (furrow or sprinkler) is needed to germinate the pepper seed. This process also favors germination of weed seeds, which can be flamed once they have emerged. The crop should be well established and free of emerged weeds before the subsurface drip irrigation is used. If conditions permit and water from the buried drip tape is sufficient to meet the needs of the crop but not ample enough to wet the bed tops, weed control can be satisfactory. However, if it is necessary to sprinkler-irrigate after peppers have emerged, subsequent weed growth will occur and require hand weeding. Perennial weeds are likely to remain a problem with this system.

With furrow-irrigation systems, maintaining deep furrows keeps the bed tops from becoming overly wet while providing adequate moisture for the crop. By keeping the bed tops drier, fewer weeds are likely to germinate in the soil surface.

Opaque Mulch

Black, brown, or green plastic mulch is used on transplanted peppers and can inhibit most weed growth on pepper beds. However, plastic mulch does not control yellow nutsedge, which can germinate and emerge through the plastic. Weeds can also establish in planting holes immediately around the pepper plant and need to be removed by hand.

Flaming

The slow emergence of direct-seeded peppers can be used as an advantage for weed control purposes. Weeds generally germinate earlier than peppers and these weeds can be controlled by flaming the beds with propane burners. In order to kill the maximum amount of emerged weeds, flame when 1 to 3% of the pepper plants begin

to emerge. Timing is critical: only a 1- or 2-day window exists for flaming once the pepper seedlings are ready to emerge because any emerged seedlings will be killed by the process. Flaming will control most broadleaf weeds when they are in the two- to four-true leaf stage; however, many grasses and volunteer cereals will not be effectively controlled. Pepper seed that has been primed germinates too fast; as a result, fields planted with primed seed cannot safely be flamed.

Herbicides

In direct-seeded peppers, paraquat (Gramoxone SL 2.0), carfentrazone (Shark), and pelargonic acid (Scythe) can be applied to the flush of weeds that emerge before the emergence of pepper seedlings, in much the same manner as the use of flaming described above. There is only one foliar-applied herbicide (halosulfuron-Sandea) that selectively controls some broadleaf weeds in peppers, but clethodim (Select Max) and sethoxydim (Poast) can be applied to control most annual and perennial grasses.

Clethodim and sethoxydim have good selectivity on peppers; however, they may cause some phytotoxic symptoms if the temperatures are above 85° to 90°F. Trifluralin (Treflan) and pendimethalin (Prowl H2O) are only labeled for use on transplanted peppers and must be incorporated into the soil; they do not control nightshade. Napropamide (Devrinol) can be applied over the top of transplants and then immediately sprinkler-irrigated into the soil.

Pendimethalin can be applied at layby when the plants are 5 to 7 inches tall. Treatments are usually applied as directed or shielded sprays on each side of the plant row and immediately incorporated by sprinkler irrigation or mechanical incorporation.

WEED MANAGEMENT FOR ORGANIC PRODUCTION (12/09)

Weed control in organic pepper production depends upon an integration of good cultural practices, careful cultivation, and hand labor. Preventing the production of weed seed in the field before planting will reduce subsequent weeding costs during crop production.

The first step in developing a weed management program is survey the planting site and identify the weeds that are there. Become familiar with each weed's growth and reproductive habits in order to choose the most effective management options. For help in identifying common weeds, see the weed photo pages that are linked to the weed list in the section COMMON AND SCIENTIFIC NAMES OF WEEDS.

WEED MANAGEMENT BEFORE PLANTING THE CROP

Crop rotations and field sanitation

The previous crop can significantly affect weed pressure in the pepper crop. A previous crop that has had excellent weed control generates fewer weed seeds that germinate in the pepper crop. In addition, it is important to keep the areas surrounding the pepper field free of weeds that have aerially dispersed seeds, such as groundsel and sowthistle. A general recommendation is to avoid fields, if possible, with infestations of field bindweed and yellow or purple nutsedge because these weeds will be expensive to control in organic pepper production.

Pregermination of weeds before bed shaping

Pregermination involves the use of irrigation or rain to stimulate weed seed germination before planting peppers. The emerged seedlings are then killed by shallow cultivation, flaming, an organic herbicide, or a combination of these treatments. Pregerminate as close as possible to the date of planting to assure that the weed spectrum does not change before the vegetable crop is planted. Changes in the weed spectrum may occur as a result of changes in the season or weather. The time of year, irrigation system, and the interval between irrigation and weed control all affect the efficacy of this technique. Waiting 14 days from the preirrigation to control weeds with shallow tillage can provide up to 50% weed control in the subsequent crop. If time permits, repeat the pregermination process to further reduce weed populations.

Pregermination of weeds after bed shaping

Once beds are shaped and ready to plant, water can be applied to stimulate a flush of weeds, thereby depleting the quantity of weed seed in the top inch of soil. The flush of weeds can be killed by shallow cultivation, flaming, or applications of organic herbicides. Be careful not to till too deeply or weed seed may be brought to the surface from deeper layers. The crop can then be planted immediately on these beds. This technique is called "stale" seedbed and it can provide substantial weed control.

WEED CONTROL AFTER PLANTING, BEFORE CROP EMERGES

Flaming or organic herbicide treatments can be used to kill the flush of weeds anytime between seeding the crop and its emergence. This technique is particularly effective on crops that have slow seed germination and has been widely used in direct-seeded peppers. Flaming and organic herbicides are effective on small (i.e. less than 2 true leaves) broadleaves but not effective on grass weeds.

Deep plowing

Deep plowing is a tillage technique that buries weed seed or propagules of perennial plants below the depth at which they can germinate. The viability of buried weed seed declines over time and a longer interval between deep plowing and subsequent deep plowing (i.e. 3-5 years) is preferred in order to avoid bringing up large numbers of viable weed seed back to the soil surface.

Cover crops

The use of cover crops is a key cultural practice in organic production. Cover crops provide a variety of benefits to crop production, but can potentially both increase or decrease weed pressure in vegetable production systems. Unfortunately, annual weeds frequently become established at the time of the cover crop, and depending upon the species of weed, they can grow and set seed unnoticed in cover crops.

Often weed plants decompose before the end of the cover crop cycle, making their detection difficult. In such cases, the cover crops act as nurse crops to weeds, making substantial contribution to the seed bank. Slow-growing winter cover crops, such as many legumes and cereal-legume mixes, can be particularly problematic in this manner, as they allow substantial weed growth and seed set early in the growth cycle of the cover crop. Fast-

growing winter cover crops, such as cereals and mustards, provide complete ground cover in the first 30 days of the cover crop cycle and are better able to compete with weeds.

Competitive cereal and mustard cover crop varieties include Merced rye (*Secale cereale*), white mustard (*Sinapis alba*), and Indian mustard (*Brassica juncea*). An adequate seeding rate is also an important factor in providing for rapid ground cover. Be sure to monitor your cover crops, particularly in the first 40 days following seeding, to make sure that they are not creating a weed problem for the subsequent pepper plantings.

Mulches

Mulches are organic materials (i.e. straw), paper, or plastic films that are placed on the soil surface to inhibit weeds and provide other horticultural benefits to pepper production. They prevent the light from penetrating to the soil surface so that the germination of weed seed is reduced. Dark-colored plastic mulches (i.e. black, brown, and green) are commonly used in pepper production. However, weeds can emerge through the planting hole and in the furrows that are not covered by plastic. Yellow nutsedge has sharp leaves that can penetrate plastic film; research has shown that placing a layer of paper between the soil and plastic film can reduce emergence of nutsedge through plastic mulch.

Soil sterilization

Soil sterilization is generally accomplished by heat generated by soil solarization or by the use of steam. Both of these techniques may have promise for organic pepper production because of the long-term nature of this crop.

WEED MANAGEMENT AFTER PLANTING THE CROP

Cultivation

Cultivation is one of the most effective cultural practices that can be carried out after planting. On double-row 40-inch beds it is possible to cultivate 80% of the bed (assuming a 4-inch wide uncultivated strip is left for each seed line). The first cultivation after transplanting cuts weeds with coulters and knives; a final cultivation is done just before canopy closure and is more aggressive than the first, as soil is thrown to the base of the pepper plants, thereby covering small weeds.

The goal of cultivation is to cut weed seedlings as close to the seed row as possible without disturbing the crop. New precision guidance systems for cultivation (i.e. EcoDan and Robocrop) can help improve the accuracy of cultivation operations. More precise cultivation allows for reducing the width of the uncultivated band and thereby removing a higher percentage of the weeds.

Removal of weeds from the seed line can be achieved by the use of specific weeding implements such as finger and torsion weeders. They will not generally remove all of the weeds but rather remove an increased percentage of the weeds that will make subsequent hand weeding operations more efficient.

Irrigation management

Burying the drip irrigation tape 4-6 inches deep in the bed can reduce the amount of irrigation water that wets the soil surface and significantly reduce weed seed germination and subsequent weed problems in peppers.

Hand hoeing

Hand hoeing is generally necessary in organic peppers. Because of peppers' long life cycles, multiple flushes of weeds germinate in a pepper field. Early-season hand weeding operations can be made more efficient with the techniques described above. Late-season weeds are particularly problematic and are always removed by hand. Even where dark-colored plastic mulches are used, hand weeding is required to remove weeds that emerge through the planting hole.

SPECIAL WEED PROBLEMS (12/09)

BERMUDAGRASS AND JOHNSONGRASS

Bermudagrass and johnsongrass are perennial grasses that have extensive underground stems called rhizomes. The plants reproduce from rhizome segments and from seeds, which are abundantly produced.

Preplant herbicides such as bensulide (Prefar), napropamide (Devrinol), or trifluralin (Treflan) effectively control these perennials growing from seed but they will not control growth from established rhizomes.

Disk fields infested with bermudagrass and johnsongrass plants several times to cut the rhizomes into short segments. This will significantly enhance the effectiveness of sethoxydim (Poast), which can be used to selectively control these two weeds in all varieties of peppers. The grasses should be growing vigorously at the time of treatment and an oil or paraffin-based adjuvant should be added to sethoxydim. If regrowth occurs, a second application will be required.

Organic growers may want to try weeder geese, which prefer to eat grasses over broadleaf plants. Geese have been reported to root out rhizomes and consume them, helping to eliminate johnsongrass.

FIELD BINDWEED

Bindweed is a deep-rooted perennial that is difficult to control once it becomes established. Herbicides are not effective against established plants. Seedlings can be easily told from established plants by the presence of cotyledons. Established plants require cultivation for control. Field bindweed is best controlled after a cereal crop when actively growing bindweed can be treated in fall with glyphosate (Roundup) or a similar material. Rotation with cotton, corn, or lettuce has helped reduce field bindweed in some areas. The frequent cultivations used in lettuce help control this weed, and in cotton, glyphosate can be applied with hooded sprayers or over the top if Roundup Ready cotton is planted. In corn, both cultivation and selective herbicides can be used to control field bindweed.

DODDER

Dodder is a parasitic plant; its seedlings must attach to a suitable host to survive. In addition to peppers, other known hosts of dodder include tomatoes, safflower, sugarbeets, alfalfa, asparagus, honeydew melon, onions, carrots, nightshades, and numerous broadleaf weeds. Rotations are generally not effective in eliminating dodder because it has a wide host range and its seeds can remain viable for years. However, rotation to nonhost crops such as cotton, corn, cereals, and garlic can help reduce the seed population. The standard way to control dodder has been to destroy the host pepper plants as soon as dodder is observed. If dodder is flowering, remove the host plants from the field and burn them to kill the seed. An application of pendimethalin (Prowl H20) preemergence, which is registered in transplanted peppers only, has been shown to reduce dodder germination and emergence by 80%.

Most dodder germinates between March 1 and May 20, so late planting or transplanting can help reduce problems with dodder.

LITTLE MALLOW (CHEESEWEED)

Little mallow is an aggressive biennial plant that produces seeds that remain viable in the soil for many years. It is only marginally controlled by napropamide and, as a result, is frequently present in pepper fields. Oxyfluorfen (GoalTender) can be used preplant to effectively control this weed. It can be removed in hand weeding and thinning operations although the deep taproot makes this job difficult. Cheeseweed that escapes control can make harvest operations difficult.

NIGHTSHADES

The nightshade family includes black nightshade, hairy nightshade, cutleaf nightshade, groundcherry, and several others. These annual weeds are related to peppers and are resistant to many of the herbicides commonly used in pepper production; S-metolachlor is effective on the nightshades. Soil fumigation with metam sodium can be very effective if it is done properly. Cultivation is also effective. Rotating to crops where available herbicides control nightshade helps to avoid seed buildup. Roguing nightshades from the field to reduce seed deposition is effective if the weeds can be distinguished from the crop plants.

NUTSEDGE

Nutsedge is a perennial that reproduces primarily through abundantly produced tubers, but can also produce viable seed. Tubers can remain viable in the soil for several years until conditions are favorable for growth. The tubers contain four to seven buds, each capable of producing a plant. Generally only one bud will germinate on any tuber; however, if the top is removed by cultivation or herbicide treatment, another bud will form a new plant. Fields infested with nutsedge should not be planted to peppers. If this is not possible, deep plowing to a depth of 10 to 12 inches with a moldboard plow has provided 95% control. The soil has to be thoroughly inverted to obtain good control. Yellow nutsedge can be particularly troublesome in Southern California because it can grow through the black plastic mulch used in this area on fresh market peppers.

Metam sodium applied before planting only delays emergence of nutsedge, especially on sandy soil, but does not provide effective control. Halosulfuron (Sandea) provides effective control of both yellow and purple nutsedge after it emerges while S-metolachlor is effective as a preemergence application on yellow nutsedge only.

COMMON AND SCIENTIFIC NAMES OF WEEDS (12/09)

Common Name	Scientific Name
Barley, hare	*Hordeum murinum ssp. leporinum*
Barnyardgrass	*Echinochloa crus-galli*
Bermudagrass	*Cynodon dactylon*
Bluegrass, annual	*Poa annua*
Bindweed, field	*Convolvulus arvensis*
Bromegrasses	*Bromus* spp.
Burclover, California	*Medicago hispida*
Canarygrasses	*Phalaris canariensis*
Chickweed, common	*Stellaria media*
Cockleburs	*Xanthium* spp.
Crabgrasses	*Digitaria* spp.
Cudweeds	*Gnaphalium* spp.
Dodders	*Cuscuta* spp.
Fescue, tall	*Festuca arundinacea*
Fiddlenecks	*Amsinckia* spp.
Filarees	*Erodium* spp.
Fleabane, hairy	*Conyza bonariensis*
Foxtails	*Setaria spp.*
Goosefoot, nettleleaf	*Chenopodium murale*
Groundcherries	*Physalis* spp.
Groundsel, common	*Senecio vulgaris*
Henbit	*Lamium amplexicaule*
Horseweed, common	*Conyza canadensis*
Johnsongrass	*Sorghum halepense*
Knotweed, common	*Polygonum* spp.
Lambsquarters, common	*Chenopodium album*
Lettuce, prickly	*Lactuca serriola*
Mallow, little (cheeseweed)	*Malva parviflora*
Miner's lettuce	*Claytonia perfoliata*
Mustards	*Brassica* spp.
Nettles	*Urtica* spp.
Nightshades	*Solanum* spp.
Nutsedges	*Cyperus spp.*
Oats, wild	*Avena fatua*
Pigweeds	*Amaranthus* spp.
Pineapple-weed	*Chamomilla suaveolens*
Polypogon, rabbitfoot	*Polypogon monspeliensis*
Puncturevine	*Tribulus terrestris*
Purslane, common	*Portulaca oleracea*
Radish, wild	*Raphanus raphanistrum*
Redmaids (Desert rockpurslane)	*Calandrinia ciliata*
Rocket, London	*Sisymbrium irio*
Ryegrass	*Lolium* spp.
Sandburs	*Cenchrus* spp.
Shepherd's-purse	*Capsella bursa-pastoris*
Sowthistles	*Sonchus* spp.
Speedwells	*Veronica* spp.
Spurges	*Chamaesyce* spp.

Common Name	Scientific Name
Sweetclovers	*Melilotus* spp.
Thistle, Russian	*Salsola tragus*
Witchgrass	*Panicum capillare*

SUSCEPTIBILITY OF WINTER WEEDS IN PEPPERS TO HERBICIDE CONTROL (12/09)

	BEFORE PLANTING					PREEMERGENCE OR PREPLANT INCORPORATED					AFTER PLANTING					
	CAR	OXY	PAR*	PEL	GLY	MEO	MET*	NAP	BEN	TRI	CAR	CLE	HAL	PEL	PEN	SET
ANNUAL WEEDS																
barley, hare	N	P	P	—	C	P	C	C	P	C	N	C	—	—	C	P
bluegrass, annual	N	P	P	C	C	C	C	C	C	C	N	C	N	C	C	N
canarygrass	N	P	P	—	C	C	C	C	C	C	N	C	—	—	C	C
burclover, California	—	P	P	—	P	—	P	P	N	N	—	—	—	—	—	N
crabgrasses	N	N	C	—	C	C	C	C	C	C	N	C	—	—	C	C
cudweeds	—	N	N	—	C	N	P	P	N	N	—	N	—	—	N	N
fiddlenecks	C	C	P	C	C	N	C	C	N	C	C	N	—	C	C	N
filarees	—	C	P	P	P	N	C	C	N	P	—	N	—	P	N	N
foxtails	N	N	C	—	C	C	C	C	C	C	N	C	—	—	C	C
henbit	—	C	C	—	C	—	C	P	N	P	—	N	—	—	C	N
knotweed, common	—	P	P	C	P	N	C	C	C	C	—	N	—	C	C	N
lettuce, prickly	—	C	P	—	C	N	C	C	N	N	—	N	P	—	N	N
London rocket	C	C	C	C	C	N	C	P	N	N	C	N	—	C	P	N
miner's lettuce	—	C	C	—	C	—	C	C	P	C	—	—	—	—	—	N
mustards	P	C	C	C	C	N	C	P	N	N	P	N	P	C	P	N
nettles	C	C	C	—	P	C	C	P	N	P	C	N	P	—	N	N
oats, wild	N	P	P	—	C	N	C	C	N	P	N	C	—	—	P	C
pineapple-weed	—	P	P	—	C	—	C	P	N	N	—	N	—	—	N	N
polypogon, rabbitfoot	N	P	C	—	C	C	C	C	C	C	N	—	—	—	C	C
radish, wild	P	C	P	—	C	N	C	P	N	N	P	N	P	—	N	N
redmaids (desert rockpurslane)	—	C	C	—	C	—	C	N	P	C	—	—	—	—	—	N
ryegrass	N	N	P	—	C	C	C	C	P	C	N	C	—	—	C	C
shepherd's-purse	P	P	C	C	C	P	C	P	N	N	P	N	C	C	P	N
sowthistles	N	C	C	—	C	P	C	C	N	N	N	N	P	—	N	N
sweetclover	N	P	P	—	P	—	N	P	N	N	N	—	N	—	—	N

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

BEN	= bensulide (Prefar)	NAP	= napropamide (Devrinol)
CAR	= carfentrazone (Shark)	OXY	= oxyfluorfen (GoalTender)
CLE	= clethodim (Select Max)	PAR	= paraquat* (Gramoxone SL 2.0)
GLY	= glyphosate (Roundup)	PEL	= pelargonic acid (Scythe)
HAL	= halosulfuron (Sandea)	PEN	= pendimethalin (Prowl H2O)
MEO	= S-metolachlor (Dual Magnum)	SET	= sethoxydim (Poast)
MET	= metam sodium* (various trade names)	TRI	= trifluralin (Treflan)

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

SUSCEPTIBILITY OF SPRING AND SUMMER WEEDS IN PEPPERS TO HERBICIDE CONTROL (12/09)

	BEFORE PLANTING					PREEMERGENCE OR PREPLANT INCORPORATED					AFTER PLANTING					
	CAR	OXY	PAR*	PEL	GLY	MEO	MET*	NAP	BEN	TRI	CAR	CLE	HAL	PEL	PEN	SET
ANNUAL WEEDS																
barnyardgrass	N	P	P	C	C	C	C	C	C	C	N	C	P	C	C	C
bromegrasses	N	P	C	P	C	—	C	C	C	C	N	C	—	P	C	P
chickweed, common	P	N	C	C	C	C	C	C	C	C	P	N	C	C	C	N
cockleburs	P	P	C	—	C	—	P	C	N	N	P	N	P	—	N	N
cudweeds	—	N	N	—	C	N	P	P	N	N	—	N	—	—	N	N
dodder	P	N	N	N	C	N	—	N	N	C	P	N	—	N	P	N
fescue, tall	N	P	C	—	C	—	C	C	C	C	N	—	—	—	—	P
fleabane, hairy	N	P	C	P	C	N	C	N	N	N	N	N	—	P	N	N
goosefoot, nettleleaf	—	C	C	—	C	P	C	C	P	C	—	N	—	—	C	N
groundcherries	C	C	C	—	C	C	C	N	N	N	C	N	—	—	N	N
groundsel, common	—	C	C	C	C	N	C	P	N	N	—	N	P	C	N	N
horseweed, common	N	P	P	—	C	N	C	N	N	N	N	N	—	—	N	N
knotweed, common	—	P	P	C	P	N	C	C	P	C	—	N	—	C	C	N
lambsquarters, common	—	C	P	P	C	P	C	C	C	C	—	N	N	P	C	N
lettuce, prickly	—	C	P	—	C	N	C	C	N	N	—	N	C	—	N	N
mallow, little (cheeseweed)	C	C	N	C	P	P	P	P	N	N	C	N	—	C	P	N
nettles	C	C	P	—	P	C	C	P	N	P	C	N	P	—	N	N
nightshades	C	C	C	—	C	C	C	N	N	N	C	N	N	—	N	N
pigweeds	C	C	C	P	C	C	C	C	C	C	C	N	P	P	C	N
polypogon, rabbitfoot	N	P	C	C	C	C	C	C	C	C	N	—	—	C	C	C
punctureVine	—	P	C	—	C	—	C	P	N	P	—	N	—	—	P	N
purslane, common	N	C	C	C	C	C	C	C	C	C	N	N	P	C	C	N
sandburs	N	N	P	—	C	C	C	C	C	C	N	C	—	—	C	C
sowthistles	N	C	P	—	C	P	C	C	N	N	N	N	P	—	N	N
speedwells	N	C	C	—	C	—	C	C	N	P	N	—	—	—	—	N
spurges	—	P	C	—	C	N	C	N	N	N	—	N	—	—	P	N
thistle, Russian	—	P	P	C	C	P	C	P	N	P	—	N	—	C	P	N
witchgrass	N	P	C	—	C	—	C	C	P	C	N	—	—	—	—	N
PERENNIAL WEEDS																
bermudagrass (seedling)	N	P	P	—	C[1]	N	C	C	C	C	N	C	N	—	C	C
bermudagrass (established)	N	N	P	N	C[1]	N	P	N	N	N	N	P	N	N	N	P
bindweed, field (seedling)	C	N	P	—	C	N	P	N	N	P	C	N	—	—	P	N
bindweed, field (established)	P	N	N	N	P	N	P	N	N	P	P	N	—	N	N	N
johnsongrass (seedling)	N	N	C	—	C[1]	C	C	C	C	C	N	C	—	—	C	C
johnsongrass (established)	N	N	N	N	C[1]	N	P	N	N	N	N	C	—	N	N	C
nutsedge, purple	N	N	N	N	P[1]	N	P	N	N	N	N	N	C	N	N	N
nutsedge, yellow	N	N	N	N	P[1]	P	C	N	N	N	N	N	C	N	N	N

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

BEN	= bensulide (Prefar)	MEO	= S-metolachlor (Dual Magnum)	PEL	= pelargonic acid (Scythe)
CAR	= carfentrazone (Shark)	MET	= metam sodium* (various trade names)	PEN	= pendimethalin (Prowl H2O)
CLE	= clethodim (Select Max)	NAP	= napropamide (Devrinol)	SET	= sethoxydim (Poast)
GLY	= glyphosate (Roundup)	OXY	= oxyfluorfen (GoalTender)	TRI	= trifluralin (Treflan)
HAL	= halosulfuron (Sandea)	PAR	= paraquat* (Gramoxone SL 2.0)		

[1] Treatment must occur year before planting; not when peppers are in field.

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

HERBICIDE TREATMENT TABLE (6/16)

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

UPDATED 6/16

Not all registered pesticides are listed. The following are listed alphabetically. When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide's properties, and application timing. Tank mixes may be necessary to achieve desired control; see Susceptibility of Winter Weeds to Herbicide Control and Susceptibility of Spring & Summer Weeds to Herbicide Control for information on specific weed control. Always read the label of the product being used.

FALLOW BEDS

A.	OXYFLUORFEN	0.25–0.5 lb a.i.		
	(GoalTender)	0.5–1 pt	24	0

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

COMMENTS: Provides both preemergence and postemergence control of broadleaf annuals. Rate depends on the size of weeds; it also affects the treatment-to-planting interval on direct-seeded peppers, which varies from 90 days at the low rate to 120 days at the higher rate. Work the beds with a rolling cultivator or similar tool to a depth of 2.5 inches before planting to avoid crop injury, which can result if beds are not thoroughly worked before planting or if seedling peppers are stressed. Once the beds have been worked, the effectiveness of the herbicide is greatly diminished and will no longer provide weed control. Can be applied 30 days or more before transplanting and 90 (for 0.5 pt/acre) to 120 (1 pt/acre) days before direct seeding. Work the beds similar to direct-seeded peppers. This herbicide lasts 4 to 8 weeks in the soil and has a 10-month plantback restriction for nonlabeled crops.

PREFORMED BEDS

A.	CARFENTRAZONE	0.031 lb a.i.		
	(Shark EW)	2 fl oz	12	0

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

COMMENTS: A nonselective, burndown application that can be used before transplanting peppers when weeds are less than 4 inches tall or in rosettes less than 3 inches across.

B.	GLYPHOSATE	0.45–3.6 lb a.e.		
	(Roundup Powermax)	Label rates	4	0

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

COMMENTS: A nonselective foliar herbicide that can be used up to 3 days before direct seeding takes place. The rate depends upon the weed species present and to some extent on weed size; control is poor when weeds exceed the maximum size indicated on the label. Cheeseweed and burning nettle require the higher rate, as do perennials. Annual weeds are best controlled when small. Apply in 3 to 20 gal water. Glyphosate provides good annual weed control and some suppression of perennial weeds. Control of perennials improves with late summer or fall applications during noncrop periods when perennials are actively growing. Recently, *Conyza* spp. (horseweed and fleabane) have shown resistance or tolerance to both glyphosate and paraquat: If these herbicides fail to control these weeds under expected circumstances, use alternative control methods.

C.	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 controls only emerged plants and has no residual activity. Applied as a band treatment over the crop row or as a broadcast treatment before seeding or transplanting the peppers or after seeding but before peppers emerge. Any peppers that have emerged at the time of application will be killed along with the weeds. Controls annual weeds and provides some suppression of perennials. Poor control of cheeseweed. Apply when weeds are succulent and from 1 to 6 inches high; larger weeds are more difficult to control. Apply in 20 to 60 gal water/acre (10 gal by air) with a nonionic surfactant added at the rate of 8 to 32 oz/100 gal. Use the high surfactant rate with cereals and heavy weed infestations. Late afternoon applications increase activity. Do not apply when weather conditions favor drift.

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
D. PELARGONIC ACID			
(Scythe)	3–5% v/v in 75 to 200 gal water/acre	12	0

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

COMMENTS: A nonselective, burndown application that can be used before seeding or transplanting peppers. The smaller the weeds, the more effective the control.

PREPLANT

A.	BENSULIDE	4–6 lb a.i.		
	(Prefar 4–E)	5–6 qt	12	0

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

COMMENTS: A preplant incorporated herbicide that controls annual grasses, but not wild oats or volunteer cereals, and certain broadleaf weeds such as purslane and pigweed. Apply in 10 to 50 gal water/acre and incorporate to a depth of 1 to 3 inches; bensulide can also be applied by chemigation or by surface application followed by sprinkler irrigation for incorporation. This herbicide has a long residual (6 months or more in some soils) and 120-day plantback restriction for nonlabeled crops. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

B.	METAM SODIUM*	50–75 gal/treated acre	See label	0
	(various trade names)			

COMMENTS: Soil fumigant. Beds must be free of clods and moist (60–80% field capacity). Weed seeds must be imbibed with water and ready to germinate for best results. Soil temperatures should be between 40° to 90°F at a 3-inch depth. Broadcast rate is 50 to 75 gal/acre, but typically a 6-inch band is applied using 5 to 7.5 gal per crop acre (single-row planting of peppers). Applications are made using a spray blade cutting 2 to 3 inches below the soil surface, depending on soil moisture. Disk hillers follow directly behind the spray blade and form a 3- to 5-inch dirt cap over the treated area. Dirt caps are removed and allowed to air before planting. The label requires a 14 to 21 day preplant interval between application and planting. Avoid moving untreated soil into the banded area. This pesticide is effective against nightshade and many other weeds. Other methods of application include incorporation with a power-driven rotary tiller to a depth of 3 inches and rolled to obtain a good seal; application by two fertilizer shanks adapted to treat the soil profile to 12-inch depth and a soil cap to seal; or application with a 3-tiered blade injector to a depth of 10 to 14 inches and the use of a soil cap to seal. Deep placement is not necessary for weed control, but does control other pests such as nematodes and soilborne diseases. It can be applied as a soil drench and is commonly applied through the drip system on beds with or without plastic mulch.

C.	NAPROPAMIDE	1–2 lb a.i.		
	(Devrinol 2-XT	2–4 qt	24	0
	(Devrinol 50DF)	2–4 lb	24	0

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 15

COMMENTS: A preplant incorporated herbicide; the rate of application of this herbicide depends on soil type. Incorporate to a depth of 1 to 3 inches soon after application to prevent loss. Band applications are frequently used to reduce cost. Controls most annual grasses and broadleaves, but not nightshades, mustards, horseweed, or flaxleaf fleabane. It has a long residual and can cause problems on crops such as lettuce, sugarbeet, and cereals planted in rotation.

D.	PENDIMETHALIN	0.475–1.425 lb a.i.		
	(Prowl H2O)	1–3 pt	24	70

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

COMMENTS: Labeled for transplanted peppers only as either a broadcast pretransplant surface application before transplanting or as a post-directed spray targeting the soil at the base of the plants to avoid contacting the foliage. Sufficient rainfall or irrigation is needed to activate the herbicide after a post-directed application. Must be applied before weed emergence. Apply lower rates to coarse-textured soils and higher rates to heavier fine-textured soils.

E.	TRIFLURALIN	0.5–1 lb a.i.		
	(Treflan HFP)	1–2 pt	12	0
	(Treflan TR-10)	5–10 lb	12	0

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

COMMENTS: Trifluralin is labeled for transplanted peppers only. Rate depends on soil type. It is volatile and must be immediately incorporated to avoid loss. It provides good season-long control of many annual grasses

	Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16				
	and broadleaves as well as partial control of seedling field bindweed. Apply in 5 to 40 gal water/acre and incorporate into the top 2 to 3 inches of the bed before transplanting. Keep treated soil above the roots.			
F.	FLUMIOXAZIN (Chateau)	0.128 lb a.i. Up to 4 oz	12	21
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14			
	COMMENTS: For use with bell and non-bell peppers only between plant beds (furrows) to control weed emergence in the furrows. Apply with ground equipment with a shield or hooded sprayer. Spray must be directed to the furrows and contact no more than the bottom 1 inch of the side of the bed. Do not allow contact to the top of the bed where the plants are to be transplanted.			
G.	S-METOLACHOR (Dual Magnum)	0.96–1.59 lb a.i. 1.0–1.67 pt	24	60
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 15			
	COMMENTS: Apply as a postemergence directed (layby) application after transplanting. Applications can be made to direct seeded peppers (at least 4 inches tall) or to transplanted peppers. Application should be made in a way that gives thorough soil coverage while minimizing contact with the crop leaves. Use lower rates on coarse textured soils and higher rates on fine-textured soils. This application is intended to control germinating and emerging weeds and will not control weeds that are already established.			
POSTPLANT				
A.	CARFENTRAZONE (Shark EW)	0.0238 lb a.i. 1.6 fl oz	12	0
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14			
	COMMENTS: May be applied to the row middles using a hooded sprayer. Take care to keep the herbicide off the crop.			
B.	CLETHODIM (Select Max)	0.091–0.12 lb a.i. 12–16 fl oz	24	20
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1			
	COMMENTS: A systemic herbicide that controls annual and perennial grasses. For ground applications, apply in 10 to 40 gal of spray solution/acre; add a crop oil concentrate at the rate of 1% v/v in the finished spray volume. Grasses must be at the proper size (see label), well watered, and actively growing for good control. Make repeat applications at a minimum interval of 14 days. Do not apply more than 64 fl oz per season.			
C.	HALOSULFURON (Sandea)	0.37–0.75 oz a.i. 0.5–1 oz	12	30
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 2			
	COMMENTS: For use on seed and transplant peppers for the control of nutsedge. Apply as a directed spray or with shields to avoid 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 due to increased risk of injury. Do not apply halosulfuron 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. Not for use in Imperial and Riverside counties.			
D.	NAPROPAMIDE (Devrinol 50DF)	1–2 lb a.i. 2–4 lb	24	0
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 15			
	COMMENTS: Apply the recommended amount of napropamide to the soil surface immediately after transplanting. It may be applied over the top of the plants. Use 20 to 50 gal spray/acre and make sure that the herbicide reaches the zone of weed seed germination. Use overhead sprinkler irrigation to wet the soil to a depth of 2 to 4 inches.			
E.	PELARGONIC ACID (Scythe)	3–5% v/v in 75 to 200 gal water/acre	12	0
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 27			

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 6/16			
COMMENTS: May be applied to the row middles using a hooded sprayer. Take care to keep the herbcide off the crop.			
F. PENDIMETHALIN	0.475–1.425 lb a.i.		
(Prowl H2O)	1–3 pt	24	70
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3			
COMMENTS: Labeled for transplanted peppers only. Registered for use as a broadcast pretransplant surface application before transplanting or as a post-directed application to transplanted peppers. It can be applied as a post-directed spray to the soil at the base of the plants, avoiding contact with foliage. Following post-directed application, sufficient rainfall or irrigation is needed to activate the herbicide. Must be applied before weed emergence. Apply lower rates to coarse-textured soils and higher rates to heavier fine-textured soils.			
G. SETHOXYDIM	0.28 lb a.i.		
(Poast)	1.5 pt	12	20
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1			
COMMENTS: A systemic herbicide that controls most annual and perennial grasses. Apply in 10 to 20 gal water; add a crop oil concentrate at the rate of 1 qt/acre. Grasses must be at the proper size, well watered, and actively growing for good control. This treatment can be repeated up to three times per season with a preharvest interval of 20 days. Read label for restrictions regarding tank mixes.			
H. S-METOLACHLOR	0.96–1.59 lb a.i.		
(Dual Magnum)	1.0–1.67 pt	24	60
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 15			
COMMENTS: Apply as a postemergence directed (layby) application after transplanting. Applications can be made to direct seeded peppers (at least 4 inches tall) or to transplanted peppers. Application should be made in a way that gives thorough soil coverage while minimizing contact with the crop leaves. Use lower rates on coarse textured soils and higher rates on fine-textured soils. This application is intended to control germinating and emerging weeds and will not control weeds that are already established.			

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

‡ 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 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.

This material is partially based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project Section 3(d), Integrated Pest Management.

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.